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Chlorine dioxide generators

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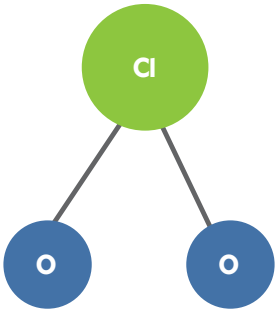
WATER DISINFECTION

Before treated water reaches the customers it must undergo a disinfection process aimed at destruction and deactivation of microorganisms and inhibition of their growth and reproduction. In order to carry out effective disinfection, it is very important to choose the right disinfectant, the optimal dose, as well as to determine the time of contact with water. An effective disinfectant should be characterized primarily by:

- high bactericidal and virucidal potency;
- ability to protect water from secondary contamination;
- no influence on the organoleptic characteristics of the water;
- possibly long duration of action.

The most commonly used disinfectants are chlorine, sodium hypochlorite, chlorine dioxide or ozone, while chlorine dioxide stands out in particular among these disinfectants because of its long duration of action and its high ability to protect the water from secondary contamination.

CHLORINE DIOXIDE - PROPERTIES AND APPLICATIONS



Chlorine dioxide - ClO_2 is a gas that shows strong antibacterial, antiviral and antifungal activity. Since 1900, it began to be used as a disinfectant. It is one of the more selective oxidants that easily penetrates and degrades pathogens. As a disinfectant it is approximately 2.5 times stronger than chlorine and sodium hypochlorite, and its effectiveness is not dependent on water pH.

Chlorine dioxide has a high oxidizing effect in water and therefore, even in small doses, the required sanitary and hygienic water quality can be achieved over a long period of time. Commercially available generators allow the production of chlorine dioxide in the form of an aqueous solution with a safe concentration of up to 2 g/l.

Chlorine dioxide is primarily used for:

- disinfection of drinking water, water in the food industry, surface water;
- reduction of *Legionella*, *Escherichia Coli*, *Pseudomonasbacteria*, etc;
- disinfection of cooling and circulation water in e.g. chemical industry, paper industry, refineries, heat and power plants, heating plants, cooling towers;
- disinfection of fruits and vegetables;
- phenol neutralization;
- sewage disinfection.

CHLORINE DIOXIDE - ADVANTAGES AND DISADVANTAGES IN WATER DISINFECTION

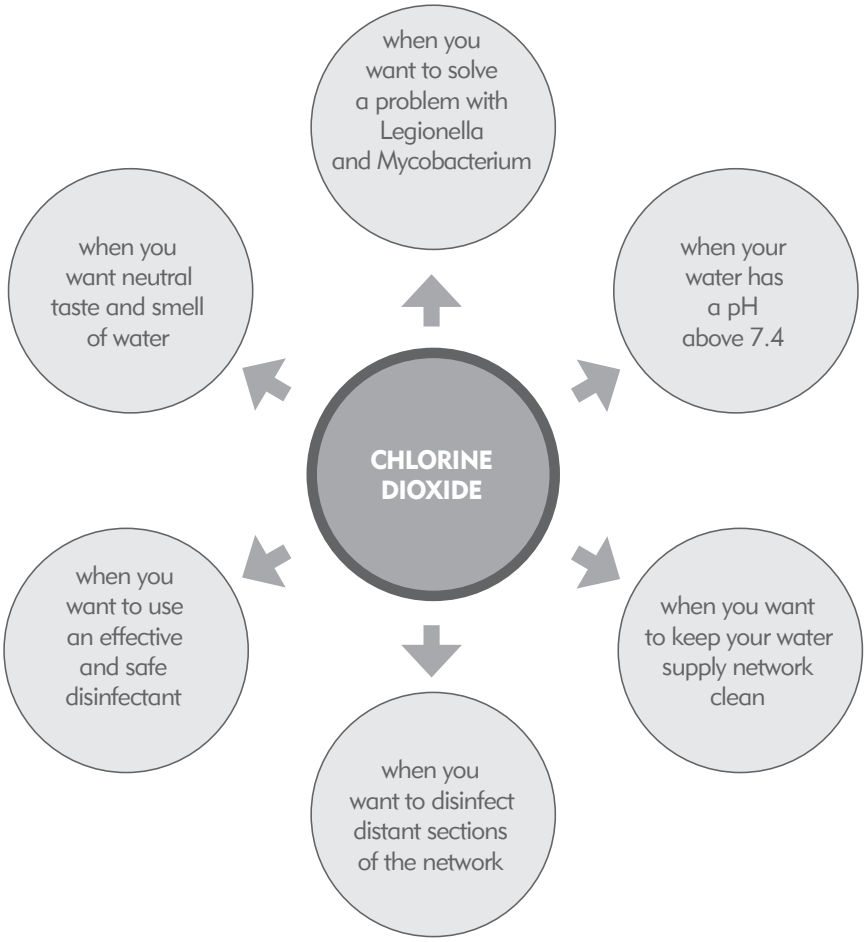
ADVANTAGES:

- low impact on water taste and smell;
- very high effectiveness (destruction of microorganisms, radicals, viruses and fungi, including Legionella and Coli bacteria, removal of biofilms, prevention of algae formation);
- three times faster germicidal effect in comparison to chlorine or sodium hypochlorite;
- durability and long time of action - efficiency in disinfection of large installations and protection against secondary contamination;
- no effect of water pH on the effectiveness (in the pH range from 2 to 10);
- no formation of THMs;
- no reaction with ammonium ion;
- prevention of biofilm formation in pipelines.

DISADVANTAGES:

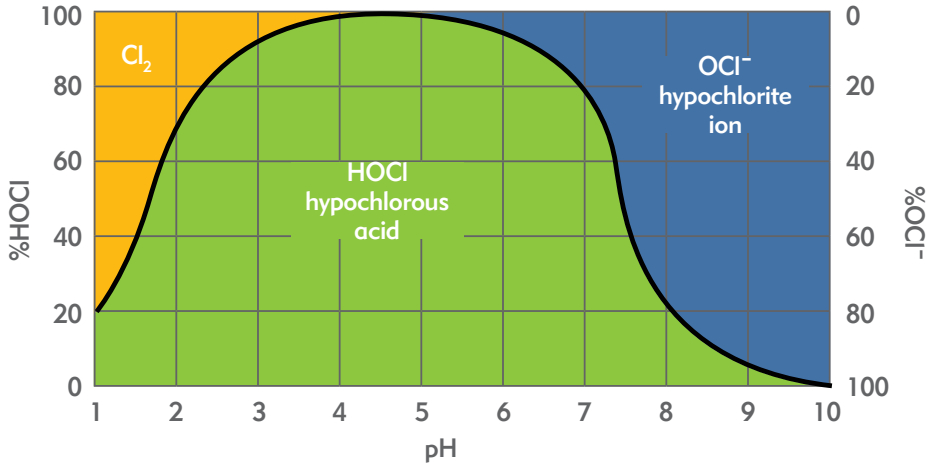
- in the initial period of its application excessive dissolution of sediments in the pipelines may occur, therefore the introduction of ClO_2 dose must be gradual, well-thought-out and with technological control;
- possibility of formation of chlorites and chlorates.

WHEN TO USE CHLORINE DIOXIDE DISINFECTION?

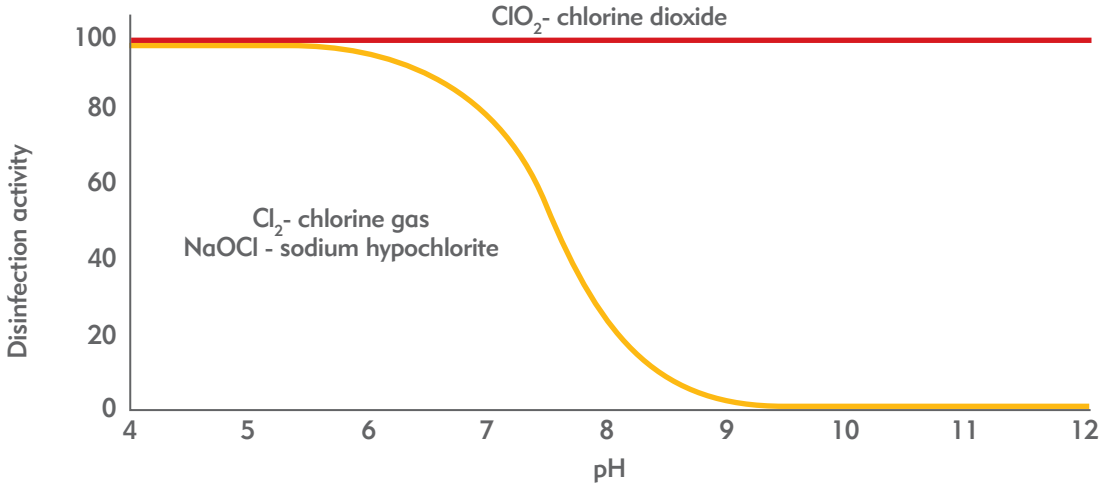


CHLORINE DIOXIDE VS OTHER DISINFECTANTS

Compared to chlorine or sodium hypochlorite, chlorine dioxide as a disinfectant has a significantly higher bactericidal power. Moreover, it does not react with organic substances, so it does not form THMs (as chlorine or sodium hypochlorite do), which are carcinogenic.
The effectiveness of chlorine dioxide does not depend on the water reaction as with other disinfectants.
For example:
The reaction product of chlorine or sodium hypochlorite with water is hypochlorous acid (HOCl) and hydrochloric acid (HCl) or sodium hydroxide (NaOH), respectively. Subsequently, the hypochlorous acid is decomposed, depending on the pH of the water, which is a very important element for the adequate disinfection efficiency of chlorine or sodium hypochlorite. The resulting hypochlorite ion (OCl^-) has about 80 times less disinfecting power than hypochlorous acid (HOCl), and its content increases with the pH of the water. As shown in the diagram below - at pH 7.5 about 50% of the chlorine is already in the form of less active hypochlorite ion, which in practice significantly reduces the effectiveness of sodium hypochlorite.



This is not the case with chlorine dioxide - unlike chlorine or sodium hypochlorite, its disinfectant properties remain practically unchanged over a wide pH range (from 4 to 10).



Another parameter indicating the effective action of chlorine dioxide is CT (C - concentration, T - time), which determines the bactericidal effect of a given disinfectant. This parameter is nothing but the required disinfectant's concentration in water [mg/l] and the contact time with the disinfected water [minutes]. The CT value is compared with respect to a specific bacterial group and disinfectant. The lower the CT value, the better the disinfectant.
The table below shows the CT parameters for chlorine and chlorine dioxide.

	Parameter CT [mg/l x min]	
	Chlorine Cl_2 Sodium hypochlorite NaOCl	Chlorine dioxide ClO_2
Cryptosporidium Parvum	1440	> 120
Giardia Lamblia	104 ÷ 122	23
Escherichia Coli	3 ÷ 4	1,2

The comparison shows that chlorine dioxide has almost three times lower values of this CT parameter. This means that by choosing it as a disinfectant we can use lower concentrations and shorter contact times with water and achieve the same results as with chlorine or sodium hypochlorite.

METHODS FOR OBTAINING CHLORINE DIOXIDE

COMMERCIAL SOLUTION OF ClO_2

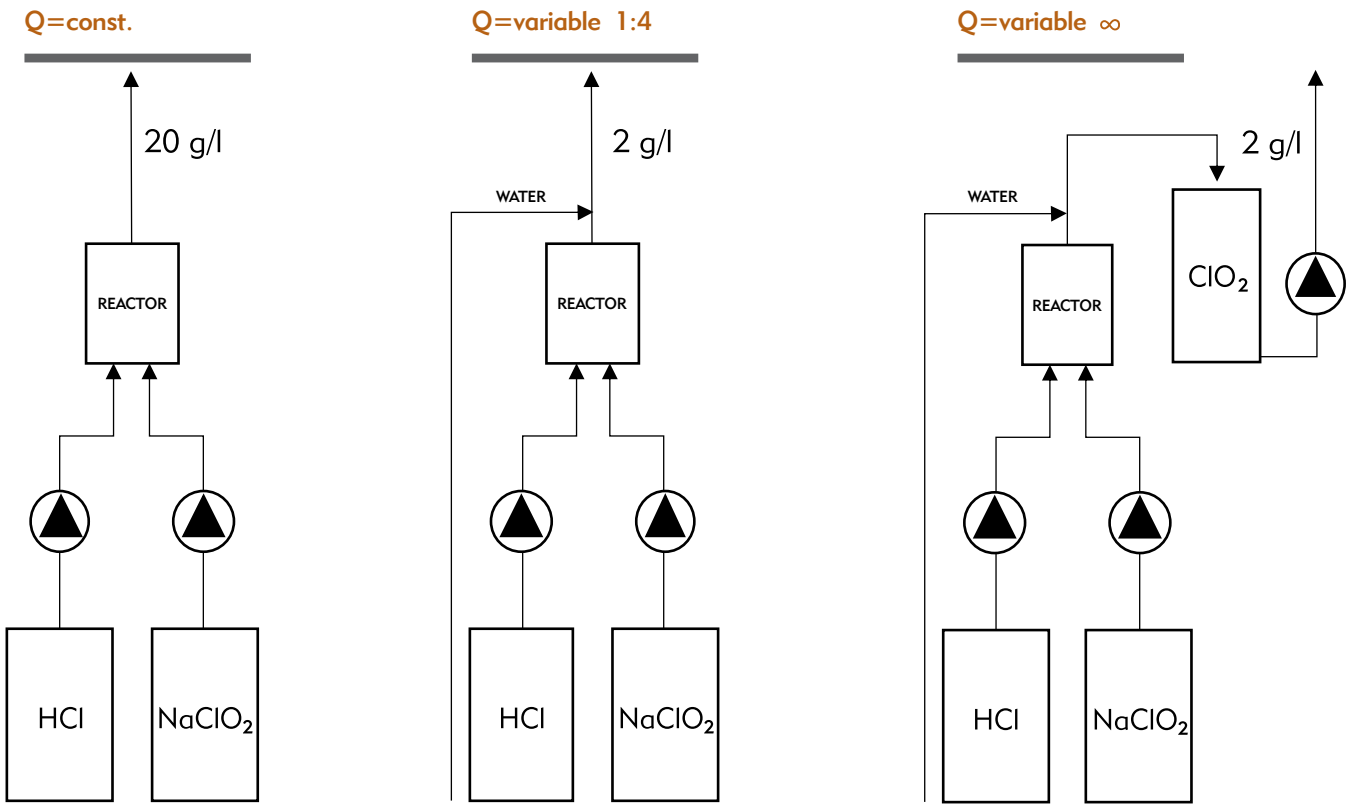
Similar to sodium hypochlorite, a stabilized solution of chlorine dioxide is available on the market with a concentration of approximately 6 g ClO_2/l. Unfortunately, due to its unit cost and shelf life, it can only be used periodically for very small applications.

ClO_2 PRODUCTION ON SITE

Chlorine dioxide can be produced in generators, directly at the point of dosing. The process of disinfectant production is not complicated and consists in proportional mixing of sodium chlorite (7.5%) and hydrochloric acid (9.0%) solutions, their temporary storage in a reactor and dilution of the resulting chlorine dioxide to a concentration below 2 g ClO_2/l. The advantage of such solution is the possibility of adjusting the production of chlorine dioxide to the current demand (limiting the formation of chlorites and chlorates) and relatively low operating costs.

On the market there are chlorine dioxide generators of simple construction (dosing pumps + reactor) and more complicated devices equipped with control and process elements. In the process of water treatment it is recommended to choose a generator with extended equipment in order to be able to control on an ongoing basis the production of the disinfectant and its dosage to the system.

The chlorine dioxide dosing system must be selected according to your needs. You can either dose the concentrated chlorine dioxide solution continuously or dose the diluted chlorine dioxide solution continuously or variably. Dosing of the diluted solution is suitable for water supply systems, while variable dosing via an intermediate tank makes it possible to cover the buffer of irregular water consumption.



CONSTANT DOSAGE
CONCENTRATED SOLUTION

CONSTANT DOSAGE
DILUTED SOLUTION

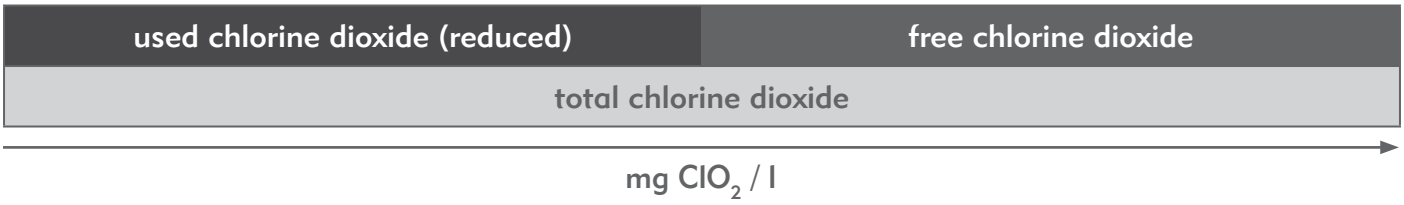
VARIABLE DOSAGE
DILUTED SOLUTION

SELECTION OF CHLORINE DIOXIDE GENERATOR

When selecting a chlorine dioxide generator for drinking water disinfection, the flow rate of the medium and the dose of disinfectant required to achieve optimum sanitary and hygienic water quality must be taken into account.

capacity of chlorine dioxide generator [g ClO_2/h]=max media flow [m^3/h] x max dose [g/m^3]

When disinfecting water with chlorine compounds, it is important to know that the chlorine they contain first oxidizes the reduced iron, manganese and hydrogen sulfide compounds present in the water, as well as organic substances, bromides and ammonium ions. Only the rest of the chlorine has a disinfecting effect.



To determine the required dosage of disinfectant a series of chlorine dioxide water demand tests are conducted. The test involves adding appropriate volumes of an aqueous solution of chlorine dioxide of known concentration to the tested water, mixing thoroughly and then measuring the amount of disinfectant remaining in the water after 30 minutes. This determines the breakpoint, i.e. the amount of chlorine dioxide that is consumed by the water. The size of the breakpoint is influenced by the content of dissolved substances in the water (iron, manganese, sulfides or nitrite) that are oxidized. It is therefore important to remember that the experimentally determined breakpoint will depend on the physicochemical parameters of the disinfected water.

Due to the high effectiveness of chlorine dioxide in removing biofilms from pipelines, it is recommended to start disinfection with the lowest dose and gradually increase it over a longer period (up to 3 years). This prevents rapid detachment of biofilm fragments and disturbance of the sediment structure covering the pipe walls, which can result in significant deterioration of water quality in the water supply system. Therefore, when introducing chlorine dioxide for disinfection, more frequent flushing of the water network should be taken into account.

Optimal production of chlorine dioxide in the generator takes place under the following technical conditions:

- chlorine dioxide is produced inside a reaction chamber with a volume that ensures a minimum reaction time of 10 minutes;
- the reagents are drawn in by independent metering pumps;
- the chlorine dioxide solution is diluted to a concentration of less than 2 g/l by an additional water flow;
- the amount of chlorine dioxide produced depends on the amount of reagents used in the process and therefore on the pump pulsation frequency;
- the frequency or capacity of the chlorine dioxide production process depends on the level in the tank of ClO_2 solution produced or the signal coming from the flow meter;
- generators must be equipped with operating disturbance detection systems that shut down production when safety conditions are not met;
- generators absolutely must be equipped with flow meters, not flow sensors which only provide the presence of flow, not the amount of flow.

PROFGENERATOR ClO_2 3, 10, 15, 20

Manufacturer: Proffico

DESCRIPTION AND TECHNICAL PARAMETERS	Profgenerator ClO_2			
	3	10	15	20
Capacity [$gClO_2/h$]	3	10	15	20
Concentration after dilution [$gClO_2/l$]	min 0.5	1.1	up to 2.0	up to 2.0
Volume of disinfected water – dose 0.5 $gClO_2/m^3$ [m^3/d]	144	480	720	960
Hydrochloric acid consumption HCl – 9.0% [ml/h]	225	750	1125	1500
Sodium chlorite consumption $NaOClO_2$ – 7.5% [ml/h]	75	250	375	500
Process water pressure [bar]	2 ÷ 8			
Process water temperature [°C]	10 ÷ 30			
Ambient temperature - operation [°C]	15 ÷ 30			
Humidity [%]	max. 90			
Power supply [V/Hz]	230/50			
Power [kVA]	0.12			
Dimensions with protective housing [mm]	980 x 1295 x 319			
Weight with protective housing [kg]	75.5			

ACCESSORIES AND PARAMETERS OF EQUIPMENT	
Control	7" color touch screen with Beckhoff, Siemens or equivalent controller
Reagent dosing	dosing by means of two peristaltic pumps, each equipped with suction lance with filter, non-return valve, dry-running sensor and reserve sensor
Control of reagents consumption	flow meter installed between each pump and the reactor and a calibration system for each dosing pump
Storing the chlorine dioxide solution	diluted solution stored in two connected in series, pressure-free tanks with a capacity of 3.4 l, equipped with level probes (protection against dry-running of the dosing pump)
Dosing of chlorine dioxide	dosing by a membrane pump: adjusted in manual mode or proportionally to flow (after supplying an impulse or current signal 0/4 ÷ 20 mA to the pump socket)

PROFGENERATOR ClO_2 50, 100, 150, 200

Manufacturer: Proffico

DESCRIPTION AND TECHNICAL PARAMETERS	Profgenerator ClO_2			
	50	100	150	200
Capacity [$gClO_2/h$]	25 ÷ 75	75 ÷ 125	125 ÷ 175	175 ÷ 225
Concentration after dilution [$gClO_2/l$]	up to 2.0			
Volume of disinfected water – dose 0.5 $gClO_2/m^3$ [m^3/d]	2400	4800	7200	9600
Hydrochloric acid consumption HCl – 9.0% [l/h]	1.25	2.50	3.75	5.00
Sodium chlorite consumption $NaOClO_2$ – 7.5% [l/h]	1.25	2.50	3.75	5.00
Process water pressure [bar]	2 ÷ 8			
Process water temperature [°C]	10 ÷ 30			
Ambient temperature - operation [°C]	15 ÷ 30			
Humidity [%]	max. 90			
Power supply [V/Hz]	230/50			
Power [kVA]	0.12			
Dimensions with protective housing [mm]	980 x 1295 x 319			
Weight with protective housing [kg]	about 70			

ACCESSORIES AND PARAMETERS OF EQUIPMENT	
Control	7" color touch screen with Beckhoff, Siemens or equivalent controller
Reagent dosing	dosing by means of two membrane pumps, each equipped with a suction lance with filter, non-return valve, dry-running sensor and reserve sensor
Control of reagents consumption	flow meter installed between each pump and the reactor and a calibration system for each dosing pump
Storing the chlorine dioxide solution	none - dosing of the solution directly into the water supply system
Dosing of chlorine dioxide	continuous dosing, directly into the water stream

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