

## UNIVERSAL MODULAR DEVICE FOR ELECTROCHEMICAL SYNTHESIS OF THE DISINFICANT

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### ABSTRACT

*For the water disinfections practically four different technologies (chlorine, ozone, hypochlorite, chlorine dioxide) are used nowadays in the world. The oldest and the most exploited one, so called conventional, is the disinfections with gaseous or liquid chlorine. The biggest producers of the equipment for the water treatment in the world mainly possess all mentioned technologies for water disinfections. It is easy to concluded that the technology of water disinfections with the hypochlorite solution produced by the electrolysis of 3% solution of sodium chloride on the site of water chlorination is not only the most convenient from the point of economical aspects, but also from the point of the ecological aspect.*

**Keywords:** water disinfections, water chlorination, *in situ* water chlorination, hypochlorite production.

### 1. OVERVIEW OF THE EXISTING TECHNOLOGIES FOR WATER DISINFECTIONS

The four main chemical substances used for the water disinfection nowadays in the world are:

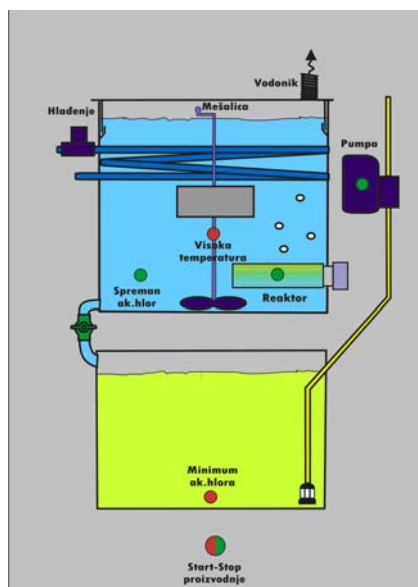
- disinfection with gaseous or liquid chlorine;
- disinfection with ozone;
- disinfection with hypochlorite solution produced by the electrolysis of 3% solution of sodium chloride;
- disinfection with chlorine-dioxide (ClO<sub>2</sub>).

The oldest and the most exploited one, which is known as conventional, is the disinfection with gaseous or liquid chlorine. During the last two decades ozonization has also been used, while only recently the other two technologies were applied. The biggest producers of the equipment for the water treatment in the world (CAPITAL CONTROLS, WALLACE & TIERNAN, PROMINENT etc.) mainly possess all mentioned technologies for water disinfection.

### 2. UNIVERSAL MODULAR DEVICE FOR ELECTROCHEMICAL SYNTHESIS OF THE DISINFICANT

System comprises: hypochlorite reactor (electrolyzer), reactor storage tank, hypochlorite storage tank, rectifier with control panel for automatic control of operation, hypochlorite dosing pump,

electromagnetic valve, and ventilation system. This type of electrochemical generator is designed with upper, reaction, and lower, reception tanks, while between is modular electrolyzer, as shown on Figure 1. Above reception tanks two or more modular reactors in which dilute solutions of sodium chloride is converted in active chlorine by electrochemical reaction. Before electrolysis reaction tank is filled with water and specified quantity of sodium chloride. After starting, mixer prepares 3% NaCl solution in reaction tank followed by automatically connection of electrolyzer. After 60 h, electrolysis is finished, power supply is automatically switched off and active chlorine solution is ready for simply manual transfer in reaction tank and use by applying micro dosing pump. At the mean time, reception tank is again manually filled with water and specified quantity of sodium chloride. By this procedure, reception tank always contains some extra volume of active chlorine for unexpected situations.



#### Basic componets of MCEG

1. Modular electrolyser - reactor
2. Switch temperature
3. Reactor tank
4. Hypochlorite storage tank
5. Heat exchanger
6. Electomagnetic valve
7. Fan pipeline
8. Switch level
9. Dosing pump

Figure 1. Schematic representation of the modular charge electrochemical generator for automatic production and dosing disinfectans with self cleaning electrodes

Depending on the capacity of the devices a salt reactor tank can contain from 200 dm<sup>3</sup> to 1000 dm<sup>3</sup> of 3% NaCl. It should be refilled with the 3% NaCl every 15 – 60 days, depending on the capacity. Into the reactor tank which was previously filled with water from fountain, 6 to 30 kg crystals of common table salt-NaCl are added. By using the manual stirrer, salt is mixed until the complete dissolution of the salt. On the end of this operation, setting of the cover provides complete isolation of solution from the environment by the water valve. The only way to the solution to come into contact with air from atmosphere is through ventilating system. On the bottom of the reactor tank, 1 to 8 reactor modules depending on the capacity are placed. The temperature sensor is placed below the reaction modules. If the temperature go over the certain value, electromagnetic valve will active the function of the spiral heat exchanger in the reaction vessel. An electromagnetic valve closes after decreasing of the temperature, and consequently the process of cooling stops. These whole processing steps are necessary due to maintain the electrochemical reaction in optimal conditions which provides maximum efficiency. Gaseous hydrogen, produced on the cathode during the electrolysis, is vented out by the ventilation system. A temperature switch is also placed in the generator, switching off the system in the case of possible increase of the electrolyte temperature over the upper limit. The characteristics of the hypochlorite storage tank can contain from 200 dm<sup>3</sup> to 1000 dm<sup>3</sup> of 1,4% NaOCl. One switch are placed in the tank. When the hypochlorite level reaches the low-level switch, the brine pump and the rectifier are automatically being switched off and devices automatically being

stopped (alarm low level hypochlorite). Depending on the system capacity, the characteristics of the rectifiers are:

*Voltage - 2 - 20 V; current - 0 - 160 A.*

The operation of the rectifier is automatically controlled from the control panel. These pumps were made of materials resistant to the very aggressive solutions such as NaCl and NaOCl solution.

Among the capacities given in this brochure, we can produce our system which can satisfy much higher needs for equivalent chlorine, up to 10 kg per day. Such system comprises all other elements except the reactor tank and hypochlorite storage tank, which are to big and must be placed separately.



*Figure 2. Picture of the modular charge electrochemical generator for automatic production and dosing disinfectants and with self cleaning electrodes*

### **3. PRINCIPLE OF THE DEVICE FUNCTION**

Into the reactor tank which was previously filled with water, crystals of NaCl are added. By using the manual stirrer, salt is mixed until the complete dissolution of the salt. On the end of this operation, setting of the cover through vessel provides complete isolation of solution from the environment by the water valve. Electrolysis process starts by pressing of the button START. Evolution of the chlorine on the anode undergoes to hydrolysis forming hypochlorite ions, until evolution of hydrogen occurs on the cathode and consequently throw the evolved gas into the atmosphere. Considering fact that part of electric energy is transform into the heat, spiral heating exchanger with water circulation is installed in the reaction tank. Circulation of the refrigerate fluid (water) is automatically provided by the measurements of the temperature during electrolysis. If the temperature go over the certain value, electromagnetic valve is opened until refrigerate fluid cooling the reaction solution to the certain stringer temperature, when is closed again. The device is turn off after 40 to 200 hours of constantly function, when the hypochlorite solution is ready to transfer by gravity into the hypochlorite tank. By using pump, the hypochlorite from the tank is dosing water in order to obtain disinfection. In addition, new batch is filled with reaction solution and parallel, new electrolysis-production of hypochlorite starts, too. After whole amount of the hypochlorite in the hypochlorite tank is consumed, alarm of low level of the present hypochlorite is turn on, which inform manipulator of the device about the situation and interrupt function of the pump. All stages in function of the device are connecting by internet and GSM net and are possible to send all the information about operating state of the device to the person in charge for the supervision or distance controller of the device.

The modular charge electrochemical generator is less expensive, trustful, drinking water disinfectant sources (based on the diluted hypo-chlorite solution) designed for the low population suburban areas.

The electrochemical generator consist the preparation-reaction tanks, with adjustable volume depending on the required quantities of disinfectants, and the electrolyser. The electrolyte is prepared in the reaction tanks, filling with water up to the marked volume and adding required mass of commercially available sodium chloride. After manual adding of the required mass of sodium

chloride, the electrolyte should be manually mixed with stirrer while whole sodium chloride was dissolved (less than five minutes), and electrolysis units should be started up, simply by pressing start-up button on external power supply. Depending on electrolyte volume, electrolysis can take 40 to 80 hours. During electrolysis, if the temperatures cross the certain value, the cooling of the electrolyte is automatically applied.

By applying the automatic mode of the electrolysis (reverse current at the certain times) the electrodes could be cleaned from carbonate deposits which is the main problem for the efficiency in such types of electrolyzers.

After the electrolysis is completed, the disinfectant solution is transferred in to the storage tank, and used due to the requirements (using the dosing pump and active chlorine sensors).

REVERSE DSA (dimension stable electrodes) is predicted to work for anodic, as well as for cathodic reaction, so water softening is not necessary. Hence, by using this system, expensive ion exchange columns and their regeneration are avoided. This type of electrolyzers is designed for water-works and water plants where constant control and measurements of active chlorine concentrations is necessary due to the regulations. This installation is in trial use.

Technological scheme of the device with signal and alarm positions is placed on the control board. Green light bulb is indication of work of the device respective component. Suitable element of the device is not in function if there is no green light on the board. Alarming situations (unsuitable temperature, low level of hypochlorite) are assigned with red light bulb. Function of the device is normal if there is no indication of red light. Red light beside sensor element indicates switching off of the device and it will show light to the length of the manual reset of the device.

By pumping the water with 0.3% of NaCl from water units through mechanical (sand) filters and electrolyzer small amount of active chlorine is produced, which is used for continual disinfections of water in the rest of the water units. Power consumption is as small as 30 to 80 Wh.

#### **4. CONCLUSION**

This solution represents confidently technological answer which could be applied for synthesis of different organic and non-organic compounds. Innovation solves the problem of electrochemical synthesis obtainment with usage of modular reactor of simple construction which provides technical support during function of the device, as well.

The system can be applied for water disinfections, in disinfections of accessories in food and meat industry. The devices are attested and represent the lowest price devices for in site disinfections, comparing with similar ones which can be found at the market.

#### **5. ACKNOWLEDGMENT**

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#### **6. REFERENCES**

- [1] Elkais Ali Ramadan, Gvozdenovic Milica M, Jugovic Branimir Z, Trisovic Tomislav Lj, Maksimovic Miodrag M, Grgur Branimir N.: Electrochemical Synthesis and Corrosion Behavior of Thin Polyaniline Film on Mild Steel, Copper and Aluminum, *HEMIJSKA INDUSTRIJA*, (2011), vol. 65 br. 1, str. 15-21
- [2] Gvozdenovic Milica M, Jugovic Branimir Z, Trisovic Tomislav Lj, Stevanovic Jasmina S, Grgur Branimir N.: Electrochemical characterization of polyaniline electrode in ammonium citrate containing electrolyte, *MATERIALS CHEMISTRY AND PHYSICS*, (2011), vol. 125 br. 3, str. 601-605