

## **OSEC<sup>®</sup> B-Pak - Frequently Asked Questions**

### **WHY CHOOSE ON-SITE HYPOCHLORITE GENERATION?**

#### **Q. What is Evoqua Water Technologies level of experience with electrochlorination?**

A. We have over 100 years of chlorination experience, and 80 years with on-site generation systems. In the 1930's Wallace & Tiernan supplied electrochlorination systems in Britain. Also at that time in the United States the movement to consider electrochlorination as a safe alternative to chlorine gas for use in municipal swimming pools began. In the 1970's W&T developed the OSEC system and after several years of field testing it was released for sale in 1980.

We've been continuously improving the products and expanding our knowledge around the world in electrochlorination. Evoqua Water Technologies is active in producing anodes, developing coatings, electrolyzer fabrication, brine-based and seawater-based systems, controls and process engineering, all within one business unit.

To date we have over 1,400 brine-based systems in operation, and more than 2,200 sea-water based systems for offshore and land installations. These systems in total produce well over 1 Million pounds of chlorine each day. The climatic conditions of these sites range from very cold areas in Scandinavia, Russia, and Alaska to very hot conditions in Middle East, Central Africa and the southwestern United States.

#### **Q. Are sodium chloride, sodium hypochlorite, and hydrogen gas health hazardous?**

Sodium Chloride (NaCl) crystals used in the OSEC process are considered non-hazardous to health unless ingested in large quantities.

Sodium Hypochlorite (NaOCl) liquid generated by the OSEC unit is <1.0wt% which is considerably weaker than commercial bulk supplies (~12.5wt%), however, care should still be taken when handling. The chemical itself is slightly alkaline and forms an oxidizing and bleaching agent which is corrosive and may cause damage to skin and clothing on contact. Mixing sodium hypochlorite with any form of acid will generate highly toxic chlorine gas, which is a health hazard.

Hydrogen (H<sub>2</sub>) gas is a flammable/explosive gas at concentrations above 4% v/v which poses a physical danger to personnel in the area. If present in occupied spaces, it can also be absorbed into the body by inhalation. Although hydrogen gas itself is non-toxic, at high concentrations, it can cause an oxygen-deficient environment. Individuals breathing in such an atmosphere may experience headaches, ringing ears, dizziness, drowsiness, unconsciousness, nausea, vomiting, and depression of the sense. In some circumstance, death may occur.

Always refer to Material Safety Data Sheets for additional information.

**Q. What is most cost-effective: chlorine, bleach or on-site hypo?**

A. In most cases, chlorine gas is the most cost-effective on a per pound basis, followed by on-site generated hypochlorite, and then most expensive typically is bulk hypochlorite. It is recommended to take the equipment, installation and operating costs into account over a period of 10-years or more.

When considering switching from gaseous chlorination to on-site generation, the true costs of the current chlorine feed approach should be taken into account. There may be costs that are hidden or built into other operating costs for the plant, such as: emergency scrubber equipment and maintenance, renewal and disposal of caustic soda or chlorine neutralization chemicals, respirator equipment and authorized operations personnel, special training and emergency response or risk management (RMP) plans.

In considering bulk hypochlorite as an alternative, there are some hidden costs associated as well that should be brought into the comparison: hypochlorite degradation (losses), energy costs to keep hypochlorite cool, price fluctuations between bid cycles, short-load (delivery) penalties, delivery/demurrage penalties, or the added cost of capital required to maintain 15-day or 30-day hypochlorite supply on hand.

While there is no one solution that fits all applications, it is helpful to know what parameters to look for in guiding you towards selecting the process that best fits your needs.

With specific data about your application, we can provide a full Life-Cycle-Cost analysis of these three alternatives for comparison.

**DESIGN AND OPERATING PARAMETERS FOR AN OSEC® SYSTEM**

**Q. What capacity of system should be selected?**

A. The system operates in a batch mode to maintain a 12-36 hour supply of dilute 0.8% sodium hypochlorite solution available for dosing. These generator skids are sized based on average and peak chlorine dosage and flow rates of the plant (to determine daily chlorine demand). To reduce rapid cycling and extend life of the equipment the capacity should be sized 20-30% greater than the peak chlorine demand. If the usage levels fluctuate heavily throughout the day we recommend to use peak hourly rate for sizing.

**Q. Can the capacity be expanded later on?**

A. The total plant capacity may be expanded by adding additional generator skids operating in parallel. However, keep in mind all the ancillary equipment and process inputs must then be scaled up to handle the additional capacities.

The generators themselves do not allow for additional electrolyzers to be added on in the field. Each system is optimized and tested to make the rated design capacity of the generator.

**Q. What is the preferred material for a hypochlorite tank, and why?**

A. Sodium hypochlorite solutions are typically stored in either high-density polyethylene (HDPE) or fiberglass reinforced plastic (FRP) atmospheric storage tanks. The difference in choice would be

attributed to life expectancy of material, and cost. FRP will last longer than polyethylene, but can cost more. Because sodium hypochlorite is corrosive the above materials are chosen for their inert nature. Stainless steel tanks are not recommended for use.

**Q. What other considerations need to be made for the hypochlorite tank?**

A. Secondary containment is always recommended for hypochlorite tanks and can come in the form of double walled construction or containment ditches. Indoor placement is recommended to avoid extreme temperatures and exposure to direct sunlight, however if product tanks must be placed outdoors, heat tracing, insulation, and provisions for sun shading are recommended to prevent degradation from UV and freezing at temperatures lower than 32°F. Important considerations for the product tank are: ventilation ductwork for tanks placed indoors, level sensors, position of overflow nozzles, pressure transducers, and intrinsic safety barriers inside the tank that will prevent sparks in a hydrogen concentrated environment.

**Q. How do I measure the concentration of sodium hypochlorite generated?**

A. There are several types of tests that can be used to measure hypochlorite concentration based on grab sample method, or continuous monitoring. Smaller test kits will often contain tablet or powder reagents to be mixed with the solution sample. Usually the change in color is compared to standards or color charts to determine concentrations. Other, more sophisticated monitoring devices can track changes in hypochlorite concentrations on a continuously basis. These are more useful for higher concentrations on hypochlorite as solution strength degradation become more of an inventory issue.

**Q. What are the key water quality parameters for operating this system?**

A. The quality of incoming water supply is very important since this will come in direct contact with the electrolyzer. Calcium and magnesium dissolved in the water can form deposits on the electrode surface which decreases overall efficiency. A water softener is often required to bring concentrations to <17 mg/L (ppm) hardness. Magnesium must be <50 µg/L (ppb) concentration. The presence of transition metal ions in makeup water can also adversely affect product quality by encouraging degradation reactions.

The water supply must have <1 mg/L chlorine residual, temperatures between 55-80°F (13-27°C), and pressure of 45-60 psig (3.1-4.1 bar).

Because the electrolysis reactions occurring in the cells generate heat energy, the solution may gain up to 20°F passing through the OSEC system. Control of inlet water temperature is essential to in order to meet and maintain the proper operating range. An inline water heater and/or chiller may be required to bring dilution water to acceptable temperatures prior to the generator.

**Q. What type of salt is required?**

A. Crystallized solar salt is harvested from seawater, salt lakes or brackish water (salt mines) by solar evaporation. These crystals may then be further refined and dried in a kiln to achieve uniform sizing and minimize moisture content. This dry commodity is non-toxic, non-hazardous, and can be safely transported through communities and neighborhoods en route to its final destination at the treatment plant.

Salt used for the generation process must be free of additives and anti-caking agents. Because calcium and magnesium contributes to scaling on cathode surfaces and decrease overall efficiency of the process, ensuring low Ca and Mg content will reduce the frequency of acid cleaning of the cells. Salt must be high grade/quality (low hardness), with 99.8 wt% NaCl, <0.14% w/w (dry basis) Ca/Mg, coarse granular or pelletized, at a ratio of 3 lb/lb (NaCl/Cl<sub>2</sub>). Commercially available solar salt in the continental U.S. typically meets or exceeds these requirements. Solar salt certified according to NSF/ANSI standard 60 is also available.

Other membrane-based electrolyzer systems such as OSEC-NXT series require a different grade of salt. Please refer to technical guidelines for more information.

**Q. Is salt other than solar acceptable?**

A. Mined salt is discouraged because of possible impurities that may appear infrequently due to influence by groundwater sources. Impurities including Mg, Silica and others may not be tested for or listed on the product specification sheet, or may not be present at time of testing. Any salt other than what is recommended by Evoqua must be approved in writing prior otherwise void warranty coverage.

**Q. How is salt delivered and stored in the plant?**

A. Salt is most often pneumatically conveyed to large storage and saturation tanks where it is stored ready for use and without harm or hazard to operations personnel. The salt is used to make a saturated brine solution as the feedstock to the on-site hypochlorite generator process. Brine is produced in a saturator that allows water to come in contact with a bed of salt for long periods of time. Achieving the right concentration of brine will directly affect the output of the OSEC system. Water and salt must be allowed to saturate to 26.4% before being fed to the electrolyzer; any lower concentration will result in lower capacities and efficiency on the product side. Therefore, a salometer is used to measure brine concentration in the feed line to the generator. Brine tanks are used to store salt and prepare saturated brine solution.

For bulk deliveries, brine tanks are typically sized to hold 15-30 day's inventory. Lower capacity systems may only require open top, indoor, manually loaded brine tanks; whereas larger capacity plants may install bulk loaded tanks outdoors. Outdoor installations may also require heat tracing and/or insulation in colder climates to prevent brine freezing. Features included in these tanks can be customized by the needs of the user: ladder/cage, brine level monitoring, tank location, material construction, size, etc.

**Q. What method for brine delivery is used: Diaphragm Pump v. Bellows or Eductor?**

A. To ensure optimal hypochlorite generation, a steady, reliable, and accurate brine delivery system is required. Mechanically actuated diaphragm pumps provide steady, reliable, and accurate delivery of brine to the inlet water stream of the electrolyzer(s), and are superior to bellows pumps or eductors for this purpose. With a continuous flow mechanical pump, flow rates can be accurately adjusted, unlike bellows pump which offer less control, and are less durable construction. With eductors, flow rate is affected by changes in water pressure so a booster pump and pressure regulating valve would have to be provided in order to maintain steady flow. Eductors offer little to no adjustment either.

**Q. Can reverse osmosis water be used as make-up water to the system?**

A. This is not recommended. Because reverse osmosis water is deficient in dissolved ions and salts, it can have aggressive properties. If used in an OSEC unit, reverse osmosis water can strip ions from metal, thus corroding the electrolyzer plates over time. In addition, the lack of dissolved salt in reverse osmosis water lowers, if not eliminates, its buffering capacity which will make it very unstable makeup water for the OSEC system. Soft, potable water is the best make up water for OSEC systems.

**Q. Can tertiary wastewater effluent be used as make-up water?**

A. This is not recommended. Tertiary filtered wastewater effluent may still contain silica and organic matter which can deposit on the surface of the OSEC electrolyzer plates. This could foul the catalytic coating on the plates, decrease electrolyzer efficiency, and cannot be removed via acid washing. Soft, potable water is the best make up water for OSEC systems.

**Q. What happens when the water temperature is out of the specified range?**

A. Maintaining product temperature is necessary because the degradation of sodium hypochlorite to chloride, chlorate, and/or oxygen is a function of temperature.

Temperatures above 104°F favors rapid hypochlorite degradation, where as temperatures less than 50°F may result in loss of electrolyzer coating as well as a significant increase in oxygen production.

**WHY OSEC® SYSTEMS ARE A SAFE ALTERNATIVE FOR CHLORINE DISINFECTION**

**Q. How is the safety of your system ensured?**

A. Overall due to our inherently safe generator design, process controls, conservative hydrogen management philosophy and advanced air flow measurement techniques we have the best safety record with OSEC. There are more OSEC systems installed and operating safely without incident than any other manufacturer of on-site hypochlorite generation equipment.

**Q. What is the concern with hydrogen gas?**

A. Hydrogen can form a flammable gas mixture when mixed with air. For hydrogen combustion to occur, two necessary conditions must be met: the concentration of hydrogen must be between 4 and 75% by volume, and an ignition source (spark or flame) must be present. Hydrogen is present in the system in three different places: inside the electrolyzer, in the pipe connecting the electrolyzer to the hypochlorite tank, and in the hypochlorite tank itself. Several measures must be taken at each of these three places to eliminate ignition sources and/or reduce the hydrogen concentration significantly below its Low Flammability Level (4% v/v).

**Q. How is hydrogen gas removed from the process?**

A. To reduce the likelihood of accumulation of large volumes of hydrogen gas in electrolyzer cells, OSEC® electrolyzers remove hydrogen at the point of generation. Diluted sodium hypochlorite and hydrogen gas leaves the electrolyzers in 2% inclined, non-isolating, straight outlet piping to avoid hydrogen traps along the lines to the product tank. We do not recommend the use of standpipes,

downward sloped piping, or isolation valves (unless outfitted with position switch). At the hypochlorite storage tank, forced air blowers and pressure differential switches are used to safely ensure that hydrogen gas is being force vented from the process to atmosphere.

**Q. Can you explain how Intrinsic Safety Barriers are used?**

A. Intrinsic safety barriers are devices that limit current, voltage, and total energy delivered to a sensor or other instrument located in a flammable atmosphere. Intrinsically safe instruments are not capable of releasing sufficient energy in a circuit to ignite a flammable atmosphere.

Within the electrolyzer, ignition sources are eliminated by using intrinsic safety (IS) barriers for all instruments mounted on the cell. To avoid exposure of electrodes to a hydrogen gas environment, the liquid level in the cell must always be maintained at a level higher than the electrode plates.

All instruments located at the top of the hypochlorite tank must have intrinsic safety (IS) barriers.

**Q. How is “Total Plant Safety” ensured for electrochlorination?**

A. Gas Detectors are used in chlorine production facilities to detect leaks in the equipment or process piping. As the OSEC system does not produce chlorine gas, the threat of a chlorine gas leak is very low and so a typical chlorine gas detector is not required (only in some countries due to local regulations).

However, as hydrogen gas is produced as a byproduct in the system, hydrogen detectors are recommended and used to continuously monitor for hydrogen gas leaks in a room. The sensors are generally placed in areas where hydrogen gas may collect, such as the ceiling over the product storage tank. Recommended installation is near the top of the hydrogen vent piping on the product tank. Transmitters are normally supplied with the sensor close coupled to the enclosure. However, for special applications, the unit can be supplied with separate sensors that can be located up to 25 feet from the transmitter.

Total plant safety ensures that these types of detection and monitoring systems are interlocked with the plant operations center to notify of emergency chemical releases.

**Q. Can the Hydrogen byproduct be converted to energy?**

Not feasibly. At typical operating conditions (T=70°F) and assuming 100% current efficiency, which represents the highest hydrogen generation rate possible, OSEC electrolyzers produce only a few pounds per day of hydrogen gas byproduct. This hydrogen gas is mostly captured, diluted, and force-vented at the product storage tank, but could also contain other byproduct gases, such as chlorine, evolving from side chemical reactions with other ionic compounds in solution. If pure hydrogen is desired for energy production, compression, concentration, and additional processing would be required.

**Q. How does the electrolysis process work in an undivided cell?**

A. We can provide more detail on this topic in our animated presentation and diagrams. Simply stated, inside the cell is a core made of anode and cathode plates that are submerged in brine solution at all times. The surface of these plates is where the electrolysis occurs, DC power supplied by the Transformer/Rectifier puts a charge on these plates, which then electrochemically oxidize and reduce the various species in the electrolyte solution, resulting in the output of hypochlorite, hydrogen gas, water and chloride.

**Q. What is the anticipated life of the equipment?**

A. The main component is the Electrolyzer which has a life span dependent on the operating and site conditions as well as proper maintenance and upkeep. Assuming ideal conditions, cells have a planned life of around 7 years, but may last longer.

The life of the system in total is dependent upon the hours of operation, environmental factors, and maintenance scheduling. The system is made up of ancillary equipment (i.e. tanks, pumps) that will wear at different rates depending upon water/salt quality and environment. Systems should last over ten years with proper maintenance and electrolyzer replacement.

**Q. Does the Transformer/Rectifier technology matter?**

A. Yes. Consistent, steady flow of direct current (DC) power to the electrolyzer is required to drive the process and therefore a Transformer/Rectifier is always provided with the OSEC system to turn available AC power to DC. These units are housed in a NEMA 3R enclosure, and placed either near the electrolyzer or a nearby electrical room. For ambient temperatures above 104°F or altitudes above 3300 ft, oversized cooling fans will be required and sized accordingly.

The OSEC B-Pak system utilizes an Silicon-Controlled Rectifier (SCR) type. With both the SCR and Solid State we must consider harmonics, longevity and cost. The fact of the matter is that we do not induce that much noise into the system using the six pulse SCR method to cause any real concern. Our systems are generally too small to warrant much discussion in that venue. This is especially true where a plant has large pumps or other power consuming devices. Harmonic filters may be used in select cases.

Another point is the durability or longevity of the two types. The Solid State is considerably more expensive, approx up to 75-100% more, than the SCR. In addition to the higher cost of the solid state you receive less robust system with higher repair costs. Bottom line, there is no good reason - functionally or financially - to utilize Solid State over SCRs at this time.

For our lowest capacity OSEC B-Pak systems (<30 VDC) we are able to utilize a very compact switching mode power supply, which is different in nature than either SCR or Solid State.

**Q. What is the BTU output of each rectifier?**

A. The BTU output of a rectifier is a function of the operating point relative to the maximum output. This may be referred to as the efficiency. Typically the rectifier for a 1500PPD system operates at greater than 93% efficiency. Using a very rough conservative numbers for purpose of cooling / ventilation we find the heat output to be approximately 10KW or 34,121 [Btu/h] for this equipment. Consult Evoqua for specific figures for your particular application.

**Q. Does the orientation of the Electrolyzer matter?**

A. Yes. The type of electrolyzers used in the OSEC B-Pak are referred to as tubular, undivided-cell electrolyzers. These are industry standard for <1.0wt% on-site hypochlorite generation since the introduction of the patented OSEC-B process to the market in 1981. The OSEC B-Pak utilizes a newer design with enhanced electrode coatings but the basic configuration of the electrolyzer with patented secondary dilution, baffle plates, and inter-stage hydrogen removal. The electrolyzers are oriented horizontally to maximize performance and safety.

Tubular electrolyzers when oriented vertically are essentially a single-pass (one cell) configuration with gas phase separation occurring towards the top of the electrodes, leading to congregation of hydrogen gas bubbles which masks the surface of the electrodes, also known simply as “hydrogen masking”. The masked electrode surface leads to inefficiencies, as less of the electrode is making contact with the dilute brine solution.

OSEC B-Pak electrolyzers with secondary dilution and baffle plates ensure optimal operating conditions. Baffle plates ensure phase separation of hydrogen occurs cross-flow before the hypochlorite product reaches the next stage, or pass. There are 4 to 8 passes per OSEC B-Pak electrolyzer. Secondary dilution water is introduced midway in the electrolyzer to optimize temperature and brine concentration in the primary pass, resulting in overall lower voltage and conditions that are beneficial to improving the life of the coating when operating with lower inlet water temperatures.

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*For more information, please visit us online at [www.evoqua.com](http://www.evoqua.com) or call us at 1-866-507-9000 in the United States. International contact information is located on our website, search term “OSEC”.*