

Safety in Numbers: Generating Sodium Hypochlorite On-site

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A 1979 train derailment in Mississauga, Ont., released chlorine gas into the air, resulting in over 200,000 people being evacuated. Luckily, there were no fatalities. The chlorine gas release caused many Canadian water treatment plants (WTPs) to revisit alternatives to transporting chlorine gas and bulk hypochlorite over long distances. On-site handling and storage of these hazardous chemicals posed additional concerns for plant personnel and nearby residents.

Today, a combination of public safety, environmental awareness, and increased transportation costs is causing many Canadian utilities, large and small, to explore installing on-site sodium hypochlorite generation systems. Hundreds of such systems have already been installed successfully throughout the U.S. in the last 30 years for drinking water and other applications. Canadians are now hoping to realize for themselves the benefits of generating sodium hypochlorite on-site.

Issues with Conventional Chlorination

Chlorination is performed in WTPs for oxidation or disinfection, specifically to protect the distribution system by maintaining a disinfectant residual.

Chlorine can be handled in a number of conventional ways: as a gas (chlorine gas, available in pressurized containers), as a solid (calcium hypochlorite, available in powder or tablets), or as a liquid (sodium hypochlorite solutions, available in concentrations ranging from 5 to 15% either as bulk liquid or in drums). Each of these conventional chlorination methods presents WTPs with various challenges.

A powerful oxidant, chlorine gas is highly toxic to humans. Since it is stored in pressurized vessels, an accidental release of this gas could represent a safety risk for operators and the public in general. Ontario has included emergency response planning for handling chlorine and other hazardous materials in its Drinking Water Quality Management System. Other provinces are also working towards this goal. In the U.S., WTPs using chlorine gas must comply with the USEPA Risk Management Plan by installing release prevention equipment such as scrubbers or emergency shut-off valves.

Calcium hypochlorite is typically used in small applications due to its high cost. This unstable chemical could potentially release chlorine gas when it comes in contact with water.

Sodium hypochlorite is more expensive than chlorine gas (on a free available chlorine content basis) and comes with its own set of challenges. Because of its high concentration, off-gassing is typical in metering pump suction lines; this creates pump air binding that requires operators to prime the pump. Sodium hypochlorite solutions degrade over time, reducing their free chlorine content.

Degradation of Hypochlorite Solutions

The degradation reactions occur spontaneously and convert hypochlorite ions into chlorates, oxygen and chloride. Temperature, exposure to sunlight and presence of transition metal ions (such as Mn, Fe, Co, Ni, and Cu) can all affect the speed of degradation; however, the most important factor is the concentration of hypochlorite itself.

High concentration solutions will degrade faster than their diluted counterparts. For example, after 30 days, the concentration of hypochlorite in a storage tank can drop from 12 to 10%. However, if the solution is diluted to 1%, the degradation reactions will occur so slowly that changes in concentration will be negligible.

In short, degradation causes plants to lose chlorine they have already paid for and to question the actual concentration percentage that remains in the storage tank.

Economic Evaluation of Chlorination Methods

After water plant managers decide to replace chlorine gas, they must choose whether to buy commercial hypochlorite or make hypochlorite on-site. Although technical considerations are important, this decision is made on economic terms, by selecting the alternative with the lowest life cycle cost (LCC). The LCC is defined as the net present value of all the expenses incurred by the plant to own, maintain and operate the equipment throughout its useful life.

To illustrate, personnel wishing to replace a 227-kgd chlorination system might consider Option A (on-site hypochlorite generation) and Option B (commercial hypochlorite).

The capital cost of A is 10 times higher than B. However, the annual operations and maintenance (O&M) cost of A is lower than B. In calculating the 20-year LCC, it is clear that the difference in O&M cost makes the LCC of Option B higher. Therefore, Option A is the most economic option.

To calculate the payback of the investment in the on-site generation system, the difference in annual O&M cost between the two options is considered as savings. Payback periods of 2 to 5 years are typical for on-site generation systems in the U.S. In the above example, by saving C\$54,600 per year, the plant will recover its C\$202,200 investment in 3.7 years.

On-site Hypochlorination Process

WTPs can make their own sodium hypochlorite on-site and on-demand through the electrolysis of a brine solution, which consumes only water, salt and power. In general, to generate the equivalent to 0.45 kgs of chlorine gas or 3.79 L of commercial sodium hypochlorite at 12%, the system requires 2 kWh, 57 L of water and 1.36 kgs of salt, which make 57 L of a sodium hypochlorite solution at a low concentration of 0.8%.

Hydrogen is the on-site hypochlorite system's only byproduct. To prevent the gas from accumulating in potentially hazardous concentrations, hydrogen is diluted to well below its flammability limit, sent into product tanks and force-ventilated to a safe outdoor discharge point.

The solution is stored in a day tank and injected into the distribution system by a metering pump. Because the sodium hypochlorite solution has such a low concentration, it does not degrade as quickly as standard commercial hypochlorite.

Generating sodium hypochlorite on-site does have a higher capital cost, compared to conventional chlorination. However, the on-site system has a lower operating cost than commercial hypochlorite and, in fact, pays for itself within a few years of installation.

Salt is the only item that needs to be transported to and stored at the plant for on-site hypochlorite generation, which greatly reduces public safety and plant personnel concerns.

About the Author

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For more information about on-site sodium hypochlorite generation systems or other disinfection/chemical feed systems, please contact the Siemens Water Technologies Canada office in Markham, Ont., at 905-944-2800 or click on www.siemens.com/osec-system.