Minimizing Chlorate in Water Disinfection

On-site Sodium Hypochlorite Generation brings Safer, Sustainable and Economic Water

Jean-Paul Monali
Product Technology Manager, De Nora

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Agenda

DBP and Chlorate

How Chlorate is Formed

Chlorate formation
Bulk Hypo
On-site Hypo Gen

On-site Hypo Gen Developments

Chlorate mitigation: Case study

Disinfection byproducts

What are DBPs?

What are they?

How are they formed?

DBPs

Disinfection byproducts are chemicals/contaminants, organic and inorganic substances that can form during a reaction of a disinfectant with naturally present organic matter in the water.

Examples: **Chlorate*,** chlorophenols, bromate, perchlorate, trihalomethanes (THM), halogenic acetic acids (HAA), chloramines, aldehydes, alkanic acids

***Chlorate:** a highly oxidized form of chlorine that can be introduced to a water source as an industrial or agricultural contaminant or into a finished water as a **disinfection byproduct (DBP)**.

Disinfection byproducts

What are DBPs?

Why are they a problem?

Chlorate Health Problems

Drinking water: The source of up to 60% of chronic chlorate exposure for infants.

Chronic exposure: over time, exposure to chlorate can inhibit iodine intake.

Reduced Iodine intake: interferes with Thyroid functioning.

Acute exposure can lead to kidney failure.

Chronic Reference Dose (RfD) is 0.03 mg/kg/day with no adverse health effects.

Controlling Disinfection By-Products

Chlorate (ClO_3^-) – general data (**WHO report, 2017**)

Official data from organizations and regulatory agencies

104 countries and territories representing

89 % of the world population

WHO Guideline value	0.7 mg/l or 700 ug/l	
N. countries setting a regulatory value	**16/104**	(15%)
N. countries setting a regulatory value greater than WHO Guideline	**3**	
N. countries setting the WHO Guideline value	**10**	
N. countries setting a regulatory value less than WHO Guideline	**3**	
Maximum value set	1.0 mg/l or 1000 ug/l	
Minimum value set	0.05 mg/l or 50 ug/l	

Controlling Disinfection By-Products

Chlorate (ClO_3^-) – area of interest
NOT UNIFORMELY REGULATED

WHO recommends limit of 700 µg/l

Canada regulates 1000 µg/l

EPA no limit - Health Reference Level 210 µg/l

EU Commission will regulate 250 µg/l

China regulates 700 µg/l

ME (Emirates, Saudi, Qatar) regulate 700 µg/l

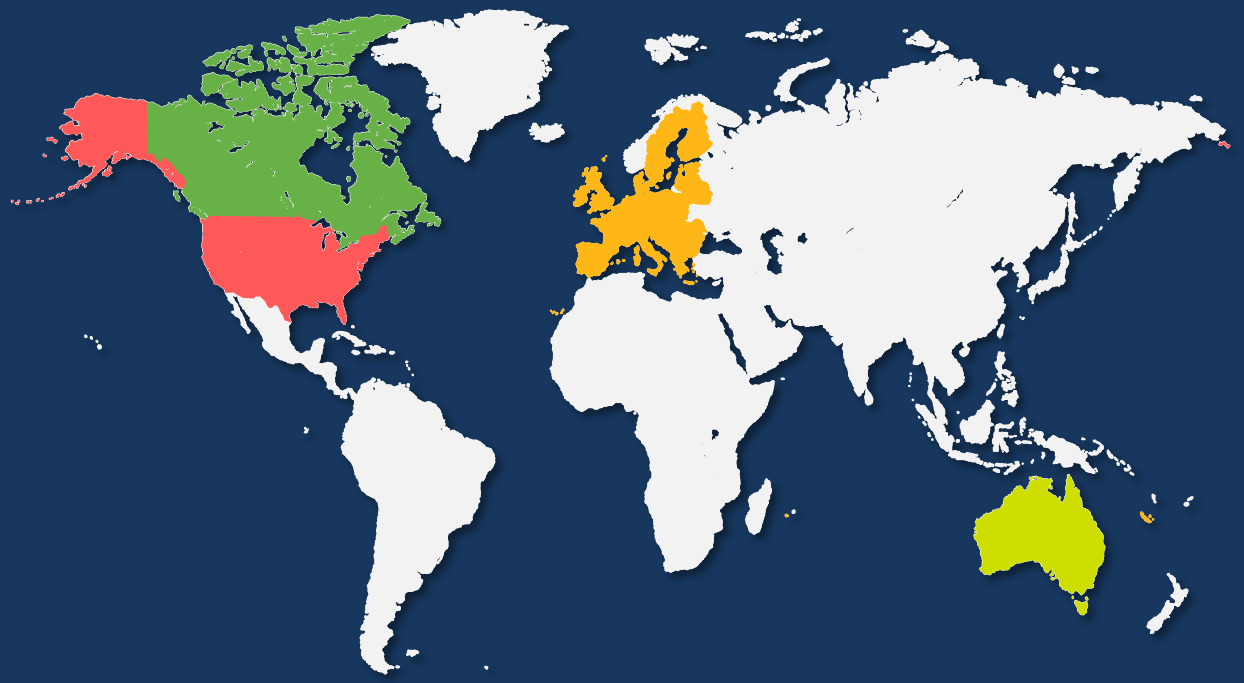
India no limit

Australia no limit - proposed limit 300 µg/l

EFSA recommends 700 ug/l

** **EFSA (European Food Safety Authority)**

Chlorate: *a highly oxidized form of chlorine that can be introduced to a water source as an industrial or agricultural contaminant or into a finished water as a* ***disinfection byproduct (DBP)****.*



- **Bromate (BrO_3^-) - Regulated**
  Gastrointestinal Symptoms, kidney effects and Carcinogen at large exposure amounts for long period of time.
  USEPA = 10 µg/L = 10 ppb (MCL)
  WHO = 10 µg/L
  European & National Drinking Water Standards = 10 µg/L

- **Perchlorate** – USEPA has ruled that Perchlorate does not meet the criteria for regulation as a drinking water contaminant. The primary effect of perchlorate is its ability to competitively inhibit uptake of iodide by the thyroid gland.
  USEPA = 15 µg/L (MCLG)
  WHO = 70 µg/L
  CA = 6 µg/L (MCL)

Chlorate Formation Mechanisms

Chlorine gas does not produce chlorate

Bulk sodium hypochlorite

$3ClO^- \rightarrow ClO_3^- + 2Cl^-$

$2HClO + ClO^- \rightarrow ClO_3^- + 2Cl^- + 2H+$

On site hypo generation: Electrolysis

$Cl^- + 3H2O \rightarrow ClO_3^- + 6H^+ + 6e^-$

$6OCl^- + 3H2O \rightarrow 3/2\ O_2 + 2ClO_3^- + 4Cl^- + 6H^+ + 6e^-$

$6HOCl + 3H2O \rightarrow 3/2\ O_2 + 2ClO_3^- + 4Cl^- + 12H^+ + 6e^-$

Factors Influencing Chlorate Formation & Mitigation Methods

Bulk Hypochlorite	Mitigation Methods
Storage Time	Reduce storage - 1 to 2 days Limit Storage Volume
Storage Temperature	Move Storage Indoors or add chiller
Concentration	Purchase lower concentration Ensure freshness when purchased Dilute conc. once delivered
Impurities	Limit heavy metals (Co, Ni)

Factors Influencing Chlorate Formation & Mitigation Methods

On-site Hypochlorite Generation

- Storage Time
- Production & Storage Temperature
- Concentration
- pH
- Impurities

Mitigation Methods

- Reduce storage - 1 to 2 days
- Chilled water pre-formation
  Chilled hypo post-formation
- Limit degradation
- Keep pH above 9
  ** Highest Chlorate formation is at 7.24
- Follow water & salt spec.
  Limit heavy metals (Co, Ni)

If chlorate formation is a concern in your potable water or food and beverage application.

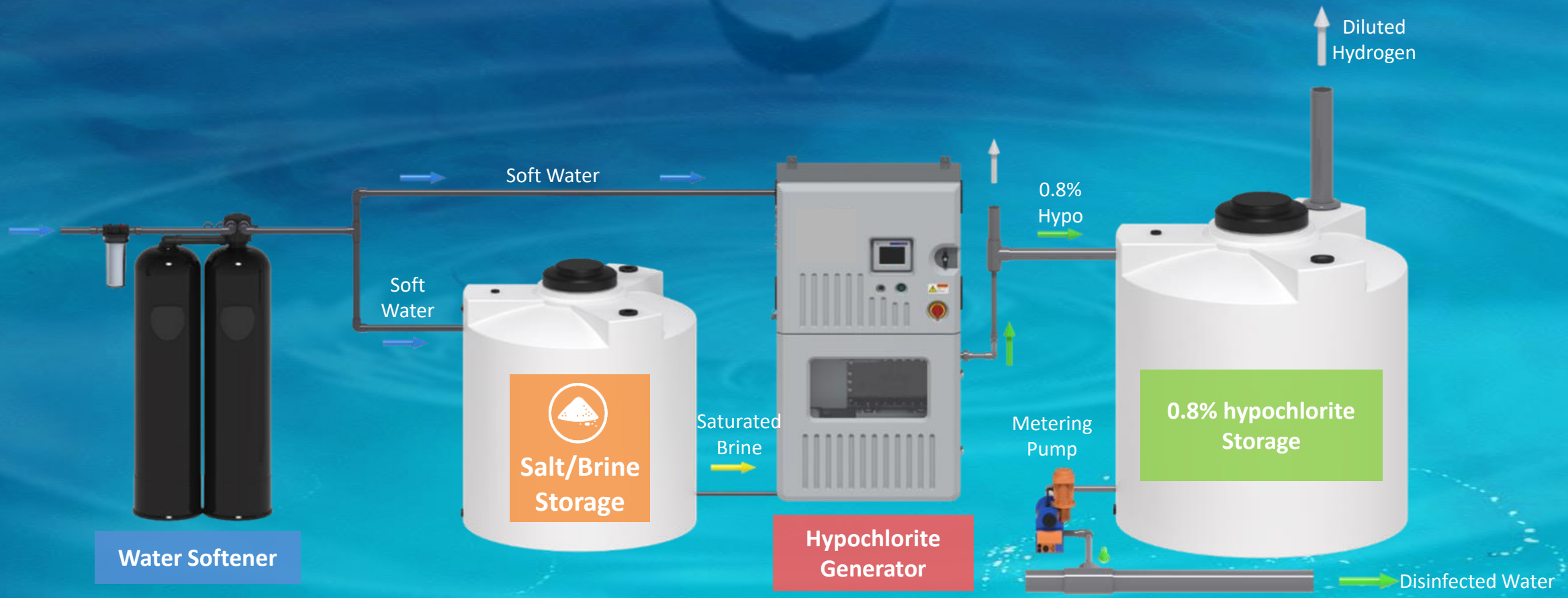
And you’re using a chlorine-based agent for disinfection.

Generating on-site can mitigate the risks.

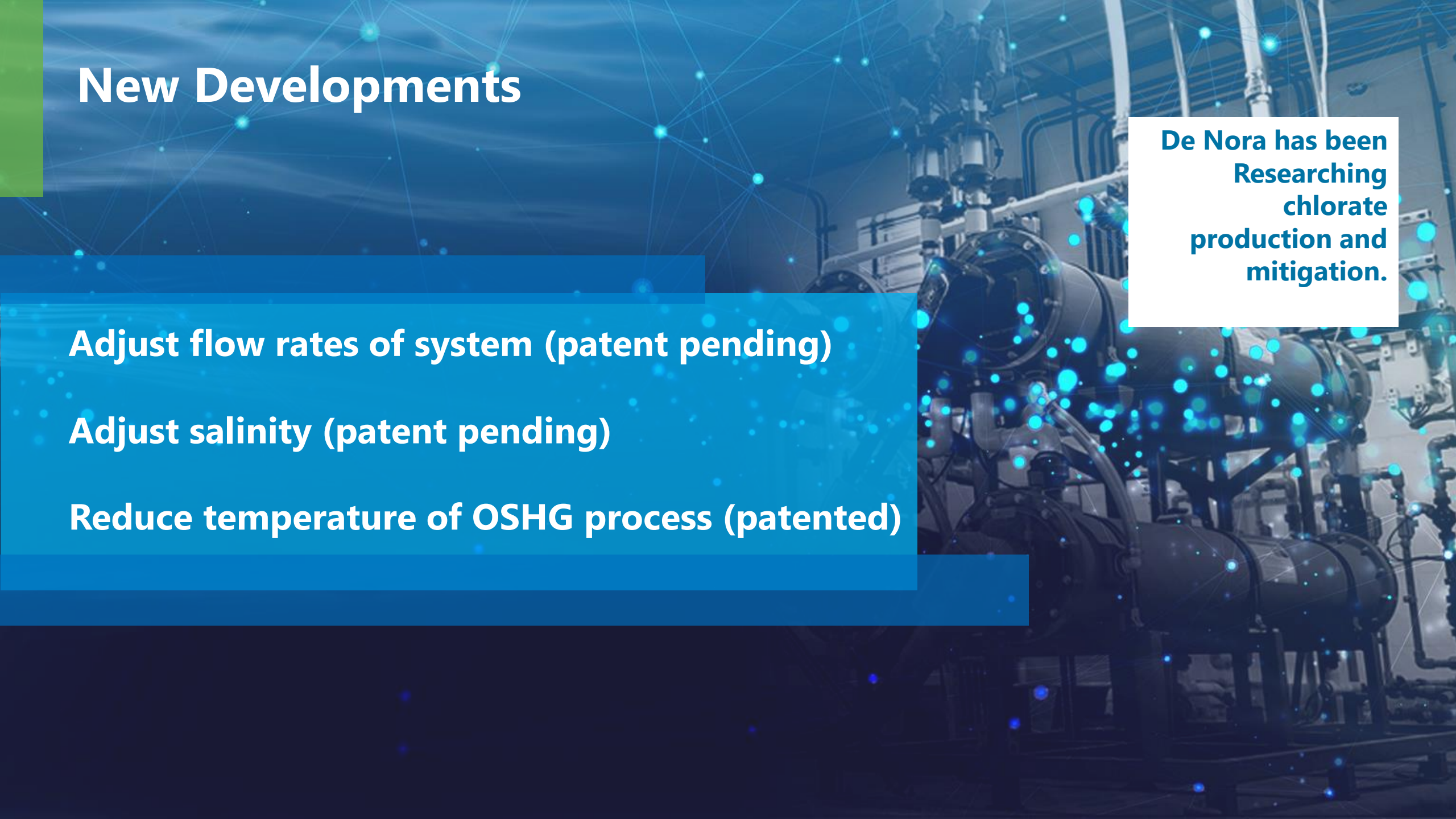
On-site Sodium Hypochlorite Generation Process

$$NaCl + H_2O + 2e^- \rightarrow NaOCl + H_2$$

Electrolysis Process – A electrical current flows through a conducting solution or electrolyte (saturated salt solution) which causes a chemical change/reaction and the production of a low concentration of a 0.8% non-hazardous solution of sodium hypochlorite.



New Developments



De Nora has been Researching chlorate production and mitigation.

Adjust flow rates of system (patent pending)

Adjust salinity (patent pending)

Reduce temperature of OSHG process (patented)

Split Flow Process – Patented Mitigation Method Pre-Chlorate Formation

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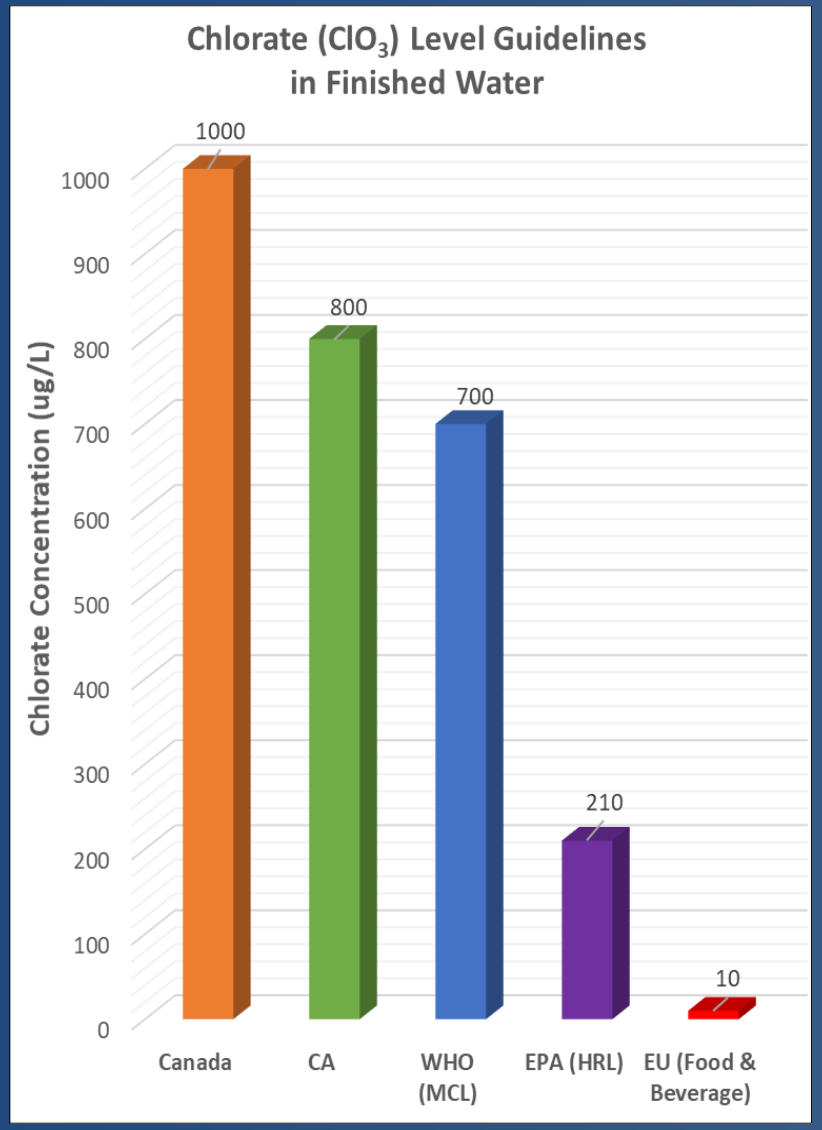
De Nora PATENTED Unique design!

Pre-Chlorate Formation Control
1. Brine Concentration Control
2. Increase electrolysis process efficiency
3. Brine Solution and Hypochlorite Solution Temperature Control
4. Salt & Water Quality Guidelines
5. Electrolyzer Maintenance

Post-Chlorate Formation Control
1. Sodium Hypochlorite Solution Storage Capacity and Time (< 48 hours)
2. Hypochlorite Solution Temperature Control

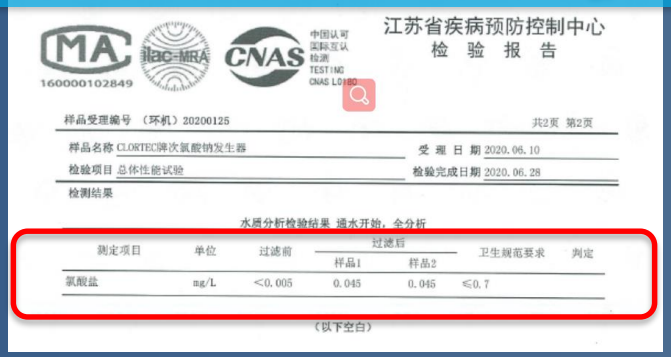
ClorTec® – Chlorate/Bromate Investigation & Results



Conclusion Based on Rigorous Testing

Patent-pending technology developed by De Nora has enable the ability to control chlorate levels produced by the ClorTec® OSHG system.

De Nora China plant let 3rd party tested Chlorate for ClorTec in water <0.7mg/L



江苏省疾病预防控制中心
检 验 报 告

样品受理编号 （环机）20200125 共2页 第2页
样品名称 CLORTEC降次氯酸钠发生器 受 理 日 期 2020.06.10
检验项目 总体性能试验 检验完成日期 2020.06.28
检测结果

水质分析检验结果 通水开始，全分析

测定项目	单位	过滤前	过滤后 样品1	过滤后 样品2	卫生规范要求	判定
氯酸盐	mg/L	<0.005	0.045	0.046	≤0.7	

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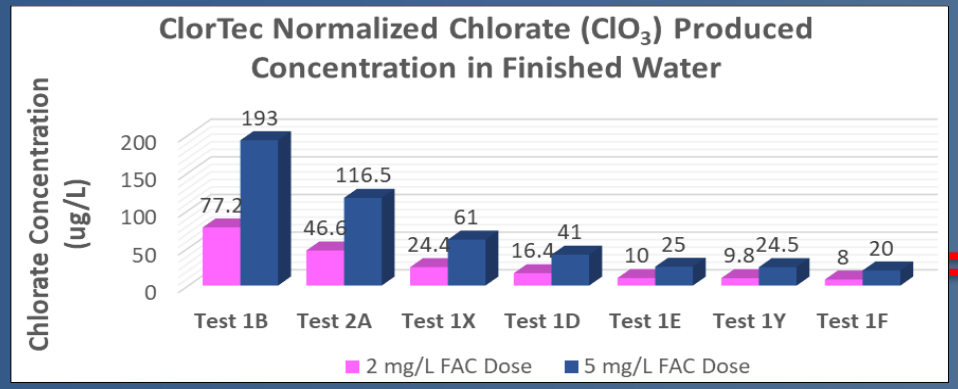

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Chlorate, Bromate, and Perchlorate Concentrations in 0.8-0.9 wt%
Sodium Hypochlorite Solution Produced by ClorTec® On-site
Sodium Hypochlorite Generation System Tests Conducted January 15 – 30

CLORTEC
ON-SITE SODIUM HYPOCHLORITE GENERATION SYSTEM

PROJECT NAME: CT OSHG BY-PRODUCT INVESTIGATION
PROJECT NO.: CZR1923 CT-RPT-CHLORATE Rev.0

DE NORA WATER TECHNOLOGIES TEXAS, LLC
1110 Industrial Blvd., Sugar Land, Texas 77478
Ph:+1 281 240 6770
Mail:info.dnwt@denora.com
Web:www.denora.com

Revision History

Rev.	Rev. Date	Description	Author	Checker's Approval	Final Approval
0	March 13, 2019	Initial Release	Lucette Falcon	Rudy Matousek	Jean-Paul Monali

20 ug/l (20 ppb)
Typical Limit Value in Soft Drinks Industry

10 ug/l (10 ppb)
Typical Limit Value in Baby Food Industry

Mitigation Method Case Study: Reduce Storage Time

Soft Drink Producer, France

APPLICATION
Disinfection of water used in making soft drinks

CHALLENGE
Reduce chlorate concentration to a level acceptable in the commercial beverage industry

EQUIPMENT
ClorTec® MCT-12 12 lbs/day
Control panel, power supply, brine tank, hypo storage tank

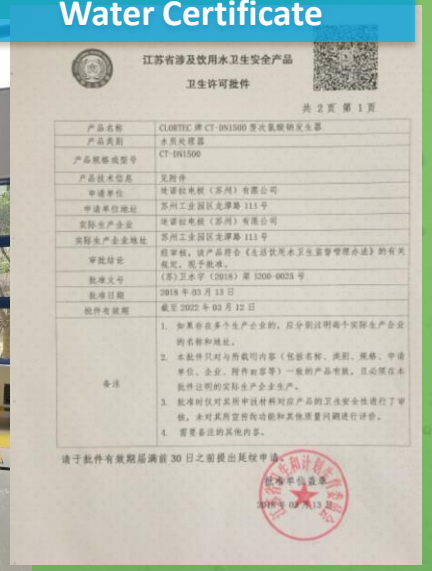
SOLUTION
Operate at lower temperature and reduce hypo storage capacity

ACHIEVEMENT
Chlorate concentration in process water met customer targets

China Case Study: Achieve Water Safety and Operation Optimization

Domestic Water Plant, Taizhou China

China Domestic Drinking Water Certificate



江苏省涉及饮用水卫生安全产品

卫生许可批件

共 2 页 第 1 页

产品名称	CLORTEC 牌 CT-DN1500 型次氯酸钠发生器
产品类别	水质处理器
产品规格或型号	CT-DN1500
产品技术信息	见附件
申请单位	克诺拉电极（苏州）有限公司
申请单位地址	苏州工业园区龙潭路 111 号
实际生产企业	克诺拉电极（苏州）有限公司
实际生产企业地址	苏州工业园区龙潭路 113 号
审批结论	经审核，该产品符合《生活饮用水卫生监督管理办法》的有关规定，同意批准。
批准文号	（苏）卫水字（2018）第 5200-0025 号
批准日期	2018 年 03 月 13 日
批件有效期	截至 2022 年 03 月 12 日
备注	1. 如果存在多个生产企业的，应分别注明每个实际生产企业的名称和地址。 2. 本批件只对与所载明内容（包括名称、类别、规格、申请单位、企业、附件和备等）一致的产品有效，且必须在本批件注明的实际生产企业生产。 3. 批准时仅对其所申报材料对应产品的卫生安全性进行了审核，未对其所宣称的功能和其他质量问题进行评价。 4. 需要备注的其他内容。

请于批件有效期届满前 30 日之前提出延续申请。

APPLICATION

- Municipal drinking water disinfection
- Used chlorine gas for disinfection before

CHALLENGE

- Operation safety concern rising from the chlorine gas
- Water plant expansion, ensure water safety for local community

EQUIPMENT

- ClorTec CT-DN1500 x 3, Capacity: 30kg/h x 3
- Control panel, power supply, brine tank, hypo storage tank

SOLUTION

- Replace existing chlorine gas by ClorTec OSHG system with China drinking water certificate

ACHIEVEMENT

- Eliminate the safety concern from chlorine gas
- Improve water quality through effective and reliable disinfection
- Secure water safety with low chlorate

De Nora Other Electro-chlorination Case Studies

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迪诺拉 ClorTec® 现场次氯酸钠制备技术为台州市引水工程带来安全、简便、经济的饮用水消毒方式

—— 台州水厂改扩建饮用水消毒项目

应用信息：

项目	台州水厂改扩建项目
技术	ClorTec® 现场次氯酸钠制备技术
应用	市政饮用水消毒
水厂规模	45 万吨 / 天（改扩建前 36.6 万吨 / 天）
前加氯	2mg/L
后加氯	1mg/L
补加氯	1mg/L
系统型号	CT-DN1500 x 3
次氯酸钠产量	30kg/h x 3
有效氯浓度	0.8%

背景：

2017 年台州市饮水工程作为浙江省八大引调水工程之一，是台州市重大水利工程项目，关系到台州市地片区 300 万人口的用水问题。台州水厂作为引水工程的重要节点之一，原制水规模为 36.6 万吨 / 天，改扩建之后增至 45 万吨 / 天，远期规划设计规模将达 60 万吨 / 天，极大地提高台州中心城市的供水保证率，成为台州集聚区及温岭东部区域的活水枢纽。

台州水厂之前原先采用液氯投加的方式进行消毒。改扩建后产量大大增加，考虑到原有液氯投加工艺所使用的氯气危险性较大，并且当地公安部门对水厂的液氯投加车间经常进行检查，无论是日常运行操作的安全性，还是应对政府检查工作，都对水厂运营团队造成了很大的压力，业主希望先借本次改扩建的机会，将饮用水消毒工艺升级为更加安全、简便、且高效的技术。

图 1 台州水厂改扩建后效果图

WATER MADE EASY

MARINE ENERGY MUNICIPAL INDUSTRIAL

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Case Study: ClorTec®
Marietta & Acworth, Georgia

Cobb County Expands "excellent production of potable water" with New ClorTec® DN OSHG System

Author: Carmelo A. Maquiran, Project Engineer, De Nora

As the second largest provider of potable water in the state of Georgia, the Cobb County-Marietta Water Authority (CCMWA) prides itself on using the latest technology and innovation in water treatment to ensure optimal efficiency and safety in its operations.

CCMWA relies on two water treatment facilities: the James E. Quarles Treatment Plant in Marietta, which treats water from the Chattahoochee River; and the Hugh A. Wyckoff Treatment Plant in Acworth which treats water from Allatoona Lake. Together, the treatment plants prepare water for wholesale distribution to 11 retail water suppliers, as well as industry and institutional customers.

The Wyckoff Water Treatment Plant, built in 1963, has grown to keep pace with regional water needs in northwest Georgia and evolved to address public health and safety issues. While chlorine gas had traditionally been used as an effective method for water disinfection, its hazardous potential became a real concern for water treatments facilities across the country. CCMWA was quick to address this through a major investment that included the installation of an on-site sodium hypochlorite generation system in 2012.

When it came time to choose a new disinfection system for the drinking water facility that serves the campus, Texas A&M University's water & environmental services department chose another proven water treatment technology: generating sodium hypochlorite on site.

Home of the Aggies - and a 61-year-old water treatment plant

Located in College Station, Texas, and with a student enrollment of more than 50,000, Texas A&M is the sixth largest university in the United States. The school is probably best known for its perennially strong "Aggies" football team, its rivalry with the University of Texas and its Corps of Cadets, which provides more commissioned officers to the United States Armed Forces that any other school outside of the service academies.

Built on the Texas prairie in 1876, the university has been in the utilities business since it opened. Since 1951, drinking water for students, faculty and other university employees has been provided by the Wellfield Pump Station located approximately 11 miles north of the campus. The university owns seven wells with a production capability of 12.8 mgd. The current average production is 4.7 mgd and has been as low as 4.0 mgd during non-drought years.

The water production serves a campus population that peaks at close to 65,000 during fall and spring semesters. The campus' entire water system includes more than 200 miles of water distribution lines, groundwater wells, pump stations, and two elevated water storage tanks. The water system is rated "Superior" by the State of Texas.

The Wellfield Station draws water from six groundwater water wells. The high-volume deep wells are located near a geothermal source, and as a result the surface temperature of the water from these wells ranges from 106 degrees F to 134 degrees F. To reduce the temperature, the water is pumped through cooling towers, lowering the temperature to below 90 degrees F.

The source water for Main Campus is clean enough that only chlorine disinfection is needed to treat the water to Safe Drinking Water Act standards. Since the Wellfield Station's opening, gaseous chlorine has been used to disinfect the water and provide an effective chlorine residual. After the water is disinfected, it is pumped through a 7.5-mile dual pipe transmission system to a booster station located adjacent to the campus, then into the water distribution system, including a 2.1 mg elevated storage tank. The elevated storage tank provides an adequate supply of water pressure for the many domestic, research, recreation, irrigation and utilities uses on the 5,500-acre campus.

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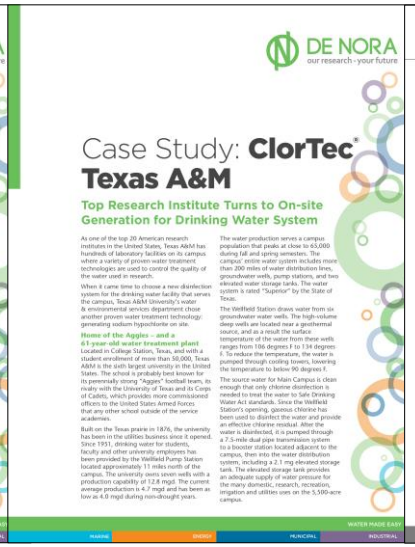

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Case Study: ClorTec®
Texas A&M

Top Research Institute Turns to On-site Generation for Drinking Water System

As one of the top 20 American research institutes in the United States, Texas A&M has hundreds of laboratory facilities on its campus where a variety of proven water treatment technologies are used to control the quality of the water used in research.

When it came time to choose a new disinfection system for the drinking water facility that serves the campus, Texas A&M University's water & environmental services department chose another proven water treatment technology: generating sodium hypochlorite on site.

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COBB COUNTY EXPANDS "EXCELLENT PRODUCTION OF POTABLE WATER" WITH NEW CLORTEC DN OSHG SYSTEM

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by Carmelo A. Maquiran
Project Engineer
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operational improvements thanks to the new system. CCMWA determined the need to expand the system by adding a third onsite generator.

"We were very pleased with the two existing generators and their productivity and were concerned that if one of them were to stop functioning properly, as can happen in the lifecycle of this type of equipment, it would be difficult for us to maintain our preferred operational level and quality," said Tony Wilson, Division Manager of the Wyckoff plant.

As the technology has continued to develop in recent years, Wilson and his team were also drawn to the new brine pump added to the ClorTec DN generator, which helps improve water pressure levels. The latest generation of the line's on-site sodium hypochlorite generation system incorporates best-in-class brine electrochlorination technology, allowing operators to more accurately control and adjust the amount of brine to the system. Replacing less efficient mechanical sensors, the new version also includes analog flow sensors for water and brine, as well as a water temperature sensor, ensuring more precise control of the logic controllers. It also offers the highest efficiency in the industry and the guaranteed lowest consumption of salt and electricity, with an upgraded instrumentation panel for greater operator control.

Installed in Spring of 2017, the additional new 1,500 pounds per day ClorTec DN generator is now part of a cycle through which the three generators alternate in use, two at a time.

"The addition of the latest generator has upgraded our entire system, with clear enhancements made by De Nora to improve operations," said Craig Schiebel, Process Control Programmer with CCMWA. "The new instrumentation panel and specifically the analog signals enable us to have not only greater flow control, but also better diagnostic capabilities should a fault occur."

As CCMWA proactively maintains its commitment to providing sustainable, reliable drinking water while also ensuring public health and safety in the region, it has found a practical solution through on-site onsite sodium hypochlorite generation.

"Even in the high-demand season of summer, we're pleased to report saves to the tune of 1,500 pounds of additional production of potable water for our satisfied customers," said Wilson.

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Case Study: ClorTec® OSHG
Mining for Safe Alternatives: On-site Sodium Hypochlorite Generation replaces hazardous cyanide in precious metal extraction

The Baia Mare Aurul gold mine in North Western Romania suffered a historic catastrophe in January 2000, when its dam burst, streaming out 100,000 cubic meters of waste water, largely contaminated with cyanide, commonly used in the process of mining gold, into tributaries of the Tisza River, a major waterway in Hungary.

Reports claimed that the water traveled as a far as the Danube River, spreading the lethal threat of cyanide to the people, animals, and environment of Serbia, Bulgaria, and Romania. In some areas, the concentration of cyanide was cited as 100 times more than the maximum level for drinking water. (Source)

This horrific event proved to be a wake-up call for the mining industry to develop alternate solutions to the use of cyanide when mining gold and other metals, particularly since the chemical compound was consequently banned in several parts of the United States, throughout Europe, and in South America. Dr. Jean-Marc Lalancette, co-founder and current Chairman Emeritus of Dundee Sustainable Technologies, was among the pioneers of this research, who leveraged his significant industry experience to transform standard extraction methods.

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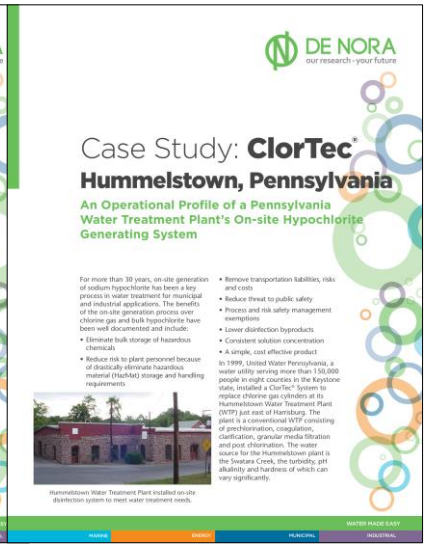

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Case Study: ClorTec®
Hummelstown, Pennsylvania

An Operational Profile of a Pennsylvania Water Treatment Plant's On-site Hypochlorite Generating System

For more than 30 years, on-site generation of sodium hypochlorite has been a key process in water treatment for municipal and industrial applications. The benefits of the on-site generation process over chlorine gas and bulk hypochlorite have been well documented and include:

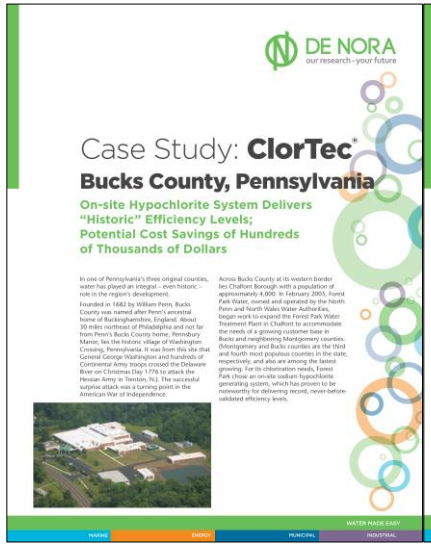
- Eliminate bulk storage of hazardous chemicals
- Reduce risk to plant personnel because of drastically eliminate hazardous material (HazMat) storage and handling requirements
- Remove transportation liabilities, risks and costs
- Reduce threat to public safety
- Process and risk safety management exemptions
- Lower disinfection byproducts
- Consistent solution concentration
- A simple, cost effective product

Hummelstown Water Treatment Plant installed on-site disinfection system to meet water treatment needs.

In 1999, United Water Pennsylvania, a water utility serving more than 150,000 people in eight counties in the Keystone state, installed a ClorTec® System to replace chlorine gas cylinders at its Hummelstown Water Treatment Plant (WTP) just east of Harrisburg. The plant is a conventional WTP consisting of prechlorination, coagulation, clarification, granular media filtration and post chlorination. The water source for the Hummelstown plant is the Swatara Creek, the turbidity, pH alkalinity and hardness of which can vary significantly.

WATER MADE EASY

MARINE ENERGY MUNICIPAL INDUSTRIAL



DE NORA
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Case Study: ClorTec®
Bucks County, Pennsylvania

On-site Hypochlorite System Delivers "Historic" Efficiency Levels; Potential Cost Savings of Hundreds of Thousands of Dollars

In one of Pennsylvania's three original counties, water has played an integral – even historic – role in the region's development.

Founded in 1682 by William Penn, Bucks County was named after Penn's ancestral home of Buckinghamshire, England. About 30 miles northeast of Philadelphia and not far from Penn's Bucks County home, Pennsbury Manor, lies the historic village of Washington Crossing, Pennsylvania. It was from this site that General George Washington and hundreds of Continental Army troops crossed the Delaware River on Christmas Day 1776 to attack the Hessian Army in Trenton, N.J. The successful surprise attack was a turning point in the American War of Independence.

Across Bucks County at its western border lies Chalfont Borough with a population of approximately 4,000. In February 2003, Forest Park Water, owned and operated by the North Penn and North Wales Water Authority, began work to expand the Forest Park Water Treatment Plant in Chalfont to accommodate the needs of a growing customer base in Bucks and neighboring Montgomery counties. (Montgomery and Bucks counties are the second and fourth most populous counties in the state, respectively, and also are among the fastest growing. For its chlorination needs, Forest Park chose an on-site sodium hypochlorite generating system, which has proven to be noteworthy for delivering record, never-before-validated efficiency levels.

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Case Study: ClorTec®
British Columbia, Canada

On-site Disinfection Helps Ensure Safety at British Columbia Water Treatment Facility

Constructed in 1997, the District of Chetwynd Water Treatment Plant (British Columbia, Canada) treats nearly 2,500 cubic meters of water per day using gas chlorination as its primary form of drinking water disinfection. With recent concerns about the safety of chlorine gas, including potential eye, skin and respiratory irritation and the risk of death with high exposure, the district elected to switch to hypochlorite generation as its primary means of disinfection.

At Tricker, chief operator at the facility, recognizing that the 12 - 15% concentration solution strength of potable grade bulk sodium hypochlorite is considered a hazardous material, recommended the use of an on-site generating system, which produces a hypochlorite solution concentration of 0.8%. The use of on-site sodium hypochlorite generation offers advantages over other forms of traditional disinfection. The disinfectant is produced and stored in liquid form with an on-site system. As a result, it is not necessary for on-site sodium hypochlorite generating system users to develop and maintain a Risk Management Plan. Utilities using on-site systems do not need to provide H2S/Cl2 monitoring or provide for the availability of self-contained breathing apparatuses.

Generating sodium hypochlorite on-site is a simple process that uses three common consumables: salt, water and electricity. The system operates by feeding softened water into a brine dissolver. The salt dissolves to form a brine solution, which is further diluted to the desired salt solution. The salt solution is then passed through the electrolytic cell(s), which apply a low voltage DC current to the brine to produce the sodium hypochlorite. The sodium hypochlorite is then safely stored in a 3,790 liter, five-day tank, and when it reaches the low-level set point the system automatically restarts to replenish its supply.

WATER MADE EASY

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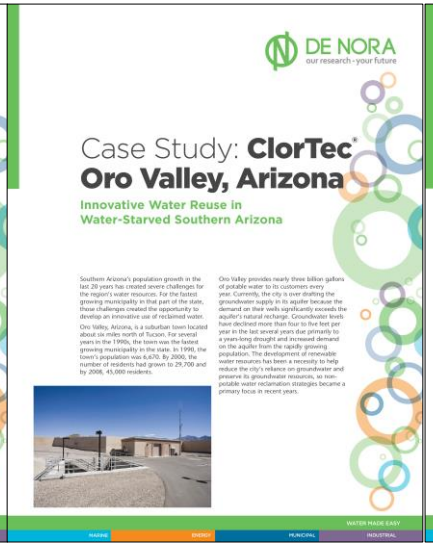

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Case Study: ClorTec®
Oro Valley, Arizona

Innovative Water Reuse in Water-Starved Southern Arizona

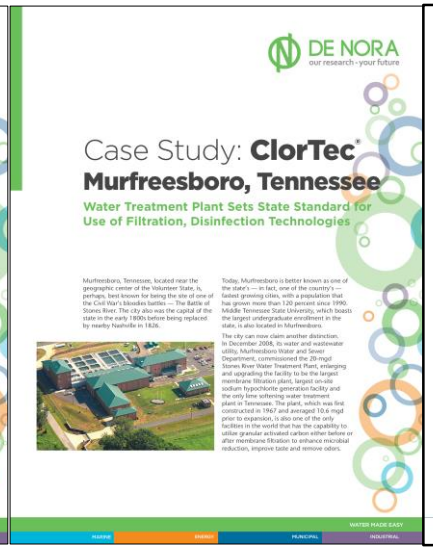
Southern Arizona's population growth in the last 20 years has created severe challenges for the region's water resources. For the fastest growing municipality in that part of the state, those challenges created the opportunity to develop an innovative use of reclaimed water.

Oro Valley, Arizona, is a suburban town located about six miles north of Tucson. For several years in the 1990s, the town was the fastest growing municipality in the state. In 1990, the town's population was 6,670. By 2000, the number of residents had grown to 29,700 and by 2008, 45,000 residents.

Oro Valley provides nearly three billion gallons of potable water to its customers every year. Currently, the city is over drafting the groundwater supply in its aquifer because the demand on these wells significantly exceeds the aquifer's natural recharge. Groundwater levels have declined more than four to five feet per year in the last several years due primarily to a years-long drought and increased demand on the aquifer from the rapidly growing population. The development of renewable water resources has been a necessity to help reduce the city's reliance on groundwater and preserve its groundwater resources, so non-potable water reclamation strategies became a primary focus in recent years.

WATER MADE EASY

MARINE ENERGY MUNICIPAL INDUSTRIAL



DE NORA
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Case Study: ClorTec®
Murfreesboro, Tennessee

Water Treatment Plant Sets State Standard for Use of Filtration, Disinfection Technologies

Murfreesboro, Tennessee, located near the geographic center of the Volunteer State, is, perhaps, best known for being the site of one of the Civil War's bloodies battles — The Battle of Stones River. The city also was the capital of the state in the early 1800s before being replaced by nearby Nashville in 1826.

Today, Murfreesboro is better known as one of the state's — in fact, one of the country's — fastest growing cities, with a population that has grown more than 120 percent since 1990. Middle Tennessee State University, which boasts the largest undergraduate enrollment in the state, is also located in Murfreesboro.

The city can now claim another distinction. In December 2008, its water and wastewater utility, Murfreesboro Water and Sewer Department, commissioned the 20-mgd Stones River Water Treatment Plant, enlarging and upgrading the facility to be the largest membrane filtration plant, largest on-site sodium hypochlorite generation facility and the only lime softening water treatment plant in Tennessee. The plant, which was first constructed in 1967 and averaged 10.6 mgd prior to expansion, is also one of the only facilities in the world that has the capability to utilize granular activated carbon either before or after membrane filtration to enhance microbial reduction, improve taste and remove odors.

WATER MADE EASY

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Disinfection

Arizona Utility Expands On-Site Hypochlorite Generation

An award-winning 2018 plant expansion increases water treatment capacity in growing Maricopa County, Ariz. BY ROBERT ANDREWS

TWO OF THE fastest-growing communities in the United States exist side by side in Maricopa County, Ariz. These Phoenix suburbs joined forces about a decade ago to address what was obviously an important need and one that would continue to grow with each new family and business that moved to the area: water.

Through an intergovernmental agreement, the town of Gilbert and the city of Chandler collaborated on building a new water treatment plant, agreeing to equally share the building costs, ongoing expenses, and water produced. Although everything is split 50-50, the town of Gilbert is responsible for operating the Santan Vista Water Treatment Plant (WTP), which went online in 2009.

PLANT DETAILS

The Santan Vista WTP gets its water from the Colorado River through a 14-mile, 48-in. raw water pipeline as part of the Central Arizona Project Canal. The plant's initial capacity was 24 mgd (12 mgd for Gilbert and 12 mgd for Chandler), but a plant expansion (Phase II) was completed in May 2018, increasing capacity from 24 mgd to 48 mgd. The plant treats the water using ballasted flocculation.

On-site sodium hypochlorite generation (OSHG) technology was selected for the facility instead of other disinfection options, first and foremost for safety. Before Santan Vista WTP was built, the team at Gilbert's original treatment facility, North WTP, was more familiar with gas chlorine disinfection. In planning the award-winning Santan Vista WTP, the design team wanted to get away from the risks and requirements associated with transporting and storing gas cylinders. By generating disinfectant on-site, the only chemical that's stored or transported is food-grade salt.

The Santan Vista Water Treatment Plant's OSHG units safely generate disinfectant using salt, water, and electricity.

OSHG SPECIFICS

The OSHG system's simplicity and ease of use were appealing. The Santan Vista design team witnessed a firsthand at the city of Chandler WTP, which has been operating a ClorTec OSHG unit from De Nora (www.denora.com) since 2007. Seeing and hearing about the unit's ease of use from the Chandler WTP operators made the decision an easy one for the town of Gilbert.

OSHG is a safe disinfection treatment method, operating with only three ingredients: salt, water, and electricity. At the heart of the OSHG system is an electrolytic cell that accomplishes the electrochemical production of chlorine. Inside the electrolytic cell, chloride ions from the sodium chloride brine are oxidized using a current passed through the cell. Through this electro-oxidation process, the sodium chloride brine that's used as a feedstock to the on-site generator is converted into a disinfectant solution containing aqueous chlorine. In the following equation, aqueous chlorine is shown as sodium hypochlorite:

Salt + Water + Electricity → Sodium Hypochlorite + Hydrogen Gas

The Santan Vista WTP originally had two ClorTec OSHG units that produce 1,500 lb/day of chlorine each. The finished product is a 0.8 percent sodium hypochlorite (bleach) solution, which is safer than common household bleach. One unit was always in use, and the other was used for backup and during maintenance.

The Santan Vista Water Treatment Plant's 2018 expansion included adding a third on-site sodium hypochlorite generator (see photo, opposite page) in anticipation of future population growth.

PLANT EXPANSION

Named for its prime view of the stunning Santan Mountains, the Santan Vista WTP was designed to meet current and future water needs as well as all regulations (among the most stringent in the country) instituted by Maricopa County and the state of Arizona. The Phase II expansion incorporated several improvements, one of which was the addition of a third OSHG unit from the same manufacturer. Because the existing two units had been successful, safe, and easy to use, plant operators and managers thought it made sense to install a third system during the expansion to boost on-site capacity in anticipation of future population growth.

Since the 2010 Census, Gilbert and Chandler have grown by 14 percent and 9 percent, respectively, with a total population of more than 500,000. Each community occupies about 65 mi², and each has been among the fastest-growing areas in the United States. The Santan Vista WTP serves about 150,000 individuals with high-quality drinking water, the balance of families and businesses are served by the North WTP and Chandler's WTP, which continues to use OSHG technology. The Santan Vista WTP meets or exceeds the environmental regulations put in place by the two communities.

Santan Vista WTP's new OSHG is another 1,500-lb/day unit in a smaller package. Currently, the plant runs one of the three units exclusively, meeting daily needs but not yet operating at maximum capacity. The system's scalable design allows for increased production capabilities.

The 0.8 percent sodium hypochlorite solution generated by the OSHG is stored in three 15,000-gal storage tanks. From there it's pumped into the treated water as needed. The OSHG automatically generates sodium hypochlorite solution based on tank level settings.

MAINTENANCE REQUIREMENTS

The OSHG unit's maintenance is minimal, involving a visual inspection to see if there's any bridging across the plates in the cells and changing out filters, which last up to two months and are easy to change. If bridging across the cells occurs, operators perform a simple acid clean, but that doesn't happen often. A remote monitoring system helps reduce the need for site visits for maintenance, as does the unit's close cell casing design that allows for visibility and easy access to all components. Additional features that add to the system's safety and efficiency include hydrogen venting of each cell, an updated control system, and a lower operating temperature.

Also, periodic testing of the brine solution is recommended. It's a simple specific-gravity test that requires three basic items to perform: a 500-ml clear graduated cylinder, a thermometer, and a hydrometer. The temperature and hydrometer readings are cross-referenced with a salinity chart to determine if the proper salt concentration is being supplied to the generator. The test requires little time or effort to perform and ensures the system runs efficiently.

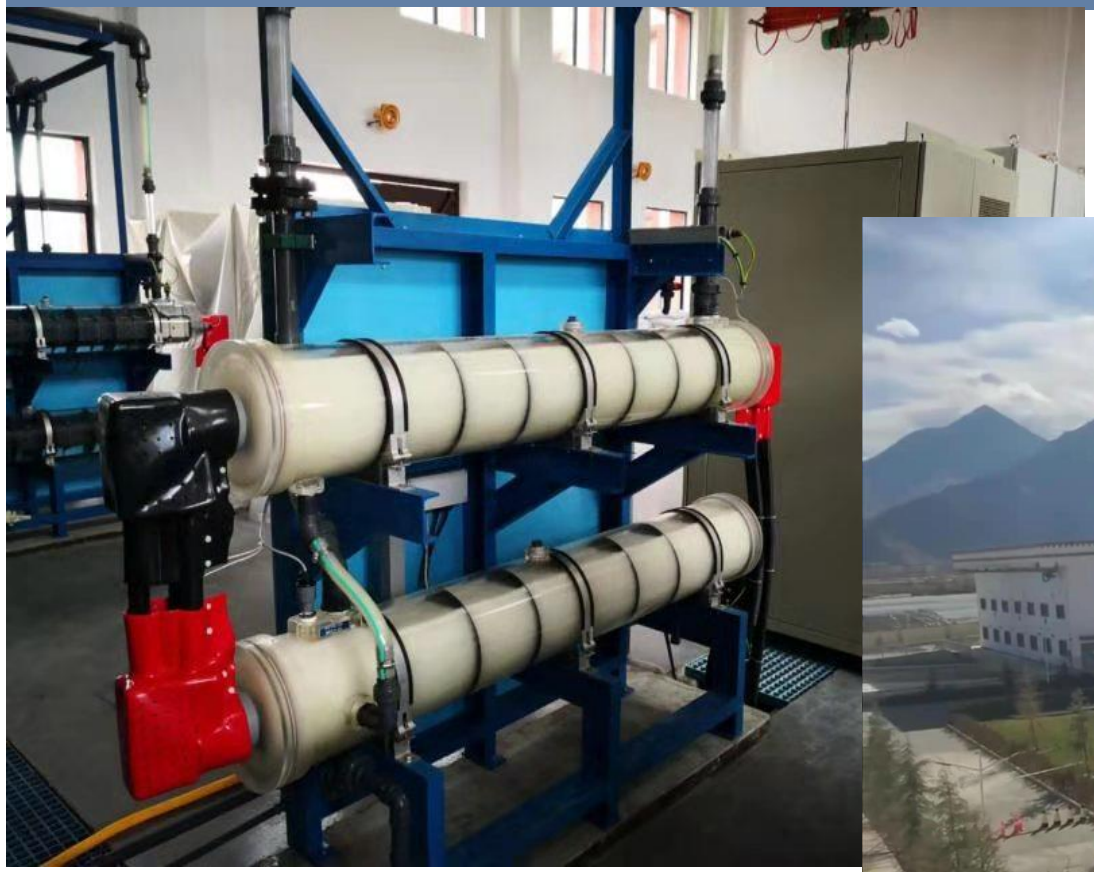
PROJECT AWARDS

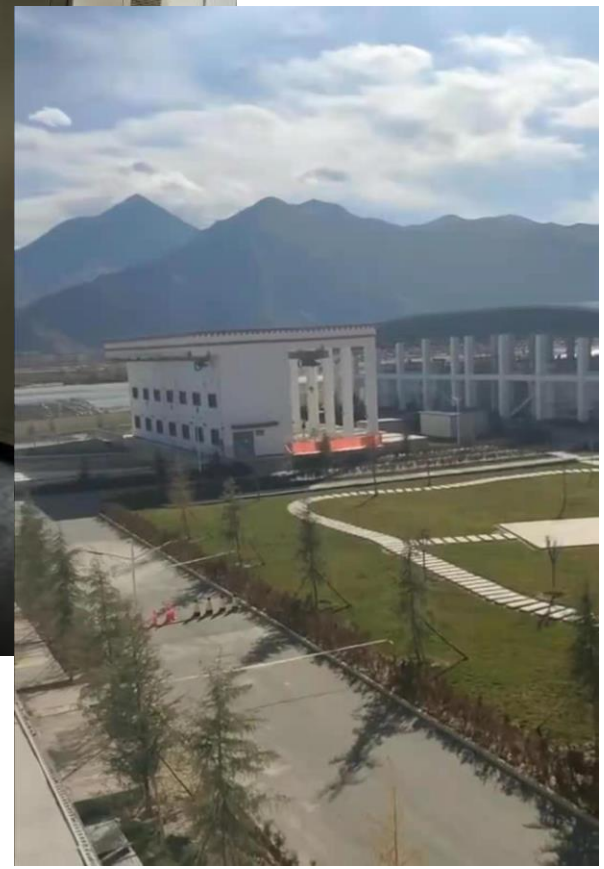
Recently, the Santan Vista WTP's Phase II expansion was recognized with two awards: The Top Project Award from *Water & Wastes Digest* and Water Treatment Plant Project of the Year from the Arizona Water Association for its success and efficiency in doubling the plant's water capacity on time and below budget. In fact, the project saved $15 million in program costs compared with the original estimate, a 20 percent cost reduction. The award also cited the project team's strong, collaborative working relationship and the careful planning that minimized shutdown time to maximize facility operations.

ClorTec® Installation

Chongli Water Plant Winter Olympics Project (Chongli, China) – 45kg/Day Drinking Water Disinfection

Tibet Lhasa Najin Water Plant Project (Lhasa, China) – 450x4kg/Day Drinking Water Disinfection





ClorTec® Installation

Signal Butte WTP (Arizona - USA) – 2 x 1800 Lbs/Day (34 kg/hr)
Drinking Water Disinfection

ClorTec® Installation

Laguna Beach County Water District (California - USA) – 150 Lbs/Day (2.84 kg/hr)
Drinking Water Disinfection

ClorTec® Installation

Prestonburg City Utility Commission (Kentucky - USA) – 1200 Lbs/Day (22.7 kg/hr)
Pretreatment and Final Disinfection

De Nora On-site Sodium Hypochlorite Generator

Safe, Efficient, Low Lifecycle Cost, Reliable and On-Demand

Key Benefits

- On-site and on-demand production of non-hazardous <1.0% chlorine solution
- Meet global disinfection byproduct (DBP) standards
- Trusted supplier of over 6,000 Electro-chlorination installations with 97 years of electrode(DSA) experience
- Optimized process for lowest salt & power usage, saving 15% in operating costs
- Generator capacities range 2–3000 lbs/day (0.04–57 kg/hr)
- Easy to install and operate with minimal maintenance
- Certified to NSF/ANSI 61 Drinking Water, UL 508A and CE Mark (model specific)

Certified to NSF/ANSI 61

EPA Est. No. 48482-TX-1

Range of Trusted Disinfection Technologies

De Nora Legacy brands with a long history of success!

ClorTec®
Sodium Hypochlorite Generator
(Brine Electrochlorination)

MIOX®
Mixed Oxidant Generator
(Brine Electrochlorination)

SEACLOR®/SANILEC®
Sodium Hypochlorite Generator
(Seawater Electrochlorination)

OMNIPURE™ & MARINER®
Marine Sewage Treatment
(Seawater Electrochlorination)

BALPURE®
Ballast Water Management
(Seawater Electrochlorination)

CECHLO®
Electrochlorination
Systems

Working with De Nora

Expertise and Support

- Globally recognized leader in water
- Decades of experience in municipal and industrial markets
- Reliable and effective treatment solutions
- Knowledgeable and expert staff
- Global aftermarket solutions
- Local partner support
- Comprehensive range of Disinfection & Filtration technologies

Thank You for Joining the Call

Your Questions Answered