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APV FX SafeWater
White Paper

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Executive Summary

Originally developed for the production of chlorine in swimming pools, electrolysis technology has been advanced to enable the production of valuable cleaning and sanitising solutions. When sodium chloride is subjected to electrolysis with a dividing membrane between the electrodes, two separate solutions are produced. These are primarily hypochlorous acid and sodium hydroxide at the anode and cathode respectively.

Hypochlorous acid is powerful sanitiser and cleaning agent and is substantially more effective than hypochlorite. The soil removal process is fast and effective without the need for heating.

This new technology revolutionises CIP and sanitation procedures. It assists in reducing the carbon footprint, saves energy and the costs of expensive formulated chemicals.

Introduction to SPX Flow Technology

Vision and commitment

SPX's Flow Technology segment designs, manufactures and markets process engineering and automation solutions to the dairy, food, beverage, marine, pharmaceutical and personal care industries through its global operations.

We are committed to helping our customers all over the world to improve the performance and profitability of their manufacturing plant and processes. We achieve this by offering a wide range of products and solutions from engineered components to design of complete process plants supported by world-leading applications and development expertise.

We continue to help our customers optimise the performance and profitability of their plant throughout its service life with support services tailored to their individual needs through a coordinated customer service and spare parts network.

Customer focus

Founded in 1910, APV, an SPX Brand, has pioneered groundbreaking technologies over more than a century, setting the standards of the modern processing industry.

Continuous research and development based on customer needs and an ability to visualise future process requirements drives continued mutual growth.



Fundamentals of APV FX SafeWater

Electrolysis of common salt with a dividing membrane between the electrodes results in two separate solutions suitable for sanitation (Anolyte) and CIP (Catholyte) – hypochlorous acid (HOCL) and sodium hydroxide (NaOH) being the main constituents. Hypochlorous acid, a weak acid that also occurs naturally in the body to combat infection, is a powerful sanitiser and cleaning agent that is substantially more effective than hypochlorite. It sanitises rapidly and effectively without the need for heating. This new technology revolutionises CIP procedures. It helps reduce carbon footprint, shortens changeover time and saves energy as well as the costs of expensive, formulated chemicals. The process of deposit removal is fast and effective without the need for heating. However, when dealing with heavy mineral deposits and pronounced fouling it may be necessary to complement with traditional CIP procedures.

The fundamentals of using natural drinking water with just a bit of food salt added and applying an electrical current to produce a natural disinfectant that is identical with nature's own have elevated the status of natural disinfection in the dairy, food and beverage industries as an environmentally friendly solution.

The fact that the process is based upon simple electrolysis using only natural ingredients such as water and salt means that SafeWater is a truly sustainable solution.

The Technology

One of the most intriguing things about SafeWater is its disinfection capabilities. In principle SafeWater has two main capabilities within bacteria control:

- Keeping the water free of bacteria by limiting further growth. This is applicable for water holding tanks and supply pipe lines
- Performing real disinfection of stainless steel surfaces contaminated by bacteria. This applies to biofilm, but more importantly for food and beverage producers, SafeWater can kill bacteria both inside and outside process equipment before production start

SPX has performed a number of process equipment disinfection tests that confirms the disinfection capabilities of SafeWater on process equipment. Bacteria analyses confirm close to zero bacteria on stainless steel surfaces and in final rinse water.

Usual levels of bacteria are down to <10 CFU/ml and bacteria log reduction of 2-5 is often seen (see table 1).

SafeWater is also sporicidal (kills spores), but efficiency is lower than against bacteria, possibly necessitating a longer contact time and/or higher concentration/temperature.

Usually the spore content present is significantly lower than bacteria content. Thus the kill rate in log reduction does not normally need to be as high as for bacteria.

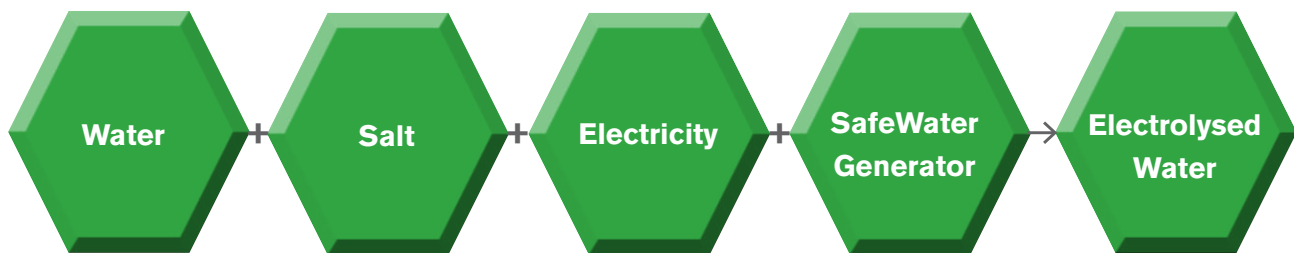


Fig. 1: Fundamentals of APV FX SafeWater technology

Organism	Strain	Positive Control Cfu/100 ml	Cfu/100 ml	Reduction
E.Coli	NCIMB 8545	1.1×10^7	<1	1.1×10^7
Salmonella Tryphimurum	NCIMB 8545	1.6×10^7	<1	1.6×10^7
Listeria monocytogenes	NCTC 11994	1.9×10^7	<1	1.9×10^7
Staphylococcus aureus	NCIMB 9518	2.4×10^7	<1	2.4×10^7
Streptococcus faecalis	NCIMB 775	7.7×10^6	<1	7.7×10^6
Pseudomonas aeruginosa	NCIMB 9027	4.8×10^6	<1	4.8×10^6
Aspergillus niger	ATCC 16404	7.0×10^4	<1	7.0×10^4
Candida albicans	ATCC 10231	6.0×10^4	<1	6.0×10^4

Table 1: Typical bacteria microorganisms against which SafeWater has a confirmed kill effect. Tested using standard suspension method with a 2 minute contact time. Source Microchem.

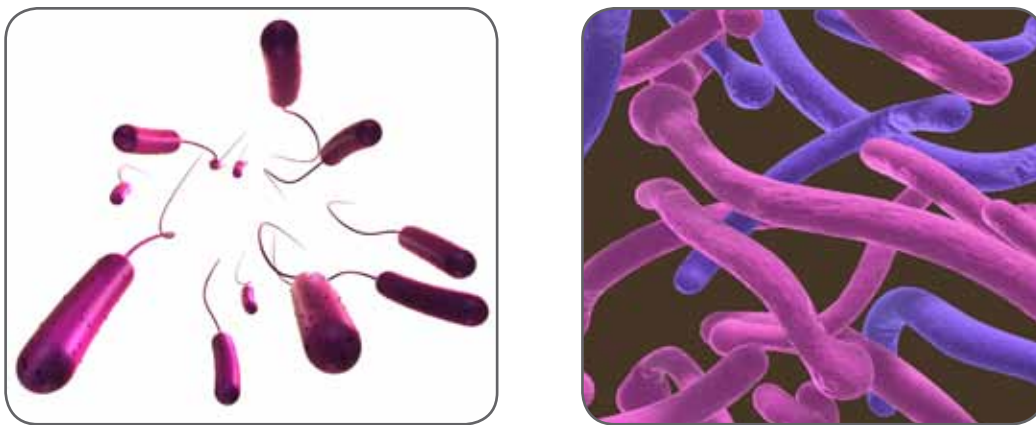


Fig. 2: E.Coli strains and Candida

Another interesting study on Biofilm removal was performed by Bonn University.

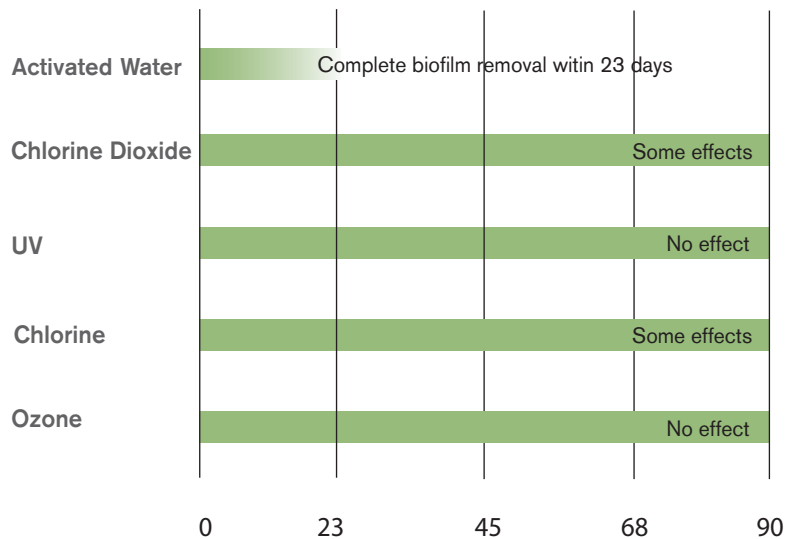


Fig.3: Biofilm removal with Activated Water (similar to SafeWater), Universitäts-klinikum Bonn.

Fig. 3 shows a comparison between SafeWater and traditional, well-known sanitisers and their effect upon biofilm removal as a function of time. As it can be seen, the traditional sanitisers showed only little or no effect after 90 days of exposure. Activated Water (similar to SafeWater), on the other hand removed the biofilm completely after 23 days.

An added strong benefit is the ability of SafeWater to clean food or beverage industrial process equipment. In order to clean process equipment SafeWater needs to be applied in a slightly higher concentration than for disinfection. Usually a concentration of 40-50 ppm (parts per million) is used for cleaning purposes. Remember that we are still talking parts per million and not percentages. This still constitutes a very low concentration and subsequently a low consumption of food grade salt.

Reduction Potential (ORP)

Besides producing a powerful and natural sanitiser (HOCL), the SafeWater generator (plate configuration) also produces large amount of "ready-to-use" caustic electrolyte that is a highly efficient cleaning agent. Due to the content of sodium hydroxide (NaOH) produced during the electrolytic process the liquid also has a large intrinsic cleaning and saponification potential owing to its large negative reduction potential (ORP).

The ORP is the actual secret behind the impressive performance of SafeWater despite relatively low concentrations of caustic (pH 11-11.5) as it reacts with the soil and removes it from the steel surface.

While the Catholyte has a large negative ORP that facilitates cleaning the Anolyte (HOCL) has a large positive ORP that has a significant synergistic effect with hypochlorous acid. The electrolysed oxidative water with high positive ORP damages the pathogen's cell membrane by inhibiting its osmotic protein pumps. This allows the sanitiser to enter the cell and cause it to burst, hence the impressive kill effect. Elimination of pathogens happens very quickly and can be regarded as a physical abolition. This is a distinctive property in comparison with traditional sanitisers used in food and beverage processing today, as this method does not create resistant strains of pathogens and does not leave any chemical residue.

Disposal of SafeWater after use is quite sustainable as it is immediately neutralised upon contact with even minor amounts of organic materials on the way to or at the waste water treatment plant. A major disposal advantage is that the water contains no dangerous disinfection chemicals of any kind.

Caution, however, should be observed upon direct contact with acids. If the sanitiser is mixed with acid and the pH is lowered, chlorine gas is produced (see figure 5). And if sufficient ventilation is not in place this gas is harmful and dangerous. Preventive measures must be taken in order to prevent this from happening and procedures must be in place in case it does happen. The SafeWater unit is equipped with venting connections to ensure that any gas produced is removed efficiently from the unit and the buffer tanks.

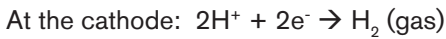


Fig. 4: Cleaning test on a process tank soiled with yoghurt milk. The cleaning procedure was mild caustic cleaning followed by 43 ppm HOCL cleaning. The soiled tank is on the left and the completely clean tank after cleaning is on the right

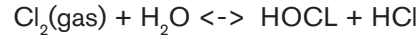
How is APV FX SafeWater produced?

The principle of the SafeWater system is an electrolytic generator in which a brine solution is passed through the electrolytic cell inside the machine. When subjected to a strong electrical DC current, the salt water is split into two main products, hypochlorous acid (HOCL) and caustic (NaOH).

The SafeWater electrolysis process consists of a reaction cell with an anode and a cathode. The reactions are

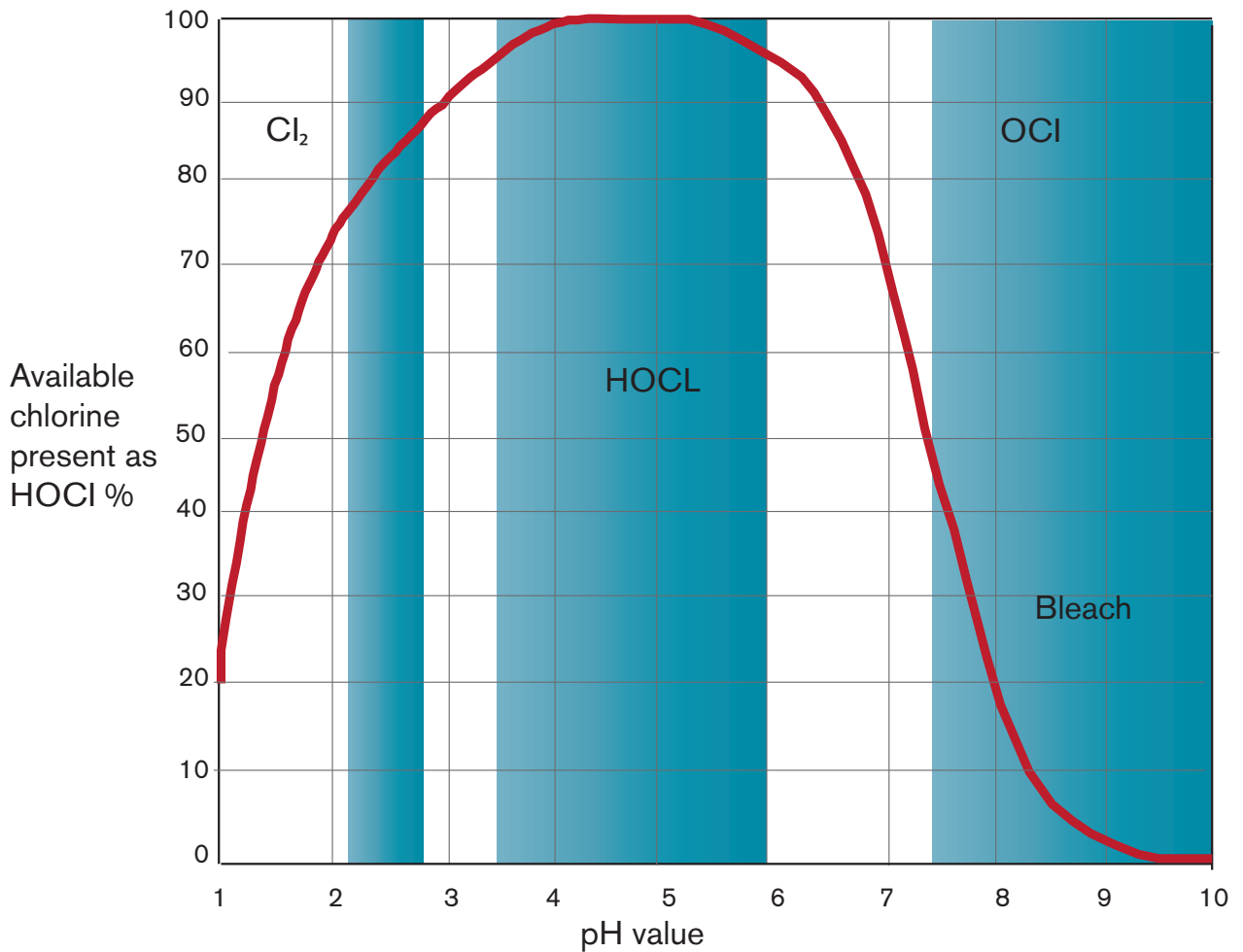


The chlorine gas produced at the anode disperses into the water and the following reaction equilibration will take place:



Producing hypochlorous acid (HOCL) and hydrochloric acid (HCl).

This equilibration is controlled by control of pH in the aqueous solution, as shown in fig. 5



Equilibrium line

Fig. 5: Optimal pH range for hypochlorous acid formation

SafeWater is produced through the electrolysis of a solution of sodium chloride or sodium carbonate. In the absence of a semi-permeable membrane, a mixture of anolyte and catholyte will be produced. This is essentially a mixture of sodium hydroxide and hypochlorous acid.

When a membrane is positioned between the electrodes, it is possible to separate the two electrolytes. A variation of the flow rate past the respective electrodes enables different concentrations of the two electrolytes to be obtained.

Fig. 6 shows the basic principle behind the APV FX SafeWater Flat Plate cell.

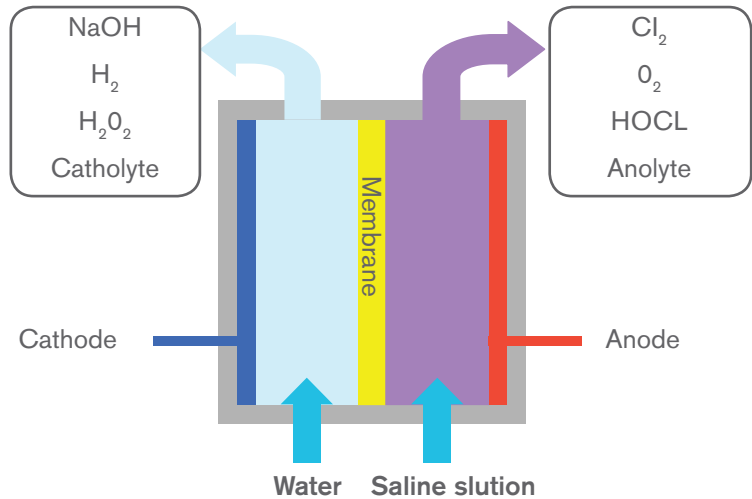


Fig. 6: APV FX SafeWater Flat Plate cell with a membrane separating the cathode from the anode

Hypochlorous acid is some 50 times more effective a sanitiser than hypochlorite. It is the chemical that the body naturally produces in response to an infection. When an infection is detected, the body sends (neutrophilic) blood cells to encircle the bacteria or virus and produce hypochlorous acid. A concentration of just 0.1ppm hypochlorous acid is sufficient to secure a log 3 reduction of E.coli within 10 seconds.

In addition to the flat plate configuration, SPX is also able to provide a co-axial configuration. It consists of a modular cell with a central circular anode surrounded by a ceramic membrane tube with an annular cathode. This results in a very compact design with high conversion efficiency. The co-axial system makes a concentrate that is diluted prior to use. The main electrolyte is the anolyte that is used both for cleaning and disinfection.

Fig. 7 shows the basic principle behind the APV FX SafeWater Coaxial generator.

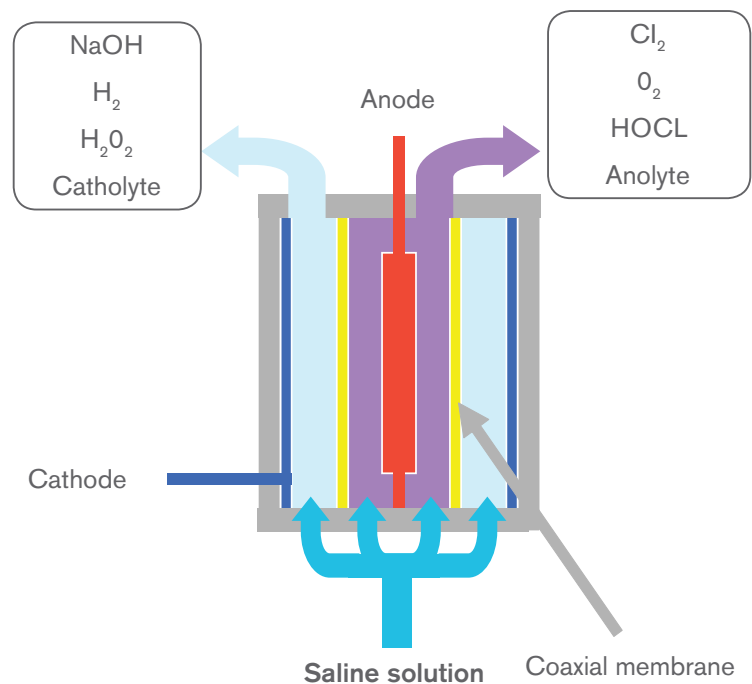


Fig. 7: APV FX SafeWater Coaxial electrolysis cell with a cylindrical membrane separating the cathode from the anode

What are the benefits and applications of APV FX SafeWater?

SafeWater has several important benefits for beverage processors:

- Replacement of chemical detergents and sanitisers
- Improved microbial efficiency
- Destruction of all forms of pathogens
- Reduction in CIP time
- Cold CIP
- Reduced water useage
- Improved effluent management
- Non Toxic, a true “clean” technology
- On-site, on demand generators
- Claimed to be harmless to man and the environment

Most application work has been conducted in the carbonated soft drinks industry where SafeWater is used as a replacement for conventional sodium hydroxide and nitric acid cleaning solutions, typically with payback times down to 4 months.

Other applications include:

- Cooling towers and ponds
- Agriculture
- Marine industry
- Medical facilities
- Hotels and public facilities
- Swimming ponds
- Meat industry – surface washing
- Drinking water
- Fruit and vegetable washing
- Waste water treatment
- Misting and fogging

How is APV FX SafeWater integrated into a process facility?

The SafeWater units are supplied as complete automated skid-mounted units that fill anolyte or catholyte into plastic (polyethylene) storage or concentrate tanks. The electrolyte is then dosed into a normal CIP system in a similar manner to that used for dosing of concentrated sodium hydroxide or nitric acid. Essentially, this means no change in the factory CIP system.

The SafeWater skid mounted units are part of the APV Factory Express (FX) Systems' high-quality, skid-mounted, Plug & Produce application solution platform marketed by SPX under its APV brand. They are designed for dairy, beverage and food manufacturers all over the world who require reduced lead time for delivery of high-quality, low-risk solutions for plant upgrades or extensions.

Based on standardised modules designed, built and backed by SPX, APV FX Systems leverage proven SPX engineering and automation, and comply with global industry standards. Fig. 9 shows a 3D model of the SafeWater Coaxial generator.

SafeWater skidded systems feed into existing or new CIP plants. In the case of retrofit into an existing production facility, an audit is recommended in order to estimate feasibility and optimise functionality. Audits are conducted by SPX CIP/SafeWater technologists.

The APV FX range also includes preassembled CIP skidded solutions with a wide capacity range. A 3D presentation of the APV FX CIP MINI skid can be seen in figure 10

Approvals for use of APV FX SafeWater

It is important to know which authorities approve and have given approval for industrial use of APV SafeWater in their region of the world. Approval has been given by the following authorities for electrolysed water:

- US Food and Drug Administration
- US Environmental Protection Agency
- US Derpartment of Agriculure
- Department of Communications, Energy and Natural Resources
- Kiwa
- TÜV Rheinland



Fig. 9 and 10: APV FX SafeWater Plate Generator (EAU Empowered Water™)





Fig. 11 and 12: APV FX SafeWater Coaxial Generator (Trustwater™ FEM-3 Coaxial)



Trademarks



EAU Empowered Water™ is a trademark of EAU Technologies

Trustwater™ FEM-3 is a trademark of Trustwater™ USA

Global locations:

APAC

ft.apac.fxqueries@spx.com

AMERICAS

ft.americas.fxqueries@spx.com

EMEA

ft.bydgoszcz.fxqueries@spx.com

SPX Flow Technology

Pasteursvej

DK-8600 Silkeborg, Denmark

Phone: +45 70 278 278 Fax: +45 70 278 330

www.apv.com

www.spxft.com



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