DECENTRALISED WATER TREATMENT:

REDUCE THE RISK OF BIOLOGICAL CONTAMINATION IN COOLING TOWERS

WITH WATER CONDITIONING AND BLOWDOWN CONTROL.

REDUCE OPEX

MINIMISE BIOLOGICAL CONTAMINATION

SAVE WATER

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The following white paper describes the water management challenges faced by industries such as food and beverages, pharmaceuticals, chemical, etc. It focuses on a reliable method to treat cooling tower water, which, in conjunction with blowdown optimisation, represents the greatest opportunity for improvements in water efficiency. Offering insights, facts and figures on cooling tower operation, the paper also discusses how services on the water treatment process can help solve customer needs.

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The global water challenge is affecting a growing number of countries around the globe, forcing various industries to look deeper into how they can reduce the impact. Water is widely used across industries as a direct component of products or core processes, for example in wash and clean. But also In utilities, temperature control applications are under focus.

Industrial cooling towers have special needs and requirements to the water they use. The operation can lead to a high consumption of freshwater and place added stress on the water situation in a community. If the water does not fulfil the requirements in terms of chemical and biological parameters, the operation can be costly, ineffective and, in case of high biological contamination, even dangerous.

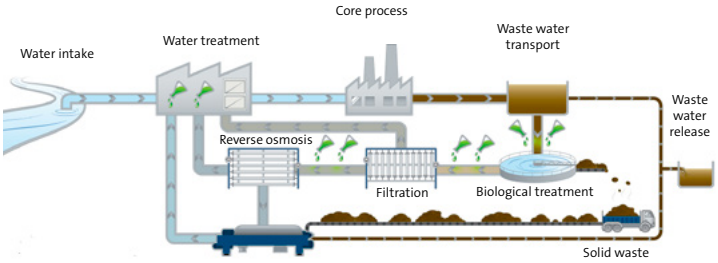
Common industrial water challenges

According to the EU, water scarcity is affecting around 11% of the population of Europe. This may seem like a low number but in the Mediterranean region, 20% of people already live under constant water stress. This number can rise to 50% during summer[1]. This is just one example of the water scarcity effect and many more can be found all over the world.

The industrial segment is a large part of this challenge. Water demand in manufacturing is expected to increase by 400% by 2050[2], as many industries are water-intensive. In this context, the industrial water segment must find ways to move away from one-time use and go towards a sustainable method of handling water.

In industrial markets, water plays an important role as a solvent, cooling liquid, wash and clean liquid and many other applications. Whenever we use water, we also change the content and the water quality. In many countries, the authorities are forcing manufacturing companies to implement a decentralised water treatment system, either a minimum liquid discharge (MLD) or zero liquid discharge (ZLD).

This is done not only to reduce the water consumption from conventional sources but also to place less stress on the municipal wastewater treatment plants and avoid contamination of the water cycle by industrial substances. A generic cycle of water usage and zero liquid discharge treatment is shown in picture 1.



Picture 1: Industrial water cycle

Water reuse as a solution

To decrease contamination and reduce water consumption, many companies are looking into water reuse. Reuse is when the used water is treated to a quality that makes it possible to feed it back into the company's water cycle. Reusing water in the core process is not state-of-the-art yet, but we see an increasing number of companies reusing the water after intensive treatment with physical, chemical or biological steps.

An example of this is water reuse for temperature control in cooling towers. This application uses high amounts of water across the industry and requires a lower capital investment than water treatment for core processes. The contamination and the treatment steps vary depending on the industrial area.

Because of its original pollutants, when water is reused, the potential for biological regrowth is extremely high, even if the treatment is tightly controlled. Water conditioning plays an important role in reuse because of this.

Case: Controlling biological regrowth

As an example, consider the cooling tower of an industrial site in Singapore. The cooling tower is installed as an open system on the roof of an industrial building, where constant sand, dust and airborne pollutants are dragged from the sprinkled water and deposited in the cooling water sump tank, creating undesired sludge.

The building hosts office and production facilities with approximately 200 people. The location of the system is on the equator, with an average outside temperature of 25-30° C. The building needs constant climatisation, so the system must provide cooling 24/7. The system consists of two towers and two chillers with a system flow of 26 l/s. The water quality is only maintained with a UV system operated in a bypass.

The cooling tower is cleaned at a monthly interval manually by operations staff, consuming valuable labour resources. The water is exchanged in bi-weekly cycles, leading to high consumption of freshwater in connection with increasing tariffs for the wastewater released.

The entire system is set up as a duty/standby system. After three years, growth of biofilm has been observed and the overall efficiency has started to decrease, increasing the need for maintenance and labour dedicated to this task (see picture 2). This has proved that the UV system installed in a bypass has provided no disinfection effect at all.

Picture 2: Biofilm growth at the pipes and the reservoir of the cooling tower

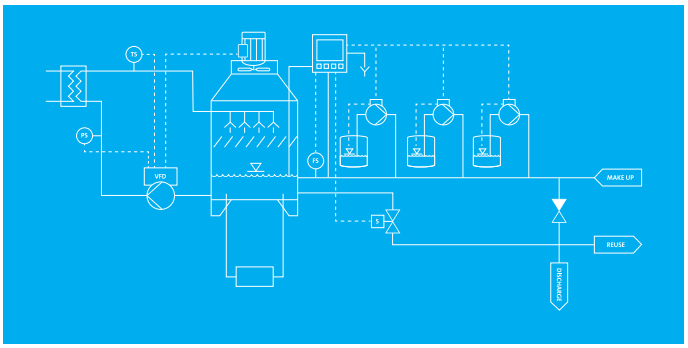
A proven disinfection solution

One way to solve the biofouling problem and remove the existing biofilm is to use Oxiperm Pro to dose chlorine dioxide instead of UV disinfection in the bypass. Chlorine dioxide (ClO_2) is a proven method to remove biofouling in cooling towers. It also makes it possible to increase intervals between cleaning, which is done manually by facility management. Furthermore, Grundfos proposes digital dosing pumps for dosing of antiscalants and pH correction.

All three chemicals are monitored by a chemical measurement system that measures chlorine dioxide concentration, pH and conductivity in the recirculation loop. Instead of a continuous dosing rate, a shock dosing strategy is applied. The number of shots per day is multiplied by four. However, the concentration in the water is measured continuously online and the four shots are only done if the ClO_2 concentration drops below a certain level.

The strategy is to minimise the use of chlorine dioxide as much as possible. A generic treatment set-up can be seen in picture 3. The goals of the new operation method are a reduction of energy loss caused by the biofilm; a reduced need for cleaning chemicals; and a reduction of man-hours needed for cleaning. Water usage savings should also be achieved as the biweekly replacement of all water in the tower is avoided.

The system should be kept clean to avoid microbiological contamination for as long as possible. A final manual cleaning of the system has been performed to start with a contamination-free system. The dosing point is located in the cooling water supply line. The measurement of the chlorine dioxide is done in the reject line of the cooling water.



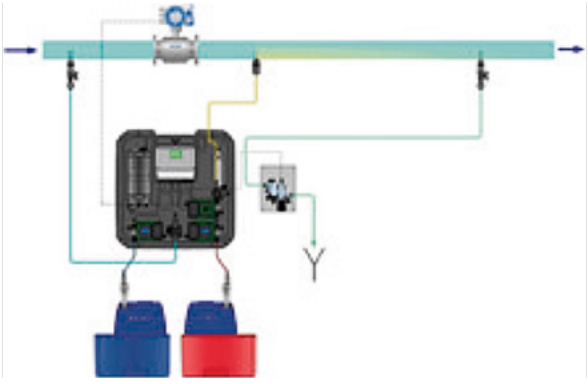
Picture 3: Generic chemical dosing set-up in an industrial cooling tower

The technical solutions in detail:

Chemical preparation for cooling towers
The Oxiperm Pro system generates a chlorine dioxide solution with a concentration of max. two g/l and a capacity of max 60 g/h. The system is specified as follows in table 1:

Table 1: System specification

Sizing	
26 l/h	CW flow
96.3 m^3/h	CW flow
0.5 ppm	Concentration of ClO_2 required during operation
46.8 g/h	Max ClO_2 capacity expected
System selection	
60 g/h	Oxiperm Pro 60
2 g/l	[ClO_2]
60 l/h	Dosing capacity
Disinfection strategy	
4 n/day	Number of shots per day
2 h	Running time per shot
46.8 L	Volume required per shot
4 h	Hours between shots
120 L	Production capacity between shots (from final of first shot to start of second shot)
Chemical consumption	
187.2 L	Daily consumption of ClO_2 solution
374.4 g	Daily consumption of ClO_2
11.5 L	Daily consumption of $NaClO_2$ (EN 938) 7.5%
10.2 L	Daily consumption of HCl (EN 939) 9%

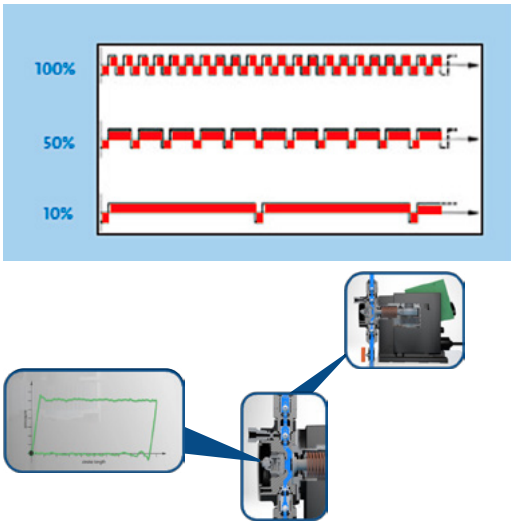


Picture 4: Installation of the disinfection system including flow and chemical measurements

To control the dosage, a measurement and control system has been installed. The whole system is connected to the BMS or SCADA to provide documentation and insights.

Precise chemical dosing in cooling towers
Cooling tower water treatment requires extremely accurate dosing of chemical additives. This maintains the proper water quality and avoids interference with the overall efficiency. It also prolongs the lifetime of the asset. Modern digital dosing pumps, such as those incorporated in systems provided by Grundfos, can deliver the required dosage of chemicals with precision[3].

The diagram below shows the nearly continuous dosing flow, which is provided by the stepping motor technology, even with small volumes.



Picture 5: Flow monitor principle and dosing flow diagram

An integrated flow control monitor (FCM) maintains the dosing flow. It can give feedback about the actual flow value in comparison to the set point. Also, the SMART Digital range will provide modular pumps for easy system integration. The clear menu structure and the plain text menu provides the information needed about the status of the pump and makes daily work easier for the system operators.

Communication with this pump is no longer a challenge in the system integration. By connecting the E-Box we have a plug and pump system, communicating in many different ways with the overall PLC. That makes operators and maintenance staff aware of any issues affecting the overall system at any time.

Controlling blowdown
As mentioned above, there is a high risk of biological matter propagation after the reuse treatment steps, that can lead to corrosion, plugging of film fill and the build-up of concentrated solids in the form of scaling, which causes corrosion, blockages and a reduction of the overall cooling tower efficiency.

Proper water treatment steps for the feed water, combined with the added chemicals for conditioning the cooling tower water loop, can reduce the negative impact of this solid build-up and the biological growth. However, after a certain point, impurities become too concentrated to keep the water circulation cost effective in the system.

When the concentration reaches a certain level (which depends on the cooling tower design), the solids must be released (known as blowdown or bleed) and new water (make-up water) must be added to keep the water balance. The term 'cycle of concentration' refers to the ratio of impurities or the total dissolved solids (TDS) in the circulating water to the TDS in the make-up water. It is one of the key parameters to control the efficiency of a cooling tower.

For instance, when the solids concentration in the circulation loop has doubled over that of the make-up water, then there are two cycles of concentration, and so on. The cycle with the lower value has a less efficient operation.

Direct TDS measurement is difficult in a practical way. Instead an indirect property, the electrical conductivity (EC) can be used.

The solution to this is a Grundfos DID measuring and control device that consists of two conductivity sensors (one for the make-up water and one for the cooling loop water) in connection with a control unit (CU 382). It will constantly measure the conductivity, ensuring the constant monitoring of any changing feed water condition or corrosion risk due to increasing salt concentration in the cooling tower loop. This puts you in control of the cycles of concentration that the cooling tower is operating at any time, without the need to wait for laboratory results or manual measurement.

To set up limits for the cooling loop water conductivity, the controller can either send a signal via the Fieldbus towards an external controller or via a built-in dry contact relay switch to react over the blowdown valve. This will release the concentrated water to avoid manual operation.

The Grundfos disinfection solution delivers reliable and safe operations

The approach of the disinfection concept described above enables the owner and operators of the building to maintain the cooling system safely and reliably. The solution allows them to reduce operational costs by cutting chemical consumption, optimising processes and energy efficiency and reducing maintenance costs. Water consumption and man-hours for cleaning and legal reporting can also be reduced.

Grundfos has developed an app to ease the chemical management in dosing applications. Managing hazardous chemicals, reporting, logging, and surveillance will no longer be a worry for cooling tower owners and operators. All components function perfectly on their own but with the chemical management app,
you can add another layer of safety, while ensuring compliance with legislation.

The onsite chemical preparation combined with the digital dosing technology, the measurement and control devices delivers safe and reliable operations for the system's end-user. For chemical suppliers and the system builders or operating companies, the solution helps secure the chemical handling and the operation of the overall cooling system.

Long-term monitoring is required to offer complete details of the benefits of the installation. However, based on the above case, the following benefits can be illustrated:

- Reduce the risk of biological contamination significantly
- Reduce health risks due to legionella and chemical handling
- Save costs on cleaning water due to optimised processes

For more information on how Grundfos can help reduce the risk of biological contamination in cooling towers, please get in touch.

Sources:

1: EC. Water Reuse. Background and policy context. UN - Water and Jobs

2: OECD. OECD Environmental Outlook to 2050: The Consequences of Inaction. OECD Publishing, Paris. 2012

3: University of Applied Sciences, Weihenstephan Triesdorf, Institute of food technology. "How good is the Grundfos SMART Digital DDA FCM really?"

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