AERIS GUARD

MULTI-ENZYMATIC CLEANING AND SANITISING OF HOSPITAL WATER COOLING TOWER

EXECUTIVE SUMMARY

Legionella and other pathogenic micro-organisms are of concern in water cooling towers. The bacteria are ubiquitous in water systems and in a cooling tower environment these survive mostly within Bio- films and Bio-burden as sessile colonies or inside larger micro-organisms.

In their sessile form they represent a risk in that the bacteria can become planktonic at indeterminate times, if conditions are favorable (changes in cooling tower operating modes or low biocide levels)the colony can multiply rapidly and then become airborne.

In this sessile form the bacteria have been found to be effectively protected from biocides in the water even at quite high concentrations of biocides in the sump.

The water temperature dropped from 29.3°C before cleaning to 27.9°C after. This demonstrates through clearing the Bio-film, the cleaning process was able to greatly increase the efficacy of the heat exchange within the cooling tower.

The average energy saving identified through performing the remediation process was 4.36%, which is an added benefit to the essential need to maintain a clear and clean cooling system free from Bio-film build-up.

The fill and surface area of the tower was visibly cleaned and the dislodged bio-film formed a visible scum layer on the surface of the water.

The results of the ATP and Total Plate Counts from the Cooling Tower Water over time conclusively demonstrate that the Bio-film has been successfully dislodged and solubilised from the water cooling tower and connected system.

AN OVERVIEW

DESCRIPTION & BACKGROUND

Product Description

AerisGuard™ Multi-Enzyme Cooling Tower Cleaner enzymatically digests water insoluble biological polymers – proteins, cellulose; and other polysaccharides from Bio-film's and organic debris to ensure destroying of Legionellae habitat and minimal insoluble organic matter present in the tower.

Background

Aeris Environmental Ltd have carried out extensive laboratory and field trials on the use of high levels of active enzymes to destroy and digest extensive layers of Bio-film and Bio-burden in cooling systems. We have found that particular combinations of enzymes will effectively digest Bio-film from the surfaces as evidenced by a substantial increase in ATP readings as well as Total Bacteria and Legionella Counts.

This combined multi-enzyme treatment has also proven to be extremely effective in providing as close as possible to virtually protozoa-free cooling tower environments and enhanced compressor efficiency.

Large concentrations of enzymes proven to be efficacious at destroying protozoa

- Significantly improves the heat exchange efficiency in condenser circuits
- Decreases scaling
- Reducing of bioburden of the towers improves efficacy of oxidising and non-oxidising biocides
- Used for ongoing maintenance and shock treatments
- Environmentally friendly
- Improves compliance with EPA and local environmental authorities require

Peer reviewed scientific research identifies widespread costs of biofilm

- **Corrosion** - In the oil and natural gas industry, bacterial biofilms costs ~ $100 Million each year through the corrosion of pipelines and process equipment and souring of reservoirs. The metabolism of bacteria in the biofilm (production of carbonic, pyruvic, citric, lactic and other acids)
- **Equipment failure** - In the paper manufacturing industry, biofilms are responsible for an estimated 10-20% of all machine downtime.
- **Reduced performance and energy loss** - In heat exchangers and cooling water systems a 250 micron thick layer of biofilm may reduce the effective heat transfer coefficient of a heat exchanger by as much as 50%.
- **Increased risk of contamination of products and staff** - Legionella bacteria are commonly spread through airborne water droplets. Mist or vapor contaminated with the bacteria can come from cooling towers according to the CDC.

(Coester and Cloete 2005; Palmer and others 2007; Vu and others 2009.)

OBJECTIVE

The objective of this water field trial was the removal of the Bio-film/Bio-burden present in the water cooling tower circuit and assessment of the effect of the Bio-film removal on compressor energy consumption.

Some energy efficiency improvements were expected on the basis of better coolant flow through and unobstructed pathways leading to greater efficiency of the cooling tower hence saving energy.

METHODOLOGY

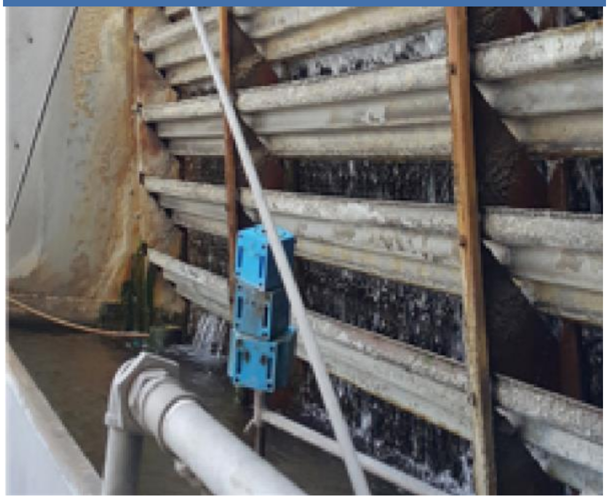
The Aeris Environmental Multi-Enzyme Cleaner Sanitiser (AMCS) was added to the sump of the Cooling Tower.

- The system, including pipe work, had a water volume of 7,500 litres.
- AMCS was dosed at 0.2% of water volume directly to water cooling tower basin.

- An ATP measurement is typicallay used as a general indicator of the presence of living cells. A water sample was taken as a baseline ATP reading and Total Bacterial Count (TBC) taken prior to the addition of AMCS.
- Water was assayed for ATP and TBC at 1, 2, 3, 4, 5 and 25 hours after addition of the enzymatic cleaner
- Temperature and energy usage measurements were taken before, during and after remediation.

VISUAL
RESULTS

BEFORE



The cooling tower before cleaning

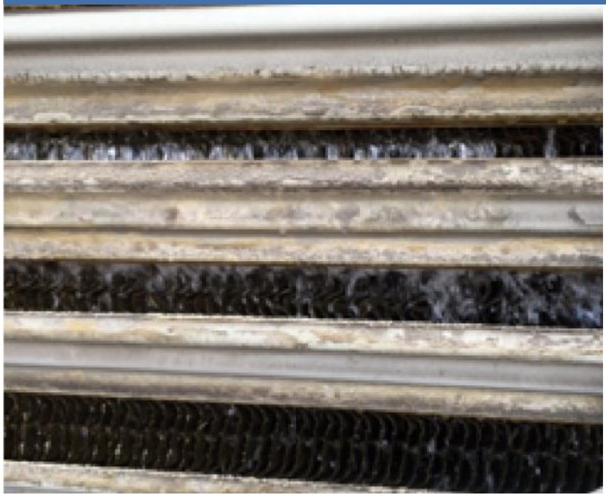
AFTER

The Enzyme reaction in the basin

As the AMCS was added to the basin the water shows active micro-bubbles and clouding as the enzymes begin to break down the protective outer layers of the Bio-cide.

The pictures below shows the water running down the outside of the cooling tower fill. For optimum heat dissipation the fill is designed to have the water pass over it. With this fill having excess microbial build up water was bypassing the fill.

BEFORE



Water flow before treatment

AFTER

Water flow after treatment

VISUAL
RESULTS

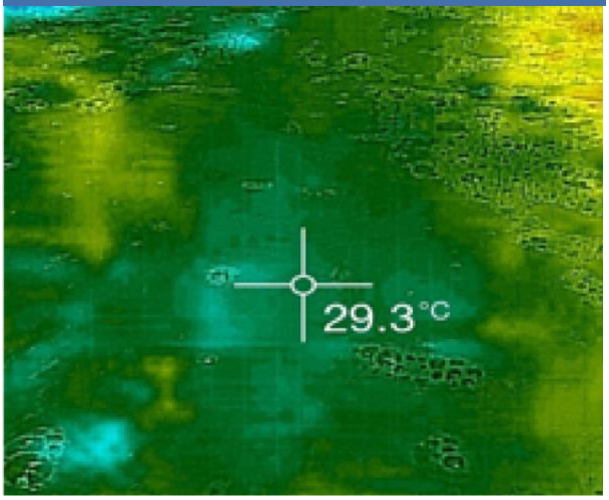
The water surface was largely clear of any visible scum or Bio-film prior to treatment being added to the basin. 24 hours after adding the AMCS there was very visible area's where the Bio-film cleaned from the tower by adding the AMCS had gathered to form a visible scum layer on the surface of the water.

BEFORE

AFTER

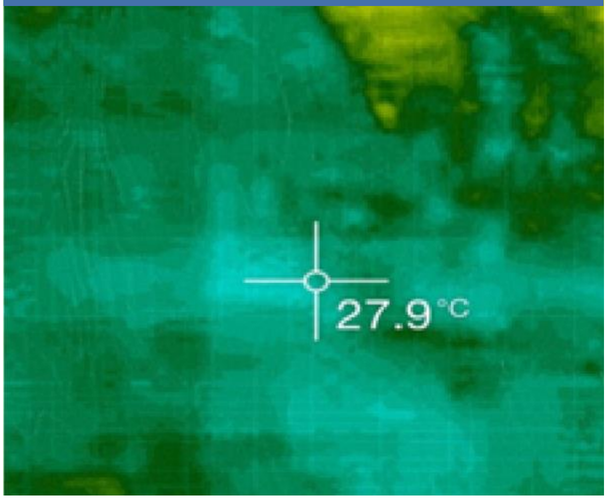
As shown below the water temperature also dropped from 29.3°C before cleaning to 27.9°C after. This demonstrates through clearing the Bio-film, the cleaning process was able to greatly increase the efficacy of the heat exchange within the cooling tower.

BEFORE



Temperature before treatment

AFTER



Temperature after treatment

MEASURED
RESULTS

ATP READINGS TAKEN AT COOLING TOWER SUMP					
BASELINE	**15 MIN**	**1 HOUR**	**3 HOURS**	**4 HOURS**	**25 HOURS**
125	1096	1006	108	150	1564

TOTAL PLATE COUNT READINGS TAKEN AT COOLING TOWER BASIN					
BASELINE	**15 MIN**	**1 HOUR**	**3 HOURS**	**4 HOURS**	**25 HOURS**
Below detectable limit	Below detectable limit	Too numerous to count	Too numerous to count	Too numerous to count	Too numerous to count

The results of the ATP and Total Plate Counts from the Cooling Tower Water over time conclusively demonstrate that the Bio-film has been successfully dislodged and solubilised from the water cooling tower and connected system.

The rate of increase in ATP and Total Plate Count over time after the addition of the enzymatic formulation is an indication of the rate of digestion of the Bio-film with the peak values achieved at:

- 1-2 hours after the addition – indicative of dislodging large amount of loosely attached Bio-burden and fresh Bio-film.
- 24 hours after the addition – digestion of the persistent mature Bio-Film that most likely is resistant to both shock doses of oxidizing biocides and mechanical cleaning.

TBC counts exceeded 105 cfu/ml after the first hour of treatment indicating that the majority of biofilm was dislodged and solubilised with the sessel bacteria trapped in the biofilm then becoming planktonic.

HEAT TRANSFER

EFFICIENCY

Bio-films have been identified as a key contributor to heat transfer reduction in both water and air heat exchange applications.

The effects of Bio-film insulation have been studied by various institutions around the world and there has been several papers written on the subject in relation to cooling water systems.

The following table indicates the insulation capacity of Bio-film when assessed against other common insulting deposits found in cooling water systems, particularly condenser circuits.

ATP READINGS TAKEN AT COOLING TOWER SUMP		
SUBSTANCE	**FORMULA**	**THERMAL CONDUCTIVITY**
Calcium Carbonate	$CaCO_3$	2.6
Calcium Phosphate	$Ca_3(PO_4)_2$	2.6
Calcium Sulphate	$CaSO_4$	2.3
Iron Oxide	Fe_2O_3	2.9
Mineral Deposit	Analcite	1.3
Organic Deposit	Bio-film	0.6

A lower number indicates a greater resistance to heat transfer

As can been seen above biofilm represents an unusually high order of resistance to heat transfer and hence should be considered an inherent problem in heat transfer equipment of any nature where Bio-films can develop or occur.

The Growth Cycle of the Bio-Film thick outer layer makes removal and cleaning difficult. It also provides a breading ground for viruses and bacteria.

BIOFILMS AND SCALE FOULING **OF WATER CIRCUITS**

To help understand the relationship of biofilms and scale forming deposits we reference the following extract, which explains the role of Bio-films in the corrosion of equipment:

Solving Biofilm Problems – Preventing Equipment fouling and corrosion.

Jim Lukanich, senior technical specialist, Formulator Chemicals Division Buchman Laboratories, Memphis, Tenn.

The development of biofilms and the role they play in corrosion and deposition processes may be the most underestimated factor in the treatment of industrial water treatment systems.

This review is designed to provide a basic understanding of biofilms, the problems they cause and what might be done to deal with them.

Problems with biofilms

Biofilm consist of microbial cells (algal, fungal or bacterial) and the extra cellular polymer they produce.

Bacterial biofilms are often responsible for fouling heat transfer equipment.

When dealing with cooling towers or spray ponds, algal biofilms are also a concern. Algal biofilms also foul distribution decks and tower fill, and provide a nutrient (organic carbon) that will also help support the growth of bacteria and fungal.

Algae do not require organic carbon for growth but instead use CO_2 and the energy provided by the sun to manufacture carbohydrate. Growth and dispersal of algal cells will provide nutrients that will support a larger and more diverse population of micro-organisms.

Micro-organisms are found in both the bulk water and on the surfaces of industrial water systems. Bacteria attached to surfaces by proteinaceous and appendages referred to as fimbriae. Once a number of fimbriae have glued the cell to the surface detaching the organism is very difficult.

One reason bacteria prefer to grow on surfaces is is the organic molecules absorbed they provide needed nutrients. Once attached, organisms begin to produce slime or extracellular biopolymer.

The biopolymer produced can greatly exceed the mass of the microbial cell and may help to provide a more suitable environment for the survival of the organism.

The extra cellular biopolymer consists primarily of polysaccharide and water. In fact biofilms are typically more than 90% water.

An example of a bacterial-produced biopolymer is xanthan gum, which is produced by Xanthamanous campestris. This biopolymer is used as a thickening agent in a number of food and consumer products. Gellation of some biopolymer products can occur on the addition of divalent cations, such as calcium and magnesium.

The electrostatic interaction between carboxylate functional groups and divalent cations results in a bridging effect between polymer chains. Bridging and crosslinking of the polymers stabilizes of the biofilm making it more resistant to shear.

BIOFILMS AND SCALE FOULING OF WATER CIRCUITS

Fouling and Corrosion

Once bacteria colonize surfaces and produce biofilms, numerous problems arise including reduced heat transfer efficiency, fouling corrosion and scale.

When biofilms develop in low flow areas such as cooling tower fill, they may initially go un-noticed because they might not interfere with the flow or evaporative efficiency. With time the biofilm becomes more complex, developing a matrix, which accumulates debris and impedes flow.

Biofilm causes fouling of filtration and heat transfer equipment.

Fouling of heat exchangers can occur quickly either due to a process leak or influx of nutrient. A sudden increase in nutrient can send bacterial populations into an accelerated growth phase with a rapid biofilm accumulation.

Algal biofilms foul cooling tower distribution decks, fill and basins. Portions of these may break loose and transport to other parts of the system causing blockage and accelerated bacterial and fungal growth.

Biofilms can also lead to the formation of mineral scales. Calcium ions are fixed into biofilm matrix by carboxylate functional groups present on the polysaccharides. Calcium ions held in place by biofilms on heat transfer surfaces are readily available to react with carbonate or phosphate anions. This process provides crystal growth sites that would not normally be present on a biofilm-free surface.

Additionally biofilm trap precipitated calcium salts and corrosion by-products from the bulk water that act as crystal growth sites. A typical bio-film induced mineral deposit is the calcium phosphate scale that forms on tooth surfaces.

The growth of bacteria and formation of biofilms can result in another problem corrosion. Microbiological corrosion may be defined as corrosion that is influenced by the growth of micro-organisms. Simply stated, corrosion occurs on a metal surface due to some inherent or environmental difference between one area on that surface of another. Those differences create anodic and cathodic sites, setting up a basic corrosion cell.

The anode is the area at which metal is lost, while electrons are consumed at the cathode. Microbial corrosion is electrochemical corrosion where micro-organisms have some influence in the creation or acceleration of the corrosion process.

Micro-organisms can influence corrosion in a number if ways. When iron or manganese oxidizing organism colonize a surface, they begin to oxidize these elements and produce a deposit. In the case of iron oxidizing organisms ferrous iron is oxidized to its ferric form with the electron being utilized by the bacterium for energy production.

The oxidation of iron or manganese by micro-organisms is not a requirement for the development of a localized corrosion cell. Corrosion can also occur when localized cells are formed, simply due to the presence of biofilm

RESULTS

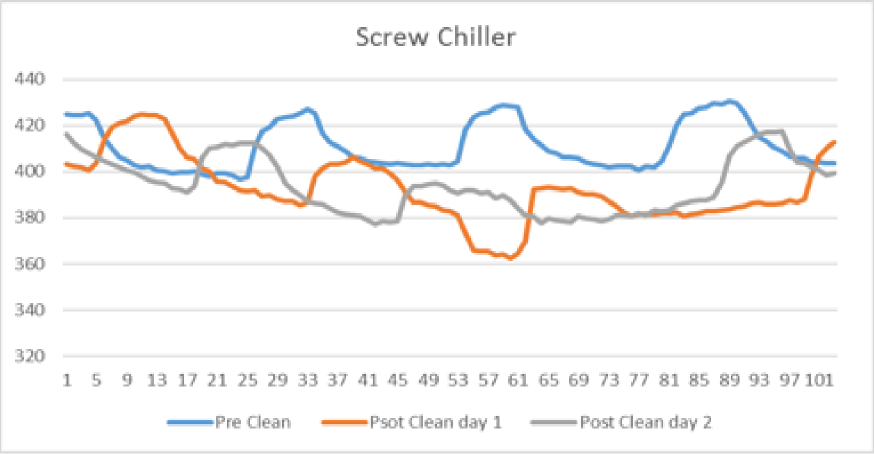
The primary focus of the Aeris Enzyme cleaning is the removal of biofilm and its effect on eliminating Legionella and the fouling within the condenser water system including the chiller tubes.

As identified previously the Aeris Treatment reduced the temperature of the cooling tower water by eliminating the biofilm. This has an effect on the operation of the associated chiller(s) and in this case there was an identified reduction in energy consumption of the 180 ton screw chiller.

The results show data collected before and after the cleaning of the cooling tower. Data was collected continuously on ACR loggers recording the current (Amps) consumed at 8 second intervals, this is then averaged over 1 minute intervals. The Ampere-hours recorded were then converted to kWh consumed over 1 hour and 43 minute periods to evaluate the energy used and the resultant savings.

ENERGY MONITORING DURING REMEDIATION PROCESS					
DATE	START	END	kWh CONSUMED	SAVINGS	AVERAGE
28/6/2016	12:27	14:09	432	-	1hr 43min
28/6/2016	14:10	15:52	412	4.52%	4.36% Saving
29/6/2016	14:10	15:52	414	4.19%	

The graph below is the analysis of the recorded data and identifies a reduced ramping in the operation of the compressor motor in the chiller operation following the cleaning of the cooling tower. This could be attributed to the reduced condenser water temperature from the clean tower.



The average energy saving identified through performing the remediation process was 4.36%, which is an added benefit to the essential need to maintain a clear and clean cooling system free from Bio-film build-up.

Through application of the Aeris Multi-Enzyme Cleaning Solution effective and non-mechancial removal of Bio-film was achieved and resulted in improved heat transfer within the cooling tower.

SUMMARY

This shows a measurable improvement in operating efficiency of the compressor which overall demonstrates the effectiveness of the process and the cleaning solution.

The Aeris Multi-Enzyme Cleaning Solutions is a uniquely successful system in preventing mould and other biological contamination in HVAC systems and biofilm growth in water systems. This success has been achieved in conjunction with dramatic environmental and energy benefits.

We believe this product offers an alternative to other methods of HVAC water treatment and has further applications for other industries at large by providing scientifically proven methods for the digestion, elimination and control of biofilms.

This product may be used as a periodic treatment for reduction of Bio-film in cooling towers and similar products are also available for use on fan cooling units for coil remediation. Use of this product should be incorporated as part of an overall energy management stratergy and maintenance plan for HVAC and Refridgeration systems.

About this Case Study

This remediation was undertaken by an Aeris Platinum Partner, in Malaysia with technical support from Aeris Environmental, Australia in June 2016.

AERIS ENVIRONMENTAL
26-34 Dunning Ave
Rosebery NSW 2018

Contact:
8344 1315
www.aeris.com.au

aeris
ENVIRONMENTAL