AQUARIUS TECHNOLOGIES PTY LTD
WATER QUALITY CONTROL

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The Cost Benefits of "Best Practice" Comfort Cooling Water Treatment Programmes

Best Practice Cooling Water Treatment programmes utilising reliable automatic dosage and control to maintain the optimum chemical levels at all times offer many cost benefits to the equipment owner.

With an effective water treatment programme which is automatically metered and controlled to maintain the optimum levels, even with the variable loads experienced in comfort cooling systems, the following **Key Performance Indicators** are easily measurable and deliverable**.**

- Corrosion rates of less than 3 mpy on mild steel and 0.5 mpy on copper, with no pitting or tubercles visible.
- Heterotrophic Plate Counts are maintained at less than 10^5 cfu/ml. and ideally at 10^3 to 10^4 to ensure negligible biofilm.
- Legionella Bacterial tests are routinely confirmed as "Not Detected"
- Condenser tubes - on annual inspection - are free of scale deposits and/or biofilm deposits
- Periodic chemical and/or mechanical cleaning of condenser tubes to remove deposits are eliminated
- Bleed off to sewer is minimised and the cooling system operates at the maximum concentrations of the particular make up water supply.
- Pump gland leaks and tower over flows or "splashing" have been eliminated.
- Consumption of both scale and corrosion inhibitor and microbiocides are reduced at maximum concentrations.
- Regular tower cleaning, with disinfection and repassivation of the system ensures the tower fill and basin is maintained clean and free from any biofilm deposits which may harbour Legionella bacteria.
- Environmental damage is reduced as less energy is consumed, less water and chemicals are consumed, and reduced amounts of water and chemicals are discharged to sewers.

The cost benefits to the owner of the cooling system can be summarised as follows:

- Reduced electricity costs per kWR due to elimination of fouling in the condenser tubes is a major saving in operating costs.
- Reduced water costs for both make up water and sewerage charges per kWR.
- Reduced chemical consumption.
- Chemical and/or mechanical cleaning costs can be eliminated.
- Increased life of the plant, corrosion rates are reduced, crevice corrosion on tube sheets can be prevented, the tower fill does not collapse under the gross weight of biofilm.
- Peace of mind !! - a Legionella outbreak is extremely unlikely to ocurr.
- Carrying out "Best Practice" water treatment is probably the best possible defence in any possible legal action on comfort cooling systems

To justify the above claims it is necessary to look at some of the costs associated with operating a comfort cooling system.

The major cost in most applications is the cost of electricity to run the compressors.

Cost of Fouling in reduced Heat Transfer

Let us consider a major hospital with 20,000 kWR installed capacity, an average load of 8000 kWR, and electricity at AUD $0.08 per kW hour. The annual estimate of electricity costs is calculated as follows:-

8000 (kWR) x $0.08 (kWh) x 8736 (hrs/year) x 0.23 (Conversion Factor - KWR to kWh)

=AUD $1,285,939.20 per annum for electricity

Similarly a shopping centre with 5000 kWR installed refrigeration capacity with an average load of 2500 kWR over 100 hrs per week would have an estimated electricity cost as follows:-

2500 x 0.08 x 100 x 52 x 0.23

=AUD $239,200.00 per annum for electricity

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The typical cost of electricity for commercial purposes vary from country to country, and city to city as the following table would indicate.

Location	Cost per kWh	= AUD $
USA	USD $0.075	= AUD $0.15
London	GBP 0.771	= AUD $0.21
Hong Kong	HK $1.00	= AUD $0.25
Singapore	SG $0.113	= AUD $0.12
Shanghai	RMB 0.75	= AUD $0.17
Malaysia	RM 0.208	= AUD $0.10
Australia	AUD $0.08	= AUD $0.08
New Zealand	NZ $0.??	= AUD $0.??

Deposits and/or fouling in condenser tubes have an insulating effect, reduce heat transfer, and can dramatically increase the electrical running costs. Different deposits have different thermal conductivity values as can be seen from the table below.

Material	Thermal Conductivity W.m.K
Polyurethane foam	0.03
Polystyrene foam	0.36
Biofilm or Slime	0.60
Silica - Amorphous	0.90
Hydroxyapatite	1.25
Analcite Scale	1.60
Magnesium Phosphate	2.16
Calcium Sulphate	2.30
Calcium Carbonate	2.60
Magnetic Iron Oxide	2.88
Boiler Steel	44.64
Copper - pure	392.90

The table demonstrates that some fouling deposits are almost as effective in insulation as is polystyrene foam e.g. biofilm and silica type deposits. Whereas silica scale is relatively rare, biofilm grows rapidly in all cooling systems and can form a significant film in 1 - 2 days when adequate quantities of biocides are not present.

The graph below indicates the loss in heat transfer for various deposits at various thickness. The loss in heat transfer will give a corresponding increase in the electrical operating costs.

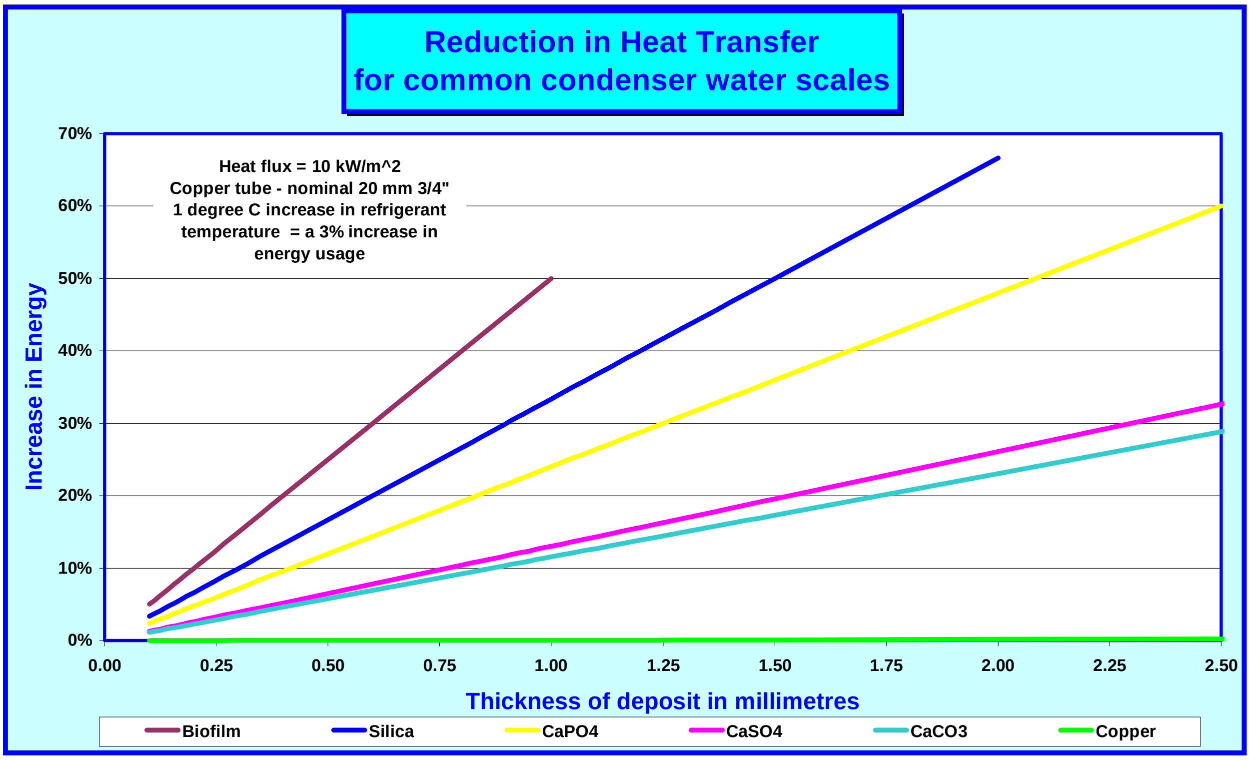
From the graph below we can estimate the cost of allowing a 1.0 mm thickness of Calcium Carbonate scale to form over a 12 month period as an additional electricity expense calculated as follows:

Annual electricity cost x % loss in heat transfer x 0.5 (average deposit thickness over the 12 months) =

(a) The hospital example
1,285,939 x 12% x 0.5 =
<u>$77,156.00 for 1 year of operation</u>

(b) The Shopping Centre
239200 x 12% x 0.5 =
<u>$14352.00 for 1 year of operation</u>

From the graph it can be seen that 0.2 mm. thickness of biofilm will reduce the heat transfer rate by a similar amount to 1.0 mm of Calcium Carbonate scale. Condenser tubes with 0.2 mm thickness of biofilm will look like clean copper tubes to the eye on inspection, and with only a slight greasy feel to the finger as an indicator of the biofilm, or it may show up as an outage on "high head pressure" on very hot days.



Cost of Reduced Condenser water Flow rates

A further loss of energy is caused by the reduced condenser flow rate in fouled tubes, as most condenser pumps operate at constant head pressure. The table below shows the loss in a nominal 20 mm.(3/4 in) copper tube circular area for varying thickness of deposits.

Thickness mm	Circular area mm^2	Loss in area
0.0	251.0	0.0%
0.2	239.9	4.4%
0.4	229.0	8.7%
0.6	218.4	13.0%
0.8	208.1	17.1%
1.0	198.0	21.1%
1.5	173.8	30.7%
2.0	151.2	39.7%
2.5	130.2	48.1%

Reduced flow rate will result in further increased refrigerant temperatures and proportionally significant increases in electrical running costs.

Cooling systems which are not using oxidising biocides as continuous treatment and controlled by ORP to dose the oxidising biocide on demand are very likely to have a biofilm of the thickness mentioned.

Biofilms are the "home" and breeding ground for Legionella bacteria and elimination of Legionella cannot seriously begin until all biofilms have been removed and prevented from reestablishing.

The cost to supply and install a complete automatic dosing and control system incorporating ORP control on oxidising biocide is approximately AUD $3500.00 for our shopping centre example - **a return on investment in about 2 months.!!**

The cost of "slight" deposition in condenser tubes is not readily apparent unless the owner is fortunate to have a complex on-line computer monitoring programme which can work out the actual electrical cost for each kWR produced. Comfort cooling loads are notoriously variable, varying with the ambient temperatures, and it is difficult for most operators to notice any increase in electrical running costs. ***Nevertheless the energy savings are there for those who want to pursue maximum efficiency from their equipment.***

Cost of Water, Sewerage and Chemicals

The cost of make up water and sewerage charges vary from country to country and city to city, and are significant costs in the overall cost of comfort cooling as the table below indicates typical costs per kilolitre.

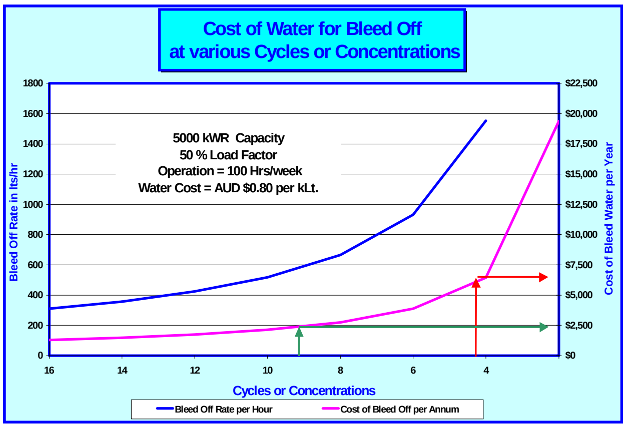
Location	Make Up	Sewerage	$ AUD
Singapore Industrial	SG $0.45	?	$0.48
Singapore Potable	SG $1.40	?	$1.45
Kuala Lumpur	RM $1.80	?	$0.90
Shanghai	RMB $0.90	$0.34	$0.22
Hong Kong	HK $4.58	$1.20	$1.15
Australia	AUD $0.80	$0.50	$0.80
Auckland	NZ $0.??	$0.??	$0.??

To minimise water and sewerage charges it is necessary to minimise the bleed rate and run at maximum possible concentrations for the particular water supply. With "Best Practice" water treatment programmes - calcium hardness can be allowed to concentrate up to 350 - 400 ppm and/or silica up to about 150 ppm with an operating pH of up to 9.0 in the cooling water.

A system operating on a manual bleed is very likely to be running very excessive bleed rates - probably only 30% - 40% of the maximum allowable concentrations. Installation of an automatic bleed off controller based on conductivity measurement and with a "Best Practice" water treatment programme, would allow the concentrations to be increased significantly, from about 4 up to 9, and show savings in water charges. For our shopping centre example the savings are approximately $4500.00 per annum - much more than the cost of the automatic dosage and control equipment.

As the bleed rate has been reduced from about 550 lts/hr. to 200 lts. per hour, the applicable costs for sewerage have been halved as well as a similar saving in chemical costs.

The graph below shows the bleed rate on the shopping centre at various concentrations **and the cost of water for bleed off ONLY per annum**.



The actual savings on a particular plant can be calculated by inputting data into a spreadsheet programme such as **CWT_Costs.xls** and highlighting all of the possible savings for that particular installation, using the local currency and water charges for both make up and sewerage as well as chemical costs.

In summary automatic bleed off with an effective water treatment programme will allow for increased concentrations, reduce the amount of make up water wasted as bleed off, reduce the sewerage charges and reduce the chemical costs for both inhibitors and biocides.

Cost and effectiveness of Biocides

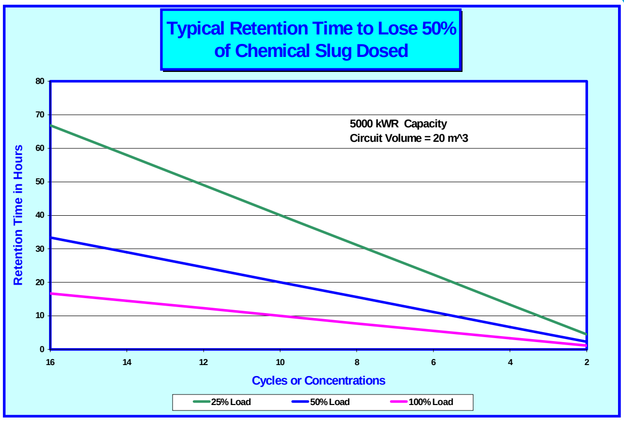
The effectiveness of any biocide is directly related to the "CT" factor which is "concentration" multiplied by the "time" the biocide is maintained within the system. With Non-Oxidising biocides the concentration is usually 100 ppm maintained for 6 - 8 hours to kill planktonic bacteria or 100 ppm maintained for 20 - 30 hours to kill bacteria in biofilms, (which incidently is where Legionella bacteria breed and proliferate.!!)

How quickly chemicals are lost from a cooling system depends on (1) System volume, (2) the load factor, (3) the concentrations maintained or the bleed rate (including pump gland leaks, splash outs and overflows). From the graph opposite we can see the retention time to reduce the concentration to 50% as a function of the cycles or concentrations maintained in the cooling system and the kWR load factor on the unit.

At low cycles or concentrations - biocides are rapidly lost from the system and the initial slug dose of biocide will need to be increased from 100 ppm to 200 ppm to 400 ppm or even 800 ppm to maintain the desired CT factor necessary for an effective bacterial kill.

By utilising automatic bleed off techniques and reducing the bleed rate - greatly improved kill rates can be obtained from lower doses of biocide due to the biocide being retained within the cooling system for a longer time.

To further increase biocide retention times and increase the T factor for biocide "Kill" both "Prebleed" and "Bleed Lockout" facilities are built into the Aquarius Technologies P/L range of controllers to allow for the bleed off to be locked out (i.e. nil bleed off) for a number of hours after the biocide is dosed and in this way maximum "kill" is achieved for the minimum possible dose of biocide, again offering savings in chemicals but more importantly an improved bacterial 'kill", lower Heterotrophic Plate Counts and less chance of Legionella Bacteria being detected in the cooling system.



In summary - Use of best practice water treatment chemical programmes when coupled with appropriate automatic dosage and bleed off equipment can show very significant energy and water savings in cooling systems.

Use of oxidising biocides, dosed on demand from the system, via ORP control will virtually eliminate biofilm deposits and offer greatly increased insurance against Legionella.

Usage of the appropriate automatic dosage equipment ensures that the desired level of chemicals are maintained in the system even with varying load factors and thus maximum benefit in corrosion protection, clean condenser tubes, minimum water loss to bleed off, and minimum consumption of chemicals is obtained as well as the energy savings outlined.

The author is Bert Topping - Managing Director of Aquarius Technologies Pty Ltd. - a Quality Assured manufacturer of automatic dosage and control equipment for the Water Treatment Industry.

An example sheet from CWT_Cost.xls