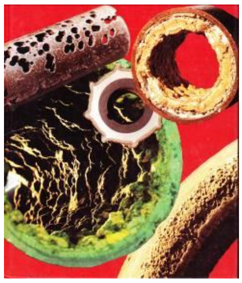
Independent Monitoring Consultants
Working with you for innovative solutions



STEPPING UP TO

THE PRO-ACTIVE SCIENCE OF

COOLING WATER SYSTEMS CORROSION MONITORING

Maintaining a constant satisfactory balance between microbiological control (especially *Legionella*) and metal wastage by corrosion in cooling water systems is *not* an art – it is cold-blooded science, with possible dire consequences if control of the balance is lost even for relatively short periods. The two processes are interactive – for example, some biocides are aggressive to metals commonly found in cooling systems - and corrosion product is a *Legionella* food source. On the other hand, and apart from Legionella control, Microbiologically Induced Corrosion (MIC) is to be avoided.

Measuring the absolute values and assessing the trends of corrosion is not just a valuable tool in assessing the overall performance of a chemical supplier – nor is it just another Key Performance Indicator (KPI); it is a *Critical Management Strategy (CMI)* for assessing the average life expectancy of cooling water systems whilst being pro-active with equipment performance and, at the same time, providing a biologically safe working environment and surrounds.

Practical corrosion monitoring techniques are classified as either real-time measurement or retrospective over time, and each category offers pros and cons of cost verses expense, ease or otherwise of installation and maintenance of monitoring equipment – and relevance of data. Either way, the objective is to avoid un-necessary cooling system plant internal inspections. Rather, practical monitoring “flags” a developing problem long before pipe wall rupture, allowing corrective action to be taken. Corrective action involves identifying the type and location of unacceptable metal loss and assessing the influence of all contributing variables – system metallurgy, plant history, biological loading, corrosivity of make-up and system water, seasonal variations in make-up water analyses and system water soluble and total corrosion products content to name but a few.

Real Time Corrosion Measurement

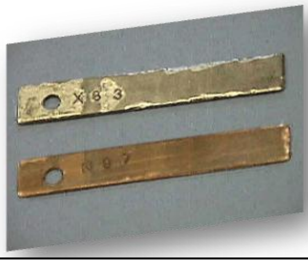
The linear polarization-resistance (LPR) technique utilizes electrode behaviour to rapidly indicate corrosion upsets. The most usual type has two electrodes – one being mild steel (anode), the other a copper based alloy (the cathode) between which is passed a very small voltage of 20mV. The resulting current generated from this applied potential difference gives a measure of the general corrosion rate in the vicinity of the electrode.

Tubercles are mounds of corrosion product and deposit that cap localized regions of metal loss. This picture shows perforation at a dush-shaped depression – a large tubercle capped the depression but was dislodged during tube sectioning. ***(Courtesy of National Association of Corrosion Engineers)***

Retrospective Corrosion Measurement

Coupon corrosion studies are inexpensive and simple to perform. This is the most direct method, aside from inspection of the actual plant equipment, to determine the efficacy of the water treatment chemical program. Coupon evaluation allows simple comparison between different alloys which provide visual examination for localized attack, such as pitting, crevice attack, dealloying, or any other form of non-uniform attack, such as MIC.

Pre-weighed and surface prepared coupons are highly susceptible to corrosion. A corrosion coupon is *not* a heat transfer surface; cleaning the coupon to make it more susceptible to corrosion helps compensate for the fact that it is not a heat transfer surface operating at elevated skin temperatures. Exposing the corrosion coupon to a cooling water stream for a known length of time for usually 90 days, and by then calculating the difference between the initial and final weight it is possible to express average corrosion rate per year for that system. The time of exposure for corrosion coupons in cooling water must be considered in the evaluation of any results. In summary, the shorter the period of exposure, the higher the corrosion rate will be.



Mild Steel (top) and Copper (bottom) coupons ready to be cleaned and evaluated.

The rate of corrosion represents an average metal penetration based on total weight loss and assumes 100% general attack. In many cases the type of attack or appearance of the coupon can provide more useful information than the actual corrosion rate obtained by weight loss. Even if the calculated average corrosion rate is low and all the attack is localised at one point on the coupon, the rate of penetration at that point could be 4 to 5 times the average rate of corrosion.

Heavy deposits and tuberculation are sure signs of unstable corrosive water, regardless of the corrosion rates. Furthermore, coupons covered with heavy deposits cannot reflect system corrosion rates, due to the deposit covering the coupon. Some types of deposits will cause an increase in corrosion while other types will form a protective coating.

For a corrosion coupon to provide useful data, it must be placed in a representative location in the system. Generally the best place is on the effluent stream of a critical heat exchanger (critical with respect to corrosion). Corrosion coupons installed on a common return line seldom are representative of critical system heat. It is important that the corrosion coupon rig flow rates correspond to the heat exchanger flow rates. Coupon rig exit flows that are high will usually result in cleaner coupons than the system metals. Excessive corrosion and fouling may result from low flow rates.

Typical Corrosion coupon rig

A flow rate which is representative of system conditions is the only flow rate which will provide meaningful information.

Corrosion coupons are a useful and meaningful evaluation tools which, when used on an ongoing basis and in combination with plant and equipment inspections will provide invaluable information on the chemical treatment programme and the level of protection that it offers. Coupons that indicate acceptable corrosion rates in a system which is experiencing severe corrosion are not properly installed or subjected to severe enough conditions. Coupons which reflect high corrosion rates in a corrosion free system are being subjected to too severe a condition assuming that the coupon environment is representative of the heat exchanger design parameters of flow and temperature.

Acceptable corrosion levels for **mild steel** should be less than 3mil and **copper** less than 0.5mil per year. Typical limits are **mild steel** 0.15mm, stainless steel 0.005mm (no pitting) and **copper** 0.005mm per year. (Imperial unit "mil", one thousandth of an inch (1mil = 0.0254mm)

Times are changing. Modern successful water management programmes no longer rely on old fashioned hand dosing or use of blind treatment controllers and service technicians performing weekly, fortnightly or even monthly service calls where their field reports are used along with quarterly weighted coupon testing to check that the best possible results are maintained. We know now that these periodic visits guarantee very little.

The ability to successfully control water quality in cooling towers depends on the monitoring and analysis of the system on a continuous basis.

Modern technology allows us the opportunity to see the inadequacies in past control methods and understand and realise what is really important in maintaining a successful water treatment programme. What we now consider as the most important tools are reliable control, data recording of information and alarms to ensure benchmarks are maintained and confirmation that systems are treated proactively through a uniformed analysis of past performances.

The selection and implementation of the correct control equipment with effective and professional management is pivotal to success.

The Aquarius Technologies KPI 3 monitor and controller provide's controls and measures that include:

a. Linear Polarization corrosion of two metal monitoring, logs and alarms
b. Automated velocity control to set point
c. Conductivity measure and automated bleed control
d. ORP measure using APL control, with time control if required
e. pH measure using APL control
f. Secondary biocide with pre-bleed and bleed lockout function
g. Inhibitor dosage control via water meter or other mode selections
h. Dispersant dosage control via water meter or other mode selections
i. Water Usage including Makeup, bleed and Backwash
j. 4-20mA input for external instrument with programmable ranging and alarms
k. Data logging of all measures and outputs
l. Remote control via GSM modem and Aquarius software
m. 4-20mA output card for building computer connection of 8 measures and relay status
n. Measure alarms, safety alarms with ORP and pH lockout alarm

Information plays a huge part in the total care used to provide both a safe, effective and efficient cooling system.

This allied with technologies that allow for a complete picture on a 24/7 basis using effective control methods and the monitoring of their affect on plant while introducing direct action capabilities through alarms and remote control coupled with professional management allow for a much improved and responsible management of treatment, water and energy.

Several things can occur in a cooling systems treatment which can jeopardise control without notice and include:

a. Contamination via exterior source
b. Equipment failure
c. Water loss
d. Empty chemical treatment tanks

e. Changes in make-up water quality

Once any of the above has occurred all balances can be thrown out and this is when the KPI 3 controller with corrosion monitoring, remote control and alarming directly to your mobile phone really demonstrates its full power and effectiveness. Alarms are generated according to user defined fields, and as deviations occur corrective actions can be implemented immediately from remote locations.

The Aquarius KPI 3 controller can assist in minimizing water and chemical consumption by providing reflective results while preventing wastage through its range of alarms in a way that traditional blind methods could never provide.

Oxidizing biocide (ORP) also provide a more environmentally sustainable sanitiser than traditional non-oxidizing biocides with online measurable levels. The provision of dispersant dosing controls can assist in maximising the cleaning powers of Oxidizing treatment.

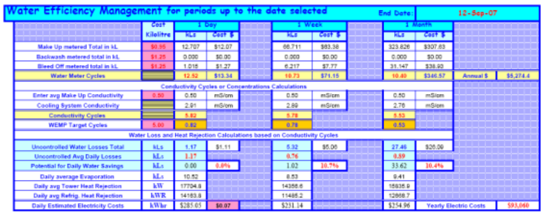
Tracking and control of all outputs to ensure programs are indeed being implemented and carried through including chemical tank alarms are used to ensure the site never runs out of chemicals.

The KPI 3 controller has no significant ongoing cost associated to its successful use unlike other high maintenance control equipment.

Test equipment used by treatment supplier representatives using reagent type diagnosis can become very unreliable if not maintained to the highest degree and although all companies seek to employ responsible technicians it has become apparent that the bells and whistles are only as good as the people that use them.

Modern day property owners and managers are now recognising the need to better manage all parts of their business and are employing modern day technology to maximise performance and minimise costs. The Aquarius KPI -3 is today's answer to best management practices for water management and control of cooling water systems.

The accompanying reports are extracted from an existing KPI - 3 controller. Despite all the efforts of a good water treatment provider and or service technician, problems still occur. The difference being that reaction times can be reduced dramatically and problems rectified and work justified on a continuing basis as and when required.



Water Efficiency Management for periods up to the date selected — End Date: 12-Sep-07

	Cost Kilolitre	1 Day kLs	1 Day Cost $	1 Week kLs	1 Week Cost $	1 Month kLs	1 Month Cost $		
Make Up metered Total in kL	$0.95	12.707	$12.07	66.711	$63.38	323.826	$307.63		
Backwash metered total in kL	$1.25	0.000	$0.00	0.000	$0.00	0.000	$0.00		
Bleed Off metered total in kL	$1.25	1.015	$1.27	6.217	$7.77	31.147	$38.93		
Water Meter Cycles		12.52	$13.34	10.73	$71.15	10.40	$346.57	Annual $	$5,274.4
Conductivity Cycles or Concentrations Calculations									
Enter avg Make Up Conductivity	0.50	0.50	mS/cm	0.50	mS/cm	0.50	mS/cm		
Cooling System Conductivity		2.91	mS/cm	2.89	mS/cm	2.76	mS/cm		
Conductivity Cycles		5.82		5.78		5.53			
WEMP Target Cycles	5.00	0.82		0.78		0.53			
Water Loss and Heat Rejection Calculations based on Conductivity Cycles									
Uncontrolled Water Losses Total	kLs	1.17	$1.11	5.32	$5.06	27.46	$26.09		
Uncontrolled Avg Daily Losses	kLs	1.17		0.76		0.89			
Potential for Daily Water Savings	kLs	0.00	0.0%	1.02	10.7%	33.62	10.4%		
Daily average Evaporation	kLs	10.52		8.53		9.41			
Daily avg Tower Heat Rejection	kW	17704.8		14356.6		15835.9			
Daily avg Refrig. Heat Rejection	kWR	14163.8		11485.2		12668.7			
Daily Estimated Electricity Costs	kWhr	$285.05	$0.07	$231.14		$254.96	Yearly Electric Costs	$93,060