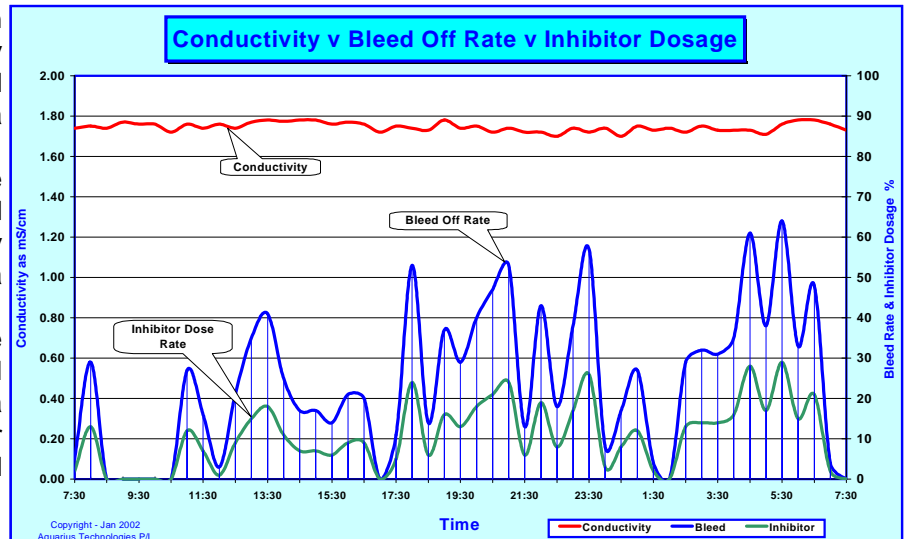


Aquarius Technical Bulletin - No. 36

Data Logging of Water Treatment Chemistry on Cooling Water Systems

For many years Aquarius has been data logging water treatment chemistry parameters on cooling systems and pools. Initially we used a laptop with data acquisition card to interface to 4 -20 mA. signals from our controllers, then with the development of the **KPI controller and data logger** where the data is digitally stored and periodically down loaded via RS232 to an Excel Sheet for trend graphs.

Our recent developments have added a portable data logger - the **KPI monitor** unit as a simple means of data logging chemistry and corrosion data over a few weeks on both cooling systems and swimming pools.

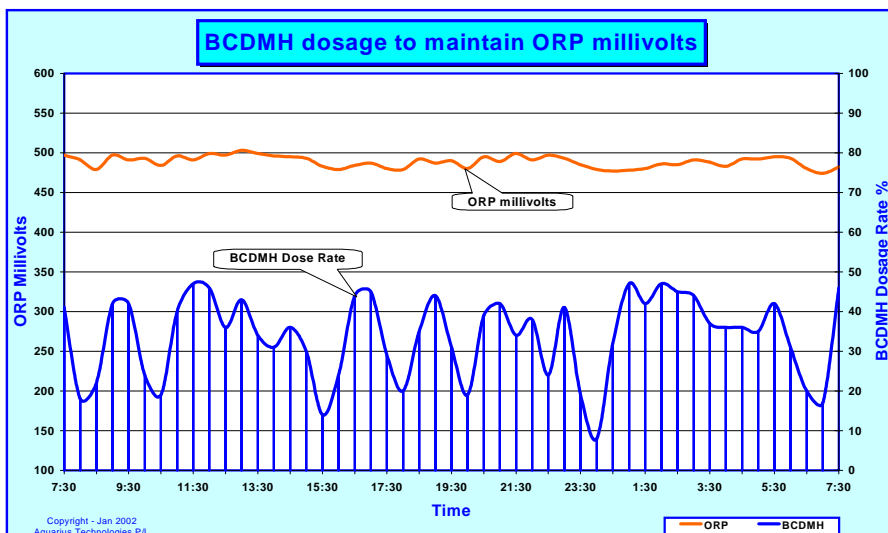


The graph on the right above was data logged on a Cooling System at a Gas Plant in Brisbane, QLD. where the evaporation load was believed to be essentially constant. The data log showed excellent control was being maintained on pH, and ORP via P.I.D. dosage outputs. Very good control was maintained on Bleed Off via automatic conductivity control. The corrosion rates and bacteria analysis was also excellent.

Note the actual bleed off rate logged shows wide fluctuations whilst maintaining essentially a constant conductivity, in this case the system was free of leakage and inhibitor dosage in proportion to bleed rate maintained a

constant level of inhibitor even under the fluctuating bleed off rates. The graph above shows that the bleed losses from the cooling system fluctuate widely, and thus scale and corrosion inhibitor must be dosed in proportion to the bleed off rate if we are to maintain a constant inhibitor level in the cooling system. Continuous inhibitor dosage or dosage proportional to flow rate will result in inhibitor levels having fluctuations similar to the bleed line shown above.

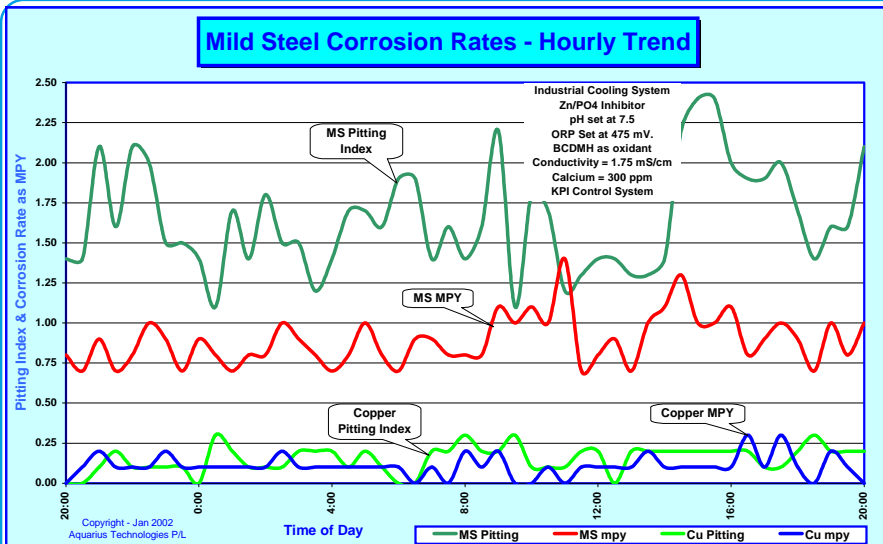
The fluctuating bleed rates, which necessitate dosage in proportion to bleed rate also means we must have a leak free system. Overflows on shutdown, or pump gland leakages cannot be tolerated in a well controlled system.



The graph to the left shows actual BCDMH dosage rates to maintain a constant ORP level of about 475 mV. (to ensure biofilm is largely prevented, and with HPC at 10^{-3} or less, and with LDB as "Not Detected")

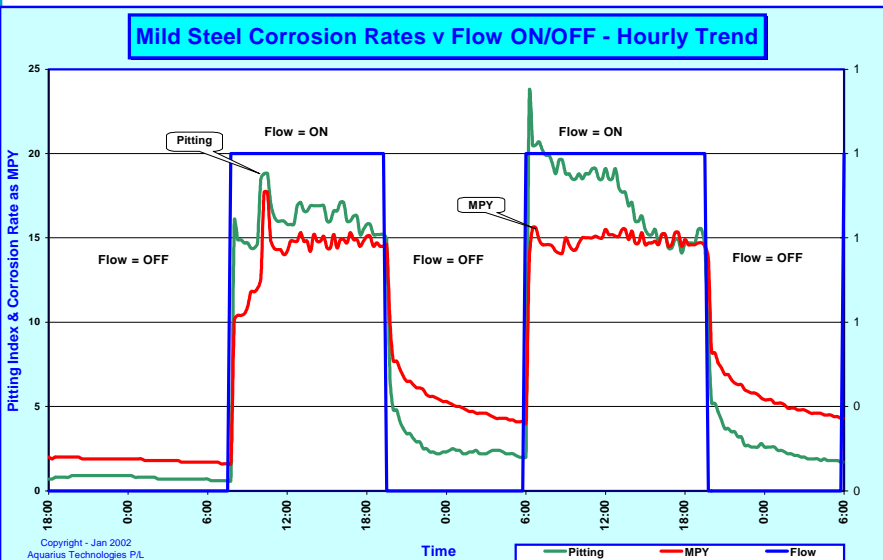
Whilst very good control of ORP is maintained with P.I.D. dosage control, the consumption of BCDMH is based on the oxidant demand from the system and the graph shows wide fluctuations in demand for BCDMH over the day.

Constant dosage of oxidant under these conditions would result in both under dosage and over dosage at points during the 24 hour period. It is very difficult for service personnel to set a constant rate based on tests.



The graph on the left is part of the overall data log from the Gas plant cooling system and demonstrates that excellent corrosion rates can be maintained even with the use of oxidants as biocides.

Corrosion rates on Copper at less than 0.25 mpy, and on Mild Steel at about 1.0 mpy for general corrosion and about 2.0 for pitting index is very acceptable on an industrial cooling system.

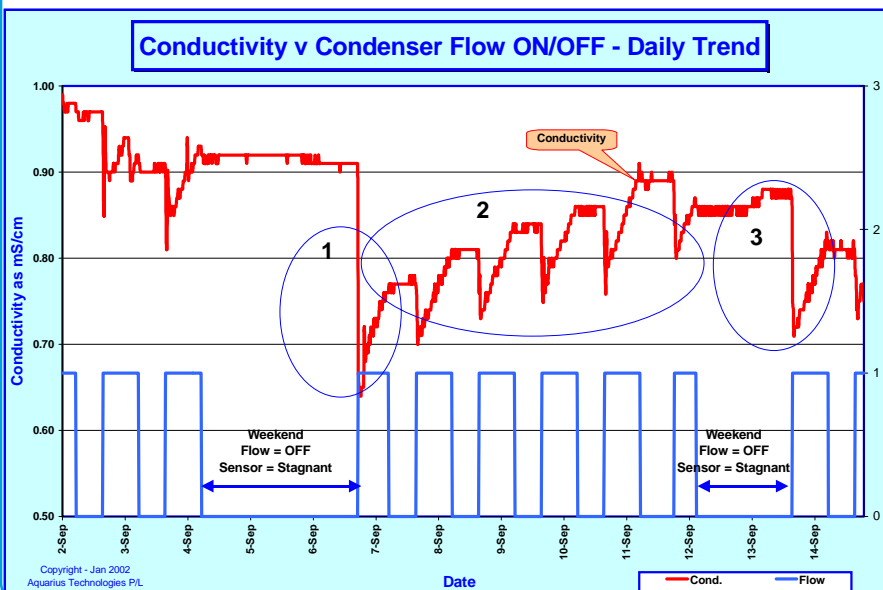


This graph was logged on a major CBD building in Sydney NSW and shows high corrosion rates when condenser flow is on, and dramatically reduced rates when flow is off and the probe tips are stagnant.

This graph highlights the need to set accurate flow rates and velocity across the probes similar to the flow rates in the heat exchangers.

The graph also highlights that dramatic improvements in corrosion rates are required.

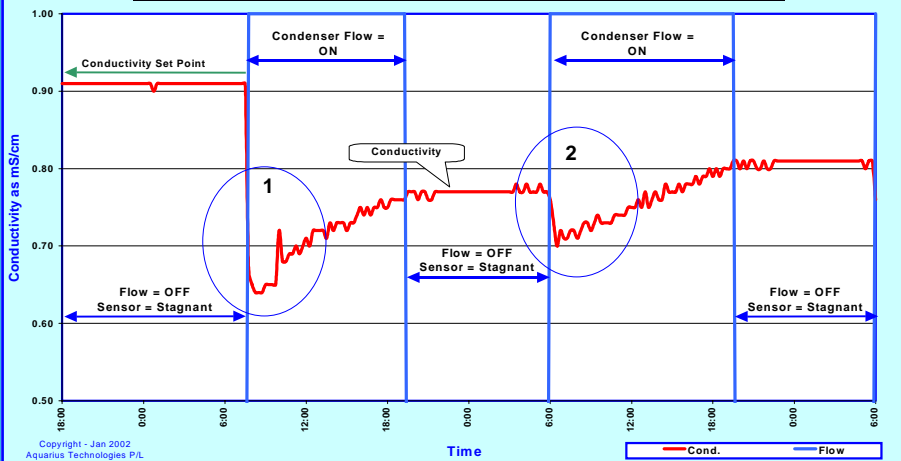
Corrosion coupons if installed in an area of low flow can show acceptable rates even with exchanger corrosion as above.



This graph to the left is part of the above data from the CBD building, and perhaps some of the reasons for the high corrosion rates above can be seen in this graph.

1. This circle shows the conductivity rapidly reduced from 0.92 mS/cm to 0.65 mS/cm on start up of circulation. This is indicative of either a leaking make up valve or overflow at shutdown
2. This circle shows water losses on start up each morning
3. Shows large water losses when system is off for weekend. Loss of system water equals loss of corrosion inhibitor

Conductivity and Condenser Flow ON/OFF - Hourly Trend



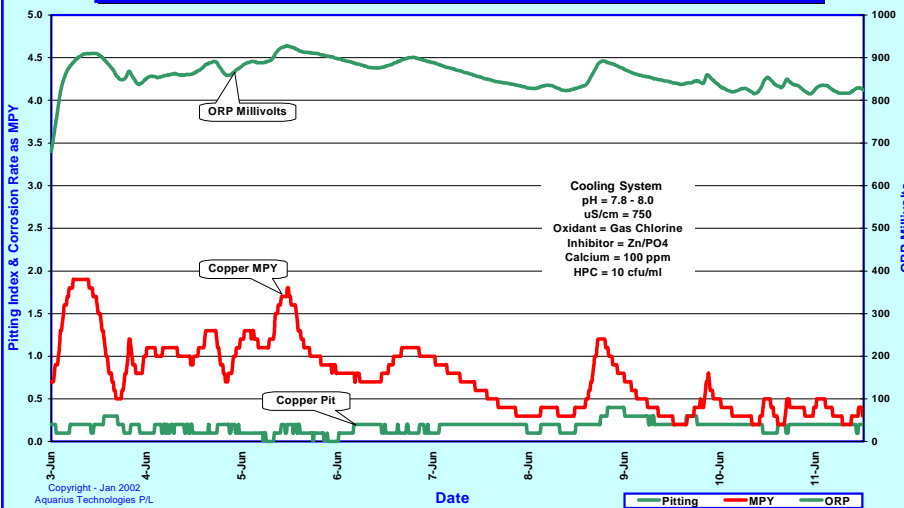
This graph is an enlarged portion of last graph such as may be used in a report to highlight the problems of water losses from the system.

1. Clearly shows conductivity falls by about 33% on start up after a weekend shutdown, and also 33% of Inhibitor would also be lost.

2. Shows that about 7% of the system volume has been lost on morning start up.

Good water treatment control dictates that uncontrolled water losses must be remedied urgently otherwise water treatment is largely wasted.

Copper Corrosion Rates v High ORP millivolts - Daily Trend

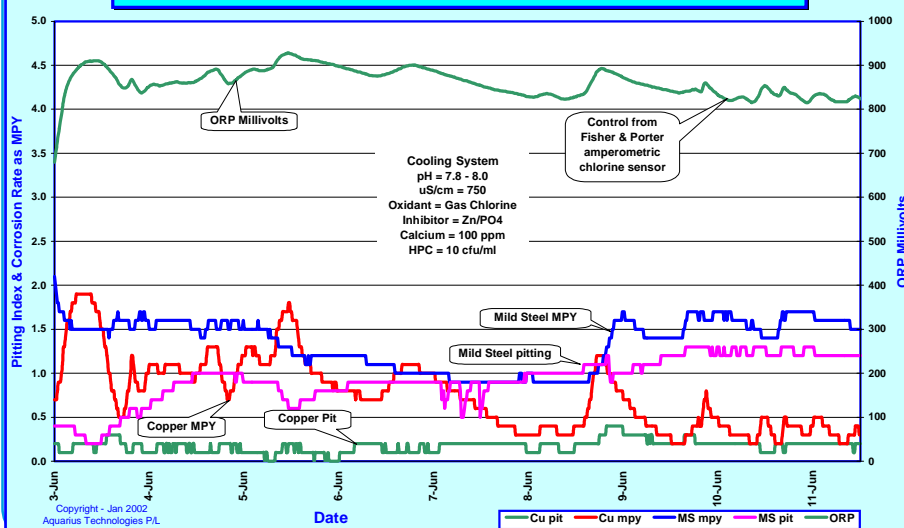


Many times we are told that oxidants are a major cause of corrosion, and this may be true in e.g. hot water systems where good corrosion inhibitors cannot be employed.

This graph shows that where corrosion inhibitor levels are consistently maintained, very acceptable corrosion rates can be maintained on copper.

The benefits of instantaneous electrochemical corrosion monitoring is that should corrosion rates increase for any reason, the fact is instantly known and rapid remedial action can be taken.

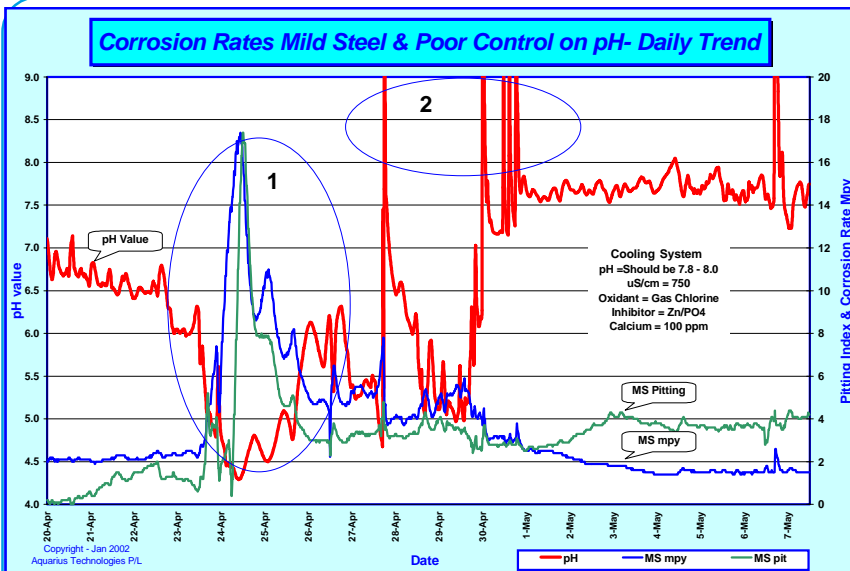
Corrosion Rates versus High ORP millivolts - Daily Trend



This graph is from the same data as that above and shows very acceptable corrosion rates on mild steel as well as copper even though the ORP millivolt readings are in excess of 800 mV. or about 5.0 ppm as free chlorine.

The control from the Fisher & Porter amperometric chlorine sensor is not as good as that achieved with the much cheaper ORP potentiometric sensor when coupled with P.I.D. dosage outputs.

HPC plate counts on this system average about 10 cfu/ml

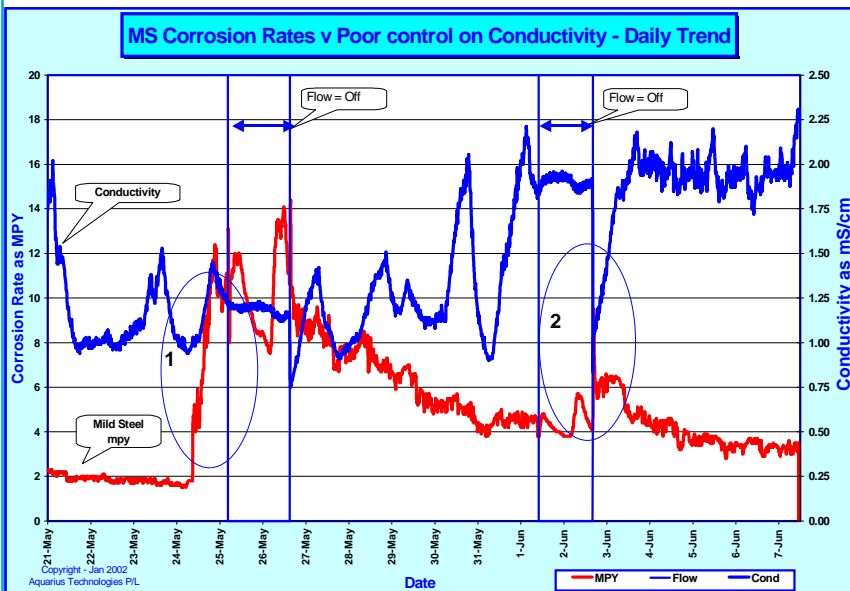


The chart on the right demonstrates the effect of poor pH control and the dramatic effect this has on corrosion rates.

Due to the large dosage of gas chlorine, which forms one molecule of hydrochloric acid as well as one molecule of hypochlorous acid for disinfectant when introduced to the cooling water. This necessitates alkali addition for pH correction.

Note that the Zn/PO₄ inhibitor gives good corrosion protection down to a pH of about 6.5, but below this corrosion rates increase rapidly as indicated in 1 on graph.

Slug doses of alkali to the system do not effectively control the pH as indicated in 2 on the graph.

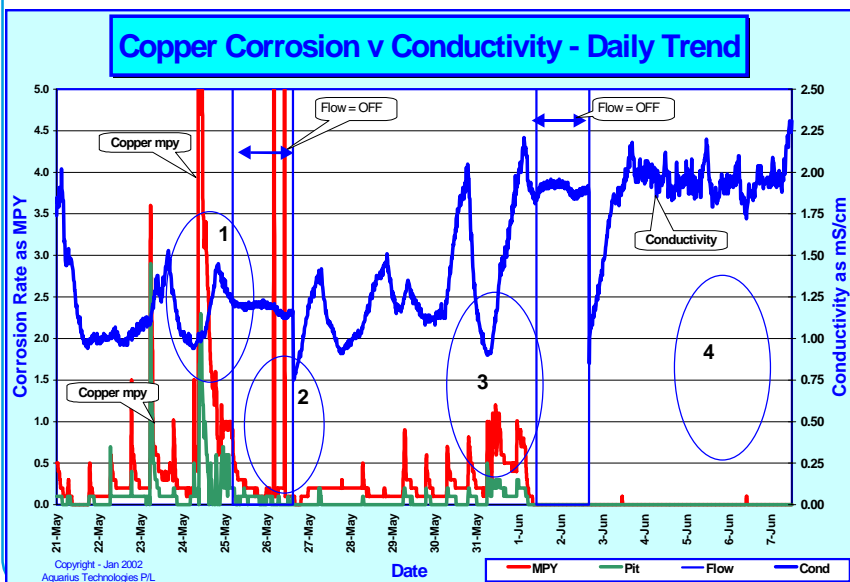


This graph was from data logged at a milk processing plant where the cooling system duty was blow molding of milk bottles. A history of poor bacterial control and a few minor LDB positive results lead to a legionella risk assessment on the entire plant.

The chart readily identifies a unreliable bleed off solenoid is the major cause of the poor control on conductivity.

1. - shows that as an excess water is bleed off, causing inhibitor losses which is then seen as an increase in corrosion rates.

2. - shows that water is lost prior to start up and again corrosion rates rapidly increase.



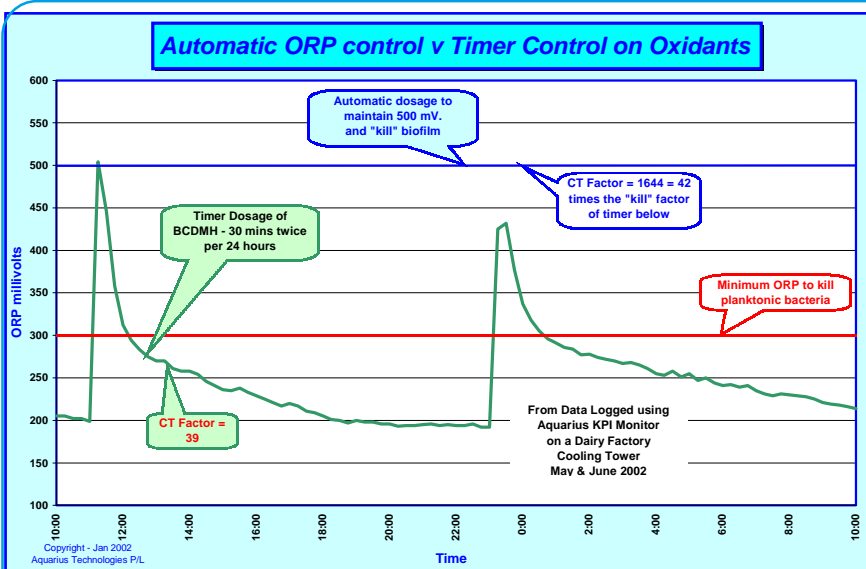
This chart is also from data logged above and shows the effect on copper corrosion - due to poor control on concentrations from uncontrolled water losses.

1. Shows increased copper corrosion rates due to an uncontrolled loss of water and thus also corrosion inhibitor.

2. as 1. above

3. as 1. above.

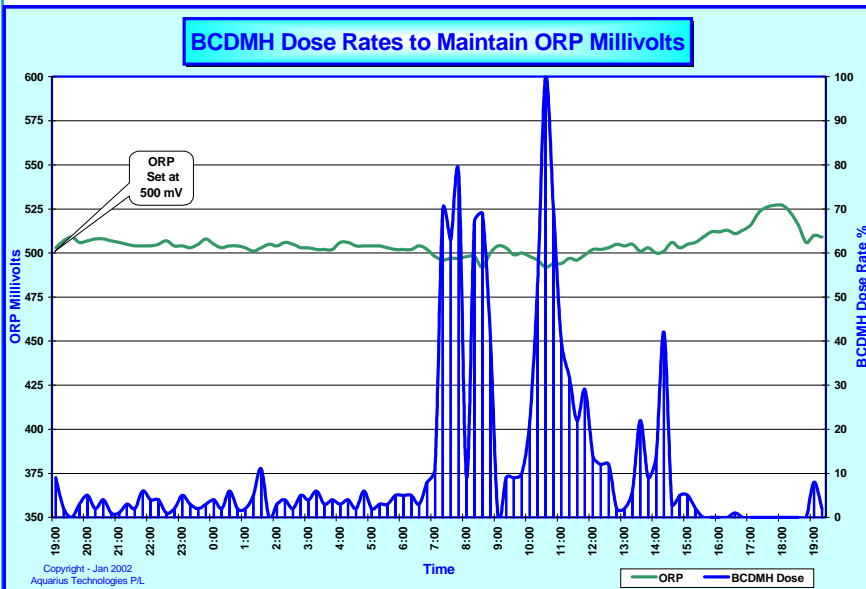
4. Shows the effect of increased conductivity levels, plus no uncontrolled water losses, and thus also an increased calcium level has all resulted in very acceptable copper corrosion rates.



This chart is also part of data logged at the milk plant. BCDMH, as oxidant biocide, was dosed via a timer for 2 x 30 minutes doses per day. Note that the ORP millivolt value is only in excess of 300 mV. for 2 hrs. out of 12 hrs. with bacteria thriving for the remaining 10 hours. Not surprisingly this tower had a history of poor bacterial control and minor LDB detections.

Use of ORP control to automatically maintain a 500 mV. a level where both planktonic and biofilm bacteria are removed was recommended.

Note the difference in CT factor - **ORP at 500 mV. has 42 times the "kill" factor of timer method.**

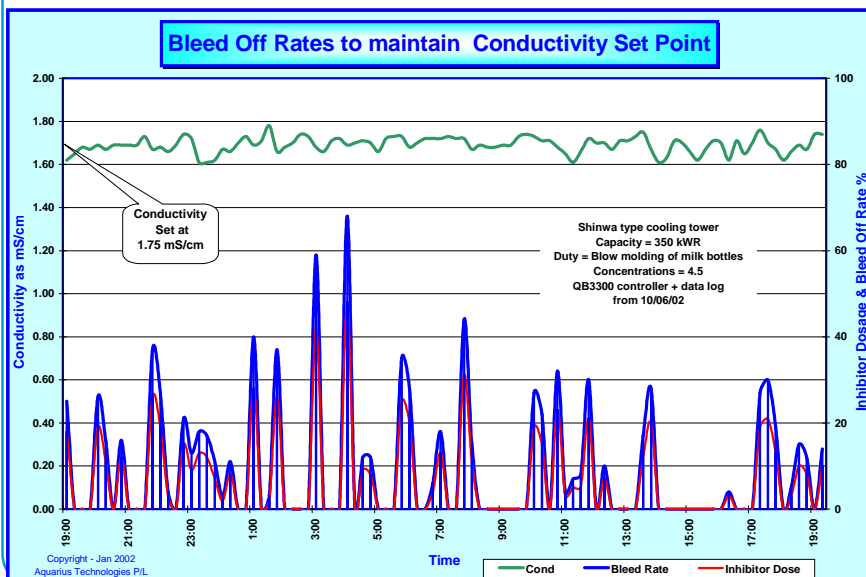


To demonstrate the capabilities of improved dosage gear with internal data logging facilities, a QB3300 unit was installed for 4 weeks demonstration.

This chart from plant above shows the varying amount of BCDMH dosage needed to meet the demand and maintain a constant 500 mV. ORP.

This chart demonstrates the need for oxidant dosage based on variable demand from the system.

The system oxidant demand will vary with load, wind direction, make up water, air pollution level, etc, etc. but to prevent LDB we must maintain a constant level of disinfection, to which ORP control is very suitable.

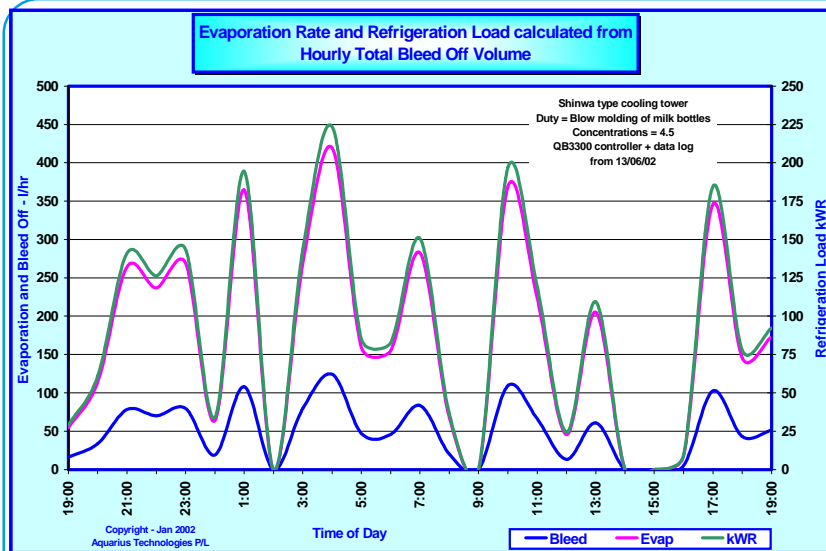


This chart is also from the QB3300 controller and data logger.

It shows that (a) having a reliable bleed solenoid has improved conductivity and (b) usage of modern electronic circuitry allows for tighter control.

The blue trace shows the actual bleed off volume during each 15 minute data log intervals, required to maintain the desired conductivity set point value.

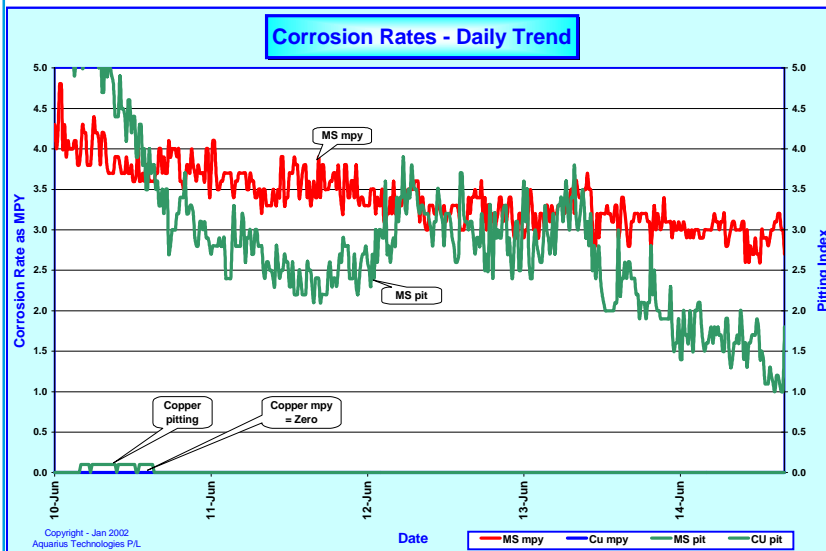
Bleed rate is a proportion of evaporation rate, in this case approx. 20% to bleed and 80% to evaporation. Evaporation is directly related to plant load in KWR - note the variation in bleed rates!!!!



From the data logged for the previous 2 graphs it was decided to total the bleed off rate into 1 hour periods to avoid any anomalies with hysteresis in the controller.

From the 1 hour bleed off totals the evaporation rates and refrigeration load in kWR were calculated and graphed on the left.

Note the variation in plant load and resulting variation in bleed rates which necessitate that inhibitor chemicals are either dosed based on demand from corrosion control, or in proportion to bleed rate. Again uncontrolled water losses cannot be tolerated, if we are to maintain good water treatment control.



This graph is a continuation of data log showing corrosion rates during the first week of the QB demonstration.

Corrosion rates on copper which were very variable under poor conductivity control are now reduced to zero with good control on conductivity and thus good control on inhibitor levels, as inhibitor dosage is now proportional to bleed rates.

Corrosion on Mild Steel is seen to be declining on both mpy and pitting over the week of logging. It is expected that these rates will continue to fall with continued good control.

Summary

The graphs shown here are a selection from data logged by us, over the past few years, and are an attempt to demonstrate the capabilities of data logging of the water treatment chemistry parameters on cooling systems.

Data logging is a very invaluable tool in identifying and rectifying problem areas, and dramatically improving the overall water treatment program performance.

In a huge number of cases of "water treatment supposed failure" to perform, it was probably not the cause of the particular chemical formulations, or the conscientiousness of the water treatment service specialist, it was more likely a case that minor engineering deficiencies were not identified and quickly rectified, such as overflows at shutdown (usually at night) faulty or unreliable dosage and control equipment, etc.

In defence of the majority of water treatment service personnel, costs dictate that the majority of medium industrial and comfort cooling systems are only visited on a monthly basis, and then only 30 - 45 minutes is spent in the vicinity of the cooling system.

It is difficult to identify problems which may occur

early in the morning or late at night, such as overflowing towers, or internal corrosion in an end box. His grab sample taken for water analysis (on a system which may very well be variable during the course of a day) is probably only valid for conditions existing + or - 30 minutes of the time of the test, but this is usually the only data on which he must make decisions on any chemical adjustments for the next month of treatment.

Corrosion problems if left unidentified until a leak shows up, and thus identifies the problem, can be very expensive to repair at this late stage of proceedings, yet instantaneous corrosion monitoring is not expensive to perform.

The KPI monitor is a portable data logger and is "the test kit of the 2000 era", the unit is portable, easily and quickly installed on any cooling system, and will data log around the clock unattended.

Most cooling systems would greatly benefit from 2-4 weeks of "round the clock" data logging as an audit of the present performance of the water treatment program and as a means to dramatically improve the overall water treatment performance.