

Aquarius Technical Bulletin - No. 03

Automatic Control of Water Treatment on Comfort Cooling Water Systems

Introduction

There are many variables operating in providing comfort cooling to buildings, such as outside temperature, relative humidity, building load, time of day and sunlight angle on building, as well as the many variables in the optimum water treatment required to be maintained on the particular plant, raw water characteristics, evaporation rate, bleed rates etc. etc.

Over the years the Water Treatment Industry has tended to work on the average kWR load, hours of operation and the water treatment calculated bleed rates to estimate the amount of chemicals required per year, and by and large these averages work well for estimating the annual chemical costs.

This article will help to demonstrate how the variables on air conditioning effect water treatment and the need for completely automatic bleed and dosing of inhibitor and biocides, if we are to maintain the desired chemical levels and provide optimum water treatment to the system, and which is capable of maintaining the desired levels independent of the many variables present.

Refrigeration Load Profile

The graph opposite (Fig. 1) was originally the plot of actual kW Hours electricity consumed, only by the chillers, in a 15 storey building in the Brisbane CBD. From the electrical data the kW refrigeration load was calculated using the formula:-

$$\text{kW Hours Electricity} \times 4.54 = \text{kW Refrig. Load}$$

It is noted that chiller was started at 0630 hrs. and rapidly rose to maximum load whilst the building internally was brought down to the required temperature, and with a slowly reduced load during the day apart from a slight increase at lunch time.

To begin to understand the variables from a water treatment view, a computer spreadsheet was set up and the various water treatment parameters calculated for each point of the varying refrigeration load.

Figure 2 opposite is the calculated cooling tower evaporation rates in litres/sec, and the bleed off rates required at each point to maintain 5 concentrations of the make up supply. - It is certainly not constant in rate!

Refrigeration Load Profile - City Building

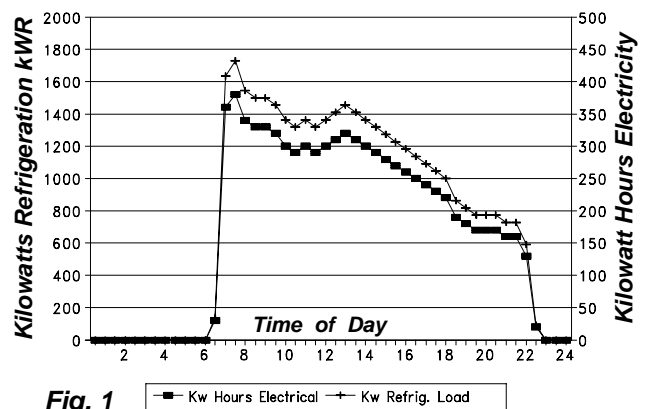


Fig. 1 —■— Kw Hours Electrical -x- Kw Refrig. Load

Plant Data

Location	- Brisbane CBD
Capacity	- 2500 kWR
Data Recorded	- Feb. 1990
Max. kWR Load	- 1750 kWR
Min.. kWR Load	- 500 kWR
Avg. kWR Load	- 1100 kWR
Operating Hours	- 84 hrs./wk.
Avg. Evap. Rate	- 0.6 l/s
Avg. Bleed Rate	- 0.15 l/s
Avg. Electrical	- 240 kW / hr.

Evaporation and Bleed Off Rates - l/sec.

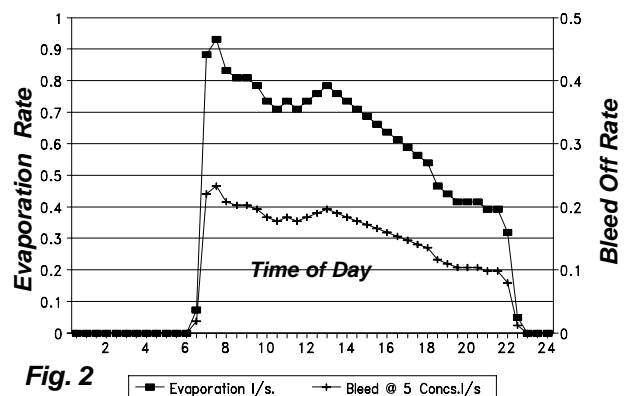


Fig. 2 —■— Evaporation l/s. -x- Bleed @ 5 Concs./s

ADVANCED TECHNOLOGY FOR THE NEW MILLENNIUM

Aquarius Technical Bulletin - No. 03 - Comfort Cooling Water Systems

The average bleed rate is calculated as 0.15 l/s. and assuming we could find the perfect manual bleed valve to maintain a constant bleed rate of 0.15 l/s, the bleed rate if we follow Fig. 3, will be sufficient on average, but dependant on load and evaporation rate, will sometimes be in excess of requirements and sometimes less than required as in Figure 3 below

Manual Bleed Rate v. Refrigeration Load

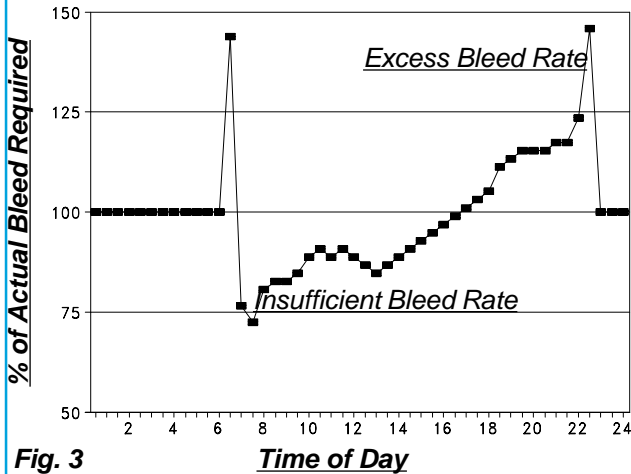


Fig. 3

If we calculate what the actual conductivity in $\mu\text{S}/\text{cm}$ would be at each point, based on this constant bleed rate, and calculating for possible different volumes in the various systems we get the graph as shown in Fig. 4 below, where on a small volume of 2.5 kL. we have allowed the system to increase up from 1750 $\mu\text{S}/\text{cm}$., to almost 2400 $\mu\text{S}/\text{cm}$ and possible scaling conditions by midday, whilst the excess bleed in afternoon returns the system to the acceptable level of 1750 $\mu\text{S}/\text{cm}$ again. The increase in conductivity is dependant on system volume, however it is usually the smaller evaporative systems which have the smallest volume to load ratio's and the units likely to have the most primitive bleed and dosing equipment. A service analysis at 0800 hrs. would indicate bleed rate as sufficient yet the same analysis at 1600 hrs. would indicate the bleed rate should be increased 25%!.

Conductivity with Manual Bleed

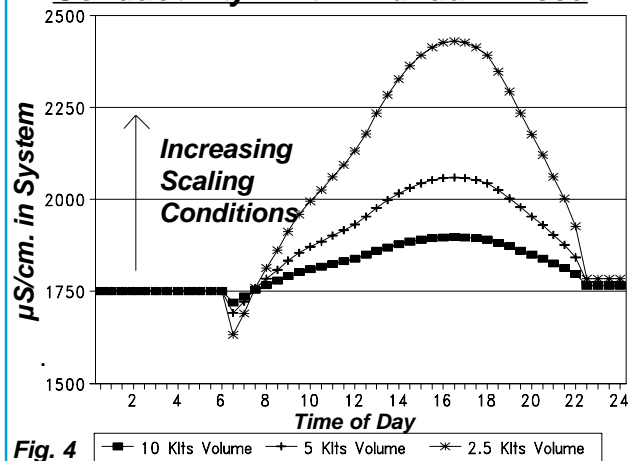


Fig. 4

A simple and inexpensive conductivity sensor will react to increasing conductivity and automatically control a bleed solenoid and maintain the desired level of bleed or conductivity, independent of load variations (or raw water variations) **i.e. a straight line on our graph, or bleed off that varies with load demand.**

Sometimes having installed our conductivity bleed or auto-bleed, we see inhibitor dosing pumps which are interlocked to condenser pumps and dose at a constant rate when the condenser pump is running.

Inhibitor chemicals are not normally consumed or lost in evaporation but mainly lost through the bleed off, necessary from the system, **i.e. inhibitor chemicals can and should be dosed in proportion to the bleed off**, and a few additional facilities built into a well "thought out" conductivity controller can easily accomplish dosage of inhibitor in proportion to bleed rate and therefore maintain a constant level of inhibitor in the system. Figure 5 shows the calculated levels of inhibitor on this load profile with inhibitor pumps linked to condenser pumps and with automatic bleed off, on the system. Again three different volumes have been used in calculations to show the effect that small volumes to load ratio's have on changes taking place.

Inhibitor levels on Continuous Dosage

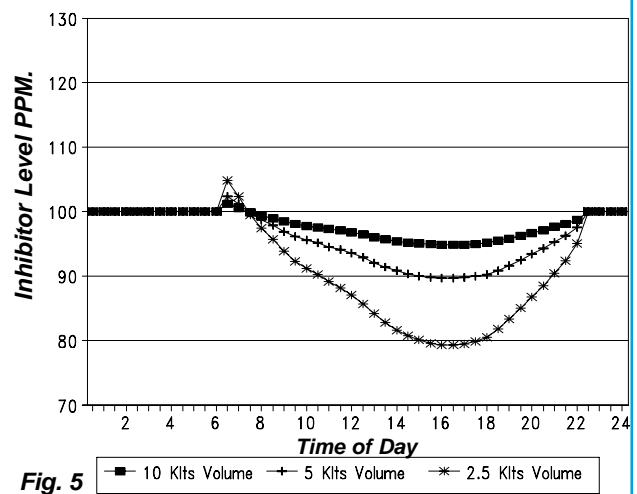


Fig. 5

Again the volume in the system has a large bearing on variations in levels maintained in the graphs above, and it was decided to look at a few specific systems to get a feel for the volume to kWR load ratio and having information for over 100 towers for Queensland State Works or Q Build on computer it was easy to work out the ratios and to graph the results. The Q Build sample is fairly representative of most cities, from large city buildings with large ratios of volume to kWR load, to small buildings with evaporative condenser systems, utilising BAC and Mueller type cooling towers. The average for the sample was 5 lts. per kWR, as high as 25 lts. per kWR, and the minimum at just 2 lts./kWR. - See Fig. 6.

Volume per kWR on Various Buildings

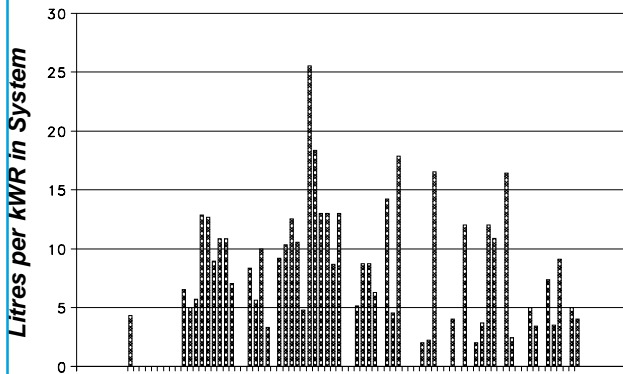


Fig. 6 Various Buildings

Closer examination of the sample showed the larger volume to kWR ratio to be the older and large city building, whilst the newer buildings have ratios in the 5 - 7 lts. per kWR, and the smallest systems in kWR also had the lowest volume to kWR ratio. Until fairly recently the large city building would have had fully automatic bleed and dosing with the smaller system having a constant drip feed of inhibitor and manual bleed off via a pet cock, as water treatment equipment. **In actual fact the smaller system is the one that is in need of fully automatic bleed and automatic inhibitor dosing as it is the system with the largest variations occurring and where only, automatic sensing, bleed off and dosing will maintain water treatment levels.**

Microbiocide Dosage and Control

Until the past few years it was not uncommon for biocides to be slug dosed on weekly or monthly service visits, mainly to prevent fouling of heat exchanger tubes and maintain plant efficiency. In recent years the ever present threat of an outbreak of Legionnaires Disease, the possible legal ramifications of negligence, and legislation passed in every State, has necessitated the automatic dosing of biocides, with routine tower cleaning and an ever vigilant eye on Total Bacteria and LDB counts.

Microbiocides researched and marketed by some of the world's major companies as excellent non oxidising biocides gave very mixed and sometimes poor results when used in the field. Most non oxidising microbiocides need both a minimum concentration and a retention time in the system of 4 or more hours to provide an effective kill of the bacterial population in the system.

It is now common to dose 2 or 3 times per week to maintain the required level of TBC in the system and with dosing spread out over a time period by using Duty Cycle of 10 % on dosing pumps (i.e. doses for 1 minute out of every 10 minutes) and **BIOCIDE LOCKOUT** which prevents any bleed off from occurring for a number of hours, maintains the biocide in the system, ensures maximum efficiency from biocide at minimum cost, and more importantly gives added protection to the prevention of Legionnaires Disease Bacteria.

Effect of Dose of Biocide at 0700 hrs.

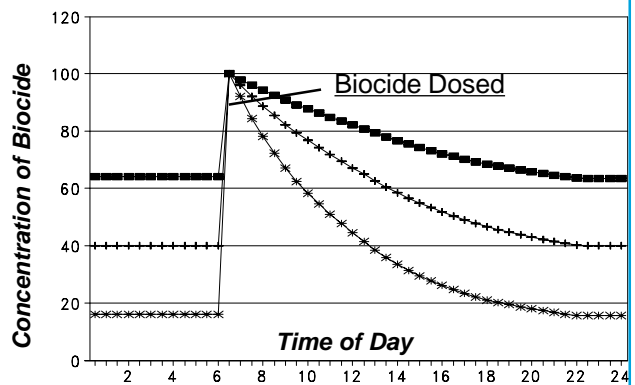


Fig. 7 10 Klts Volume 5 Klts Volume 2.5 Klts Volume

In Figure 7 above over 50 % of the biocide has been lost in 2 hours due to bleed off, with the system running under high load (on 2.5 kL. Volume) and wastage of biocide and poor kill rate of bacteria. By the use of a 7 Day Digital time clock the biocide could have been programmed to dose approx. 30 minutes before shutdown of the plant, where 95% of the biocide is retained in the system for over 9 hours whilst the system is off line overnight, and will obviously give a much increased kill rate of bacteria.- See Fig 7 .

Similarly biocides can be scheduled to dose on Friday afternoons, 30 minutes before shutdown to allow for adequate mixing, and provide almost 60 hours retention if the system is off-line for the weekend

Effect Of Dose of Biocide 30 mins. before shutdown

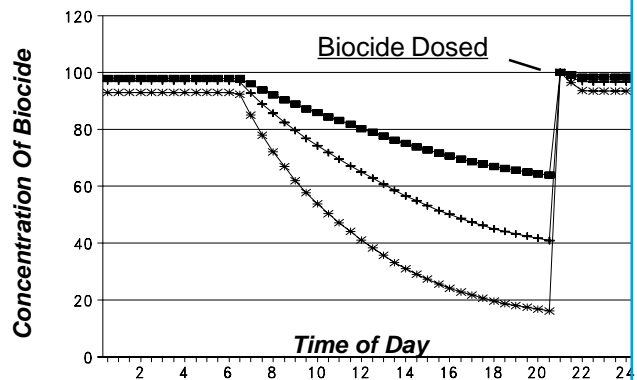


Fig. 8 10 Klts Volume 5 Klts Volume 2.5 Klts Volume

Prebleed & Bleed Lockout

Prebleed & Bleed Lockout are facilities designed into the range of Cooling Water Treatment Controllers such as **Aquarius AT533 Controller**, where a time period is programmed for Prebleed and where bleed off is prevented from occurring for a number of hours after commencement of dose of biocide.

This ensures biocide is retained in the system at the original dose concentration for maximum "kill" efficiency on the bacteria, and is, in my view, a essential to ensure a high "kill" from the biocide.

Aquarius Technical Bulletin - No. 03 - Comfort Cooling Water Systems

Bleed lockout can greatly increase the effective kill from a particular biocide by retaining the biocide in system for a longer time period than if bleed were occurring normally. **The use of microprocessor circuitry automatically limits Prebleed to 87.5% of Set Conductivity value & Bleed Lockout to 112.5% and ensures that water and chemicals are not wasted at Prebleed and that conductivity is not allowed to increase up into the scaling region during bleed lockout.**

The increase in conductivity per hour can be calculated from the following formula:-

$$\frac{\text{Increase in Conductivity per Hour} = \text{kWR (Load)} \times 1.94 \times \mu\text{S/cm in make up water}}{\text{System Volume in Litres}}$$

e.g. our system has average load of 1750 kWR from 0700 to 1200 hrs. and system volume is estimated at 5 kL.

$$= \frac{1750 \times 1.94 \times 400}{5000}$$

= 272 $\mu\text{S/cm}$ per hour - and the maximum safe lockout at this time of day would be 2-3 hours.

If we calculate for the period 1600 to 2230 hrs. the average load is approximately 700 kWR and the increase in conductivity with Bleed lockout would be 82 $\mu\text{S/cm}$ per hour and lockout for 4-6 hours is possible.

In winter or periods where the system is off line for long periods the system should be circulated at least weekly and the biocide dosed and mixed in the system, or the cooling system drained and kept dry.

Summary

From the above data it should be fairly obvious that comfort cooling systems are a mass of varying conditions, with the only constant being the water treatment levels we must maintain, for performance from efficiency, corrosion and microbiological control.

The only method of maintaining optimum water treatment control under these conditions is by means of sensing, automatic bleed off, with automatic dosing of inhibitor, programmed dosage of biocide incorporating Prebleed and Bleed Lockout facilities.

All of the above are incorporated in a simple to install package - **AQUARIUS-AT522 Controller** at an installed cost of approx. \$2250.00, or amortised over 10 years an annual expenditure of approx. \$270.00 for full protection.

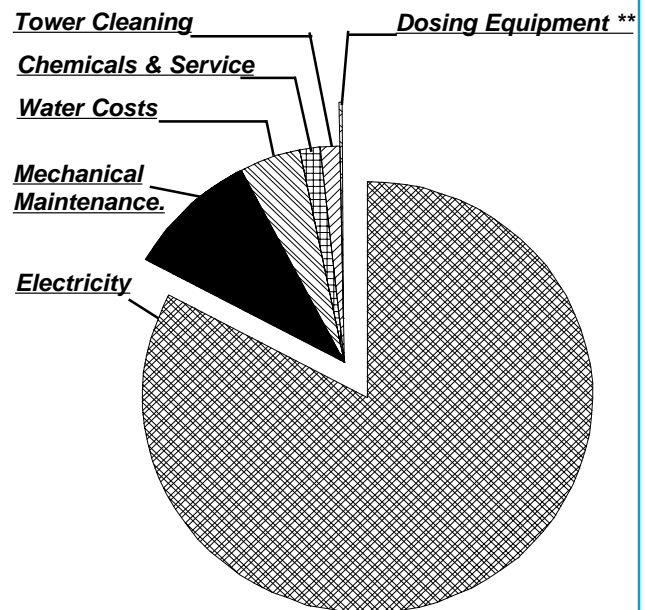
When compared with the total maintenance expenditure on this system of approximately \$100,000 per year, it seems such a paltry sum to protect a system with a value in excess of \$0.5 million, and an insurance liability of much more in the case of a proven outbreak of Legionnaires Disease.

Typical annual maintenance costs

Operating 60 hrs./wk. 52 weeks/year

Electricity costs	-	\$86000
Water Costs	-	\$4500
Mechanical Maintenance	-	\$10,000
Chemicals & Service	-	\$1500
Tower Cleaning	-	\$1500
Dosing Equipment **	-	\$2250

Note automatic dosing equipment is normally a once only purchase with a life expectancy similar to the remainder of air conditioning equipment, and amortised over 10 years amounts to less than \$270 per year.



Typical Annual Maintenance Costs Breakdown

Bert Topping commenced work as a Laboratory Technician and studied Textile Chemistry at Belfast College of Technology, before migrating to Australia in 1967. From 1967 to 1989 he was involved in sales and service of water treatment chemicals, with experience in NSW, Vic. and Qld. Since 1983 he has developed and manufactured conductivity control equipment on a part time basis, until 1989 when Aquarius Technologies P/L was formed to specialise in control equipment for the water treatment industry. Bert is the principal of Aquarius, leading a very dedicated staff of twelve, designing and manufacturing a range of water treatment control equipment sold and appreciated throughout Australasia.