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COOLING TECHNOLOGY INSTITUTE

CONTROLLED HYDRODYNAMIC CAVITATION FOR COOLING TOWER WATER TREATMENT

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Controlled Hydrodynamic Cavitation for Cooling Tower Water Treatment
CTI, New Orleans, LA, February 10, 2015, 9:30 am to 10:00 am

Cliff Ashbrook created our non-chemical Controlled Hydrodynamic Cavitation (CHC) technology. Mr. Ashbrook conceived the CHC concept while observing bullets being shot into water. He noticed a white trail that followed the bullets path. As a scientist, he understood the white trail was calcium carbonate ($CaCO_3$) precipitating from the water caused by the bullet's rotational cavitation. Mr. Ashbrook went on to develop the CHC technology. In the early 1990's, he licensed the CHC technology to the Lancer Corporation.

Our CHC technology falls in the mechanical energy device category of Non-chemical Devices (NCD's), as the system relies on kinetic energy through Controlled Hydrodynamic Cavitation (CHC) in addition to chemical equilibrium to control scale, corrosion, and bio-fouling without the issues associated with chemical treatment.

Adding a filtration component to the CHC technology for $CaCO_3$ removal completes the solution. Cooling towers, in addition to their primary heat rejection purpose, are also massive air washersThe two stage filtration system helps remove the ingested environmental dirt and debris from the water that is often associated with cooling tower inefficiency in addition to the precipitated $CaCO_2$.

The removal of the precipitated $CaCO_3$ from the water by filtration allows for an increase in the Cycles of Concentration (CoC), the ratio of make-up water in to blowdown water out. With a higher CoC ratio, make up water consumption (In) and the blowdown rate (Out) are lowered. The concept is brilliant in its simplicity, but can be difficult to understand when $CaCO_3$ is removed. The goal is to clarify this understanding.

The CHC technology has evolved over the ensuing years. While the CHC chamber has remained virtually unchanged, the system has seen continuous upgrades. Systems are now built in our factory as a unified package that is "plug and play". We build the skid package and test it before shipment to the customer. Once it arrives, the unit is set in location, and the external plumbing and electrical is installed. This has reduced installation to start up from weeks to days.

The other key improvement over the years has been the filtration package. In the early days, the system used bag and cartridge filters that required frequent changing by the end user. Today, our dual stage filtration package is PLC controlled and fully automated.

Marmon Water, a Berkshire Hathaway company, acquired the business assets including the significant intellectual property portfolio in 2014.

The cavitation chamber as shown in Figure 1 is a set of opposing nozzles optimally configured to generate the cavitation "cloud". The following processes occur inside the CHC unit:

• Water from the sump is first pumped into the chamber under pressure.

There are hundreds of CHC technology systems operating throughout the world. The data in Figure 8 shows three examples of real world water and sewer savings from 1 million to over 10 million gallons per year.

BACTERIA CONTROL AND LEGIONELLA

The word "Legionella" came into our vernacular when the American Legion opened its annual three-day convention at the Bellevue-Stratford Hotel in Philadelphia, Pennsylvania on July 21, 1976. More than 2,000 Legionnaires, mostly men, attended the convention. The total number of cases reached 221, and of those, 34 had died.

In January 1977, the Legionella bacterium was finally identified. The bacterium isolated was found to be breeding in the cooling tower of the hotel's air conditioning system, which then spread it through the building. This finding prompted new regulations worldwide for climate control systems.

In April 1985, 175 patients were admitted to the District of Kingsmead Stafford Hospital with chest infections. A total of 28 people died. Medical diagnosis showed that Legionnaires' disease was responsible and the immediate epidemiological investigation traced the source of the infection to the air conditioning cooling tower on the roof of the Stafford District Hospital.

As the world recognized the source and the threat of Legionnella, the UK Health and Safety Executive (HSE) published their first Approved Code of Practice (ACOP) for "The Control of Legionella Bacteria in Cooling Towers" in 1991.

The Centers for Disease Control and Prevention (CDC) stated in their MMWR report (*Legionellosis --- United States, 2000—2009. MMWR Morb Mortal Wkly Rep. 2011;60(32):1083-86*) that between 2000 and 2009 cases have tripled. During this period there were 22,418 reported cases of Legionella with an average of 8% resulting in death.

CHC technology was introduced to the UK in 2007. An independent analysis of the effectiveness of CHC as a means of controlling Legionella was carried out in 2008 by representatives from Merican Sciences, J Usher and G. Hatchhroft and Principle Consultant Alan Edwards C.Chem MRSC from Alan Edwards and Partners who acted in consultation with the HSE in the production of the ACOP L8 document.

The Graphical data shown in Figure 8 conclusively demonstrates that the CHC technology has the ability to reduce the number of *Legionella Pneumophila* serogroup 1 from concentrations of 1 X 10^7 cfu/litre to 0 cfu/litre within 5 passes of operation of the unit.

"The CHC cavitation zone is extremely efficient in controlling or even eliminating all microorganisms. This is achieved by impacting high velocity rotating streams of water together. The tremendous localized temperatures and extreme fluctuations in fluid pressure within the CHC chamber causes cell walls of microorganisms to rupture." – Alan Edwards

Today, the United Kingdom has the strictest Legionella regulations on the planet called L8. Failing to meet their criteria is more than a civil offense . . . offenders have gone to jail.

Based on their survey of cooling towers over a twelve month period, the UK HSE has validated and recommends cavitation technology as a viable non-chemical solution for controlling Legionella.

The L8 regulations are going to eventually be embraced by the rest of the world in the future. Quebec, Canada has recently adopted their version of L8 imposing very strict regulations for the control of Legionella.

In the United States, ASHRAE has prepared their Standard 188 for Legionella control. At this point in time, the standard is only a suggestion and does not have any legal power.

VALUE PROPOSITION

The use of NCD's directly reduces the cost and lowers the environmental impact of the chemical treatment currently used today to manage cooling tower water quality. The CHC technology package offers a complete solution that does an exceptional job of controlling scale, biological, and corrosion in the water. The CHC system also filters the water to provide a clean and efficient operation.

The value to the user is:

1. Make up water use is reduced on average by 20% saving the cost of water and preserving our natural and vital resource.
2. Blowdown to sewer is reduced on average by 50% saving cost of sewer charges, but also reducing demand on our increasingly limit water treatment infrastructure.
3. Elimination of direct chemical costs, handling, and environmental risk.
4. Because blowdown from a CHC system is chemical free, it can be used for other grey water purposes such as irrigation.
5. While the CHC system presents an additional energy load, scale reduction improves heat transfer efficiency and will offset the energy cost with a potential net energy savings.
6. Reduction in tower maintenance to clean the sumps saves labor costs.
7. CHC qualifies for USGBC LEED-NC (New Construction) Innovation and Design (ID) Credit 1.1. An additional point may be earned (Water Efficiency 1.2) by using cooling tower blowdown for landscape irrigation.

CONCLUSION

The key design principles and performance of the CHC non-chemical water treatment system for cooling towers allows us to focus on serving the needs of our customers and conserving water resources. With cooling towers collectively consuming billions of gallons of our potable water supply per year, water conservation—using water efficiently and avoiding waste—is fundamental to ensuring water availability in the future.

In this day and age, "Green" historically has meant environmentally friendly, but may not work quite as well and be more expensive. CHC is a proven technology that delivers very high quality tower water treatment that is equal or better than the use of chemicals, has a lower cost of operation, saving money, and also happens to be "Green".

Figure 1 – Inside the CHC Cavitation Chamber

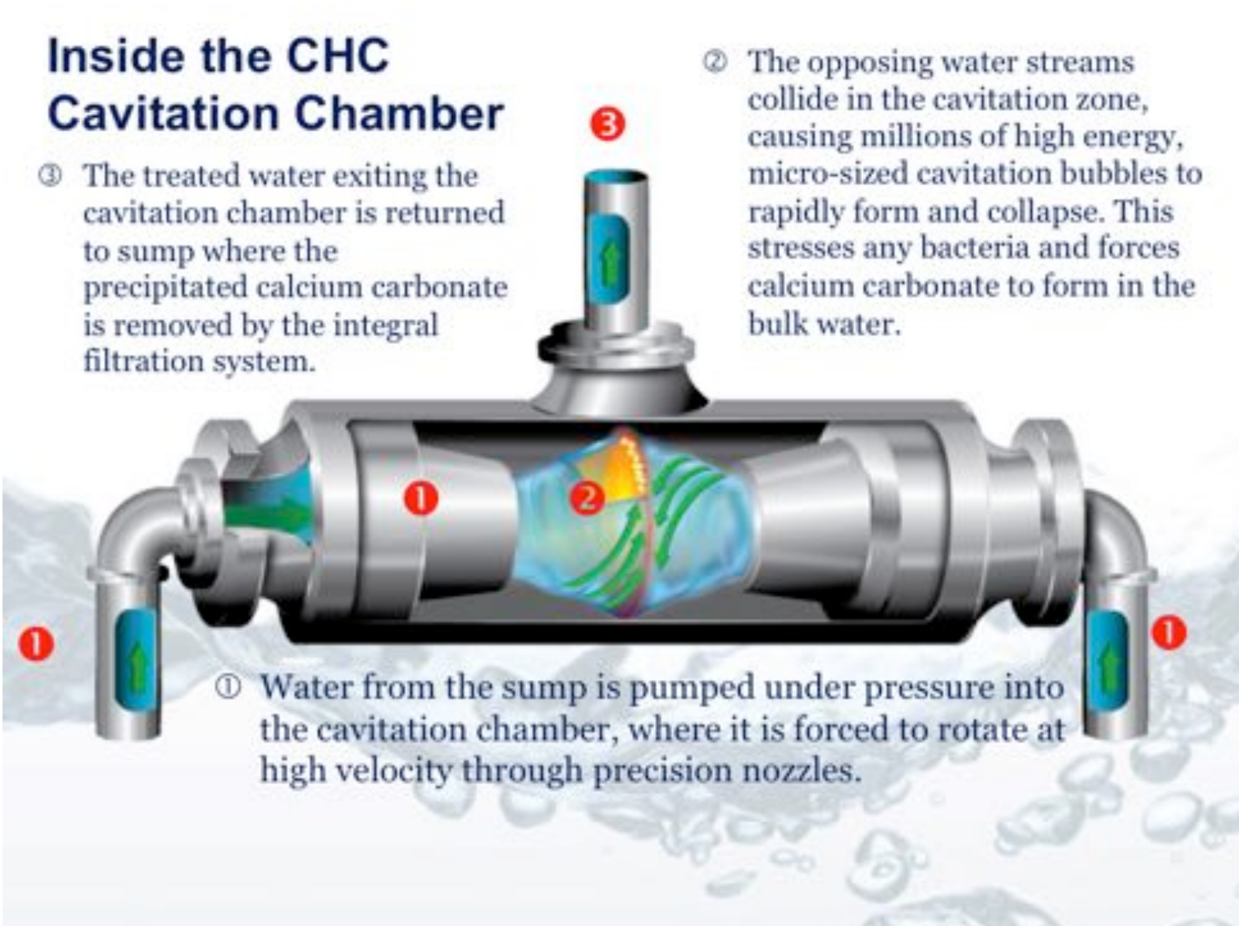


Figure 2 – Aragonite

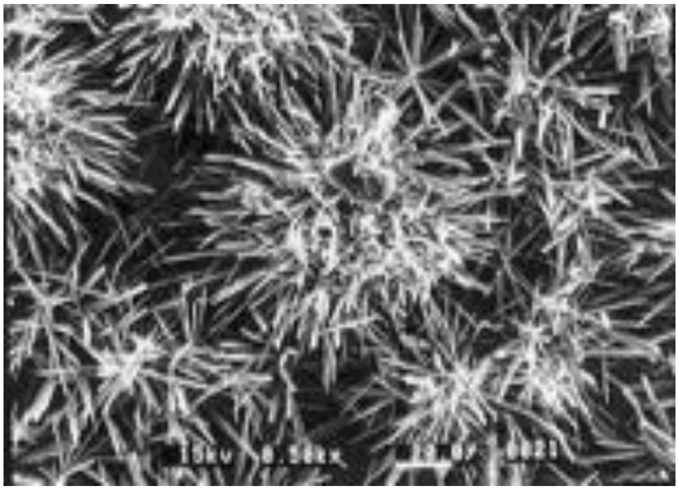


Figure 3 – Calcite

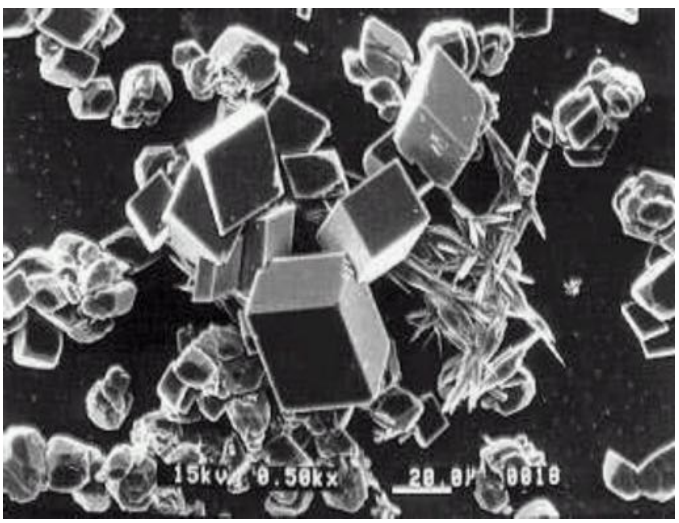


Figure 4 – Traditional Mass Balance

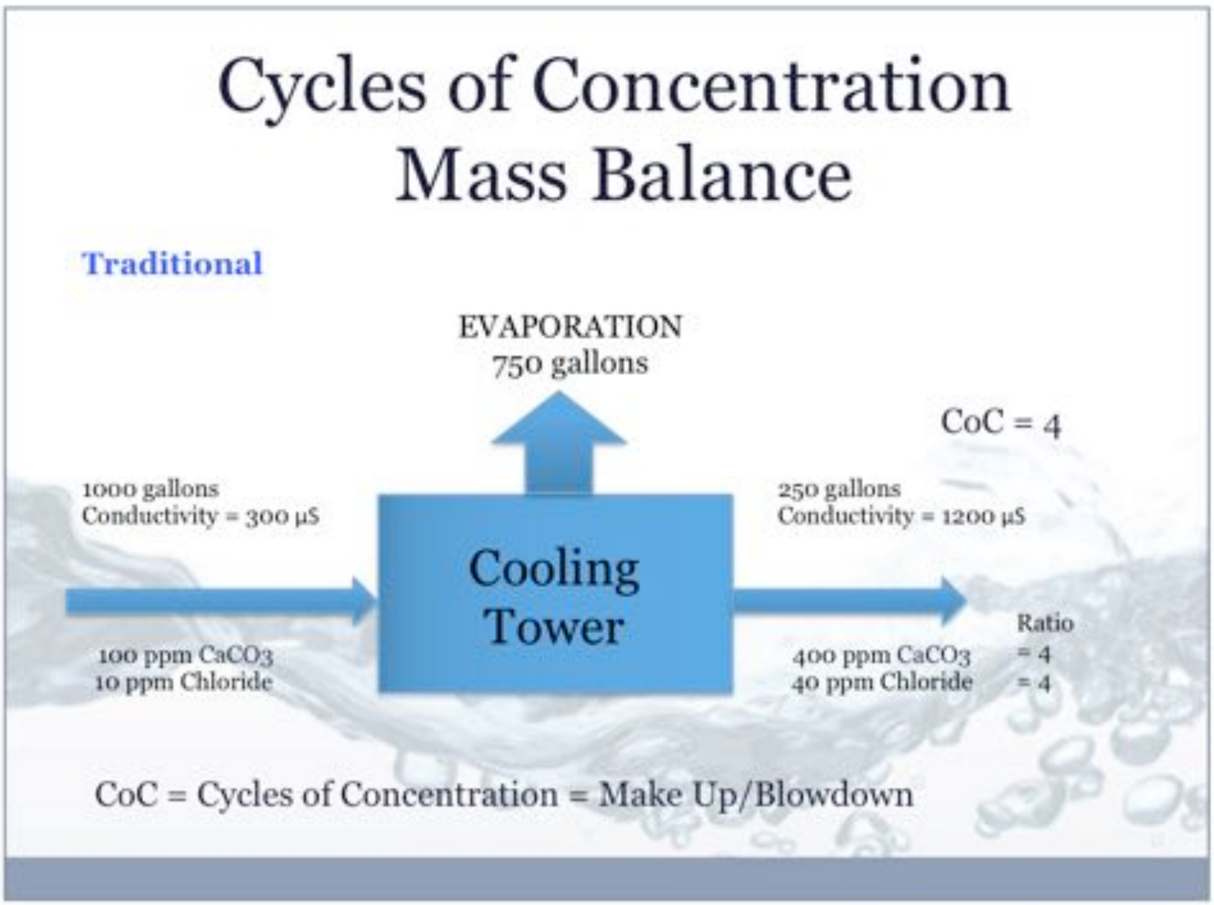


Figure 5 – Mass Balance with CHC

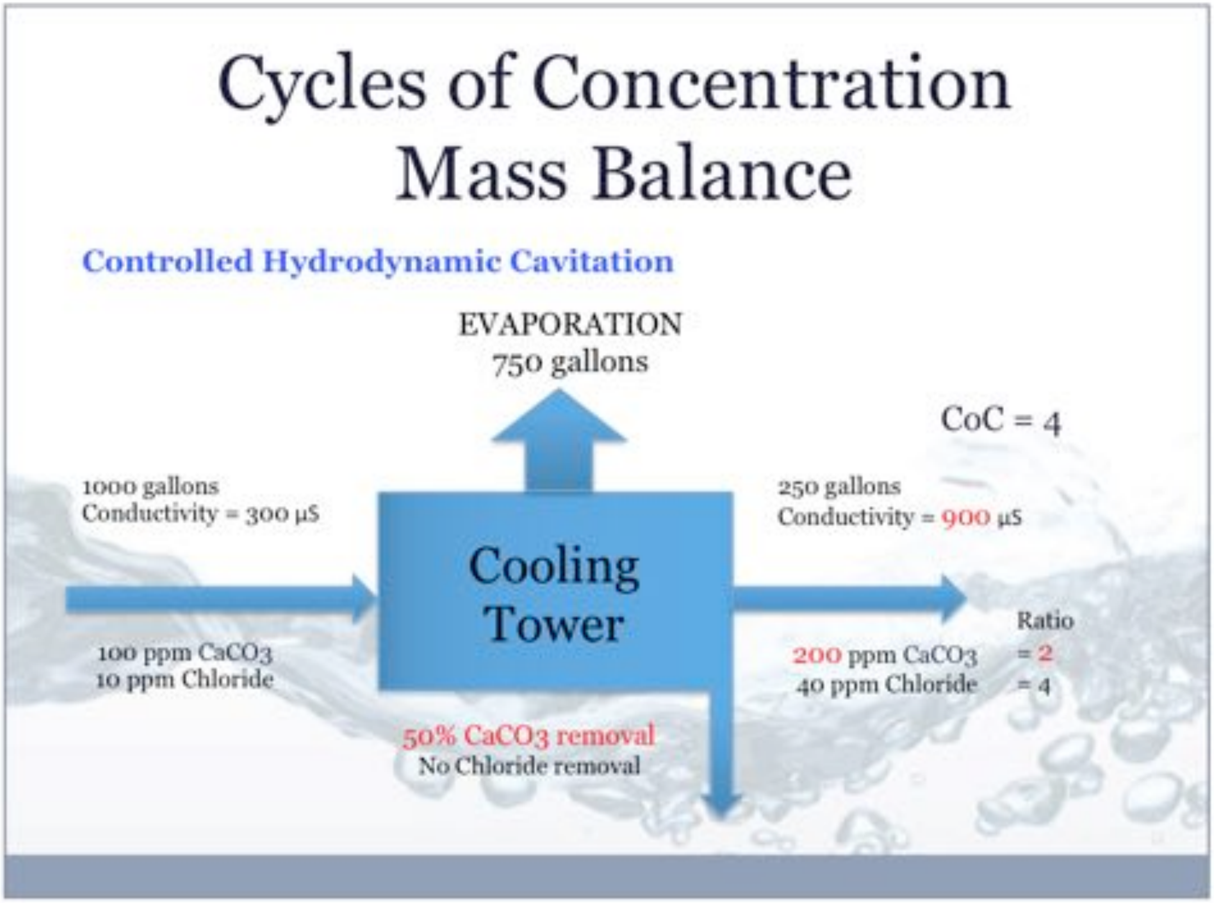


Figure 6 – Mass Balance showing increased CoC

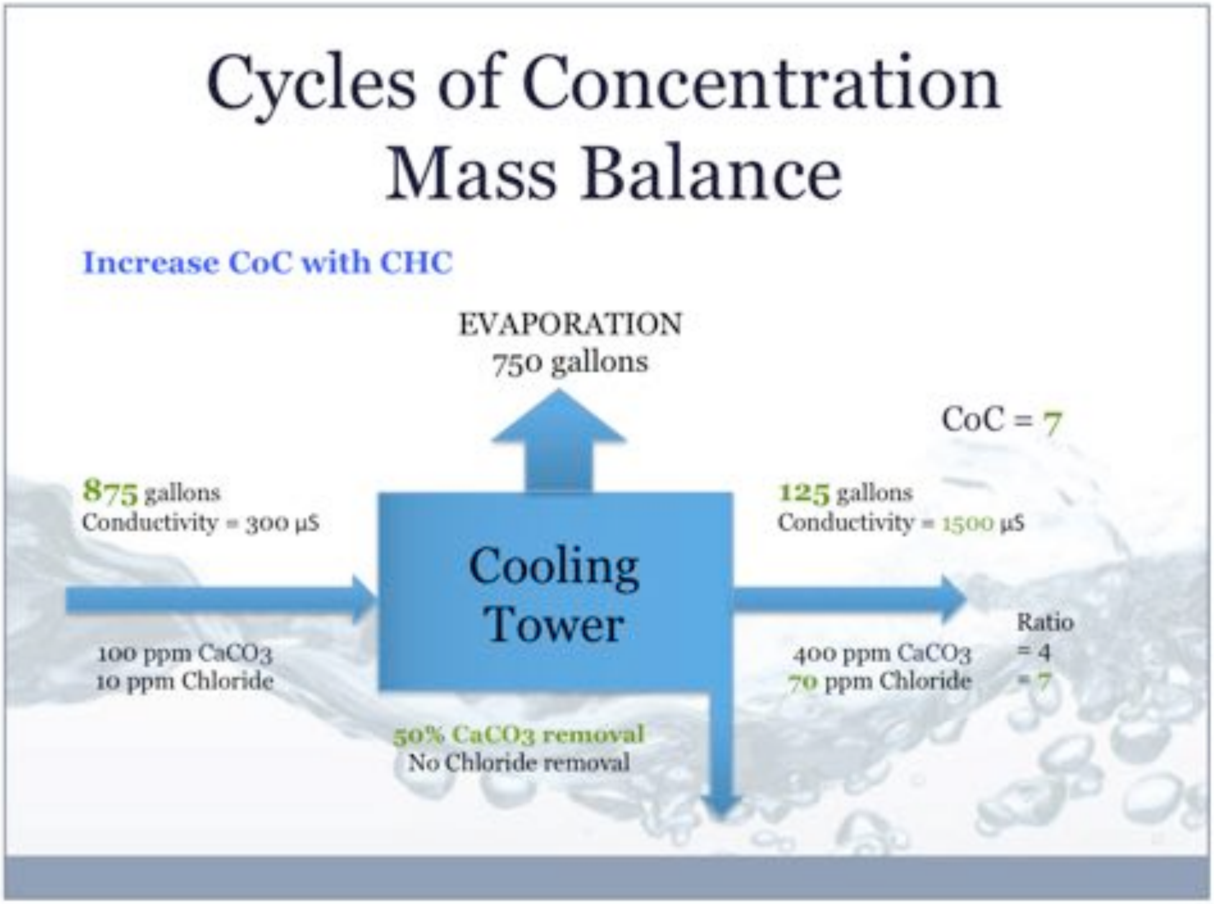


Figure 7 – CoC Summary

Cycles of Concentration
SUMMARY

		50% $CaCO_3$ REMOVAL	
	Traditional	With CHC	Water Savings with CHC
Make Up (Gal)	1000	1000	875
Blowdown (Gal)	250	250	125
Evaporation (Gal)	750	750	750
Make Up/Blowdown	**4**	**4**	**7**
Conductivity IN (µS)	300	300	300
Conductivity OUT (µS)	1200	900	1500
OUT/IN	**4**	**3**	**5**
$CaCO_3$ IN (ppm)	100	100	100
$CaCO_3$ OUT (ppm)	400	200	400
OUT/IN	**4**	**2**	**4**
Chloride IN (ppm)	10	10	10
Chloride OUT (ppm)	40	40	70
OUT/IN	**4**	**4**	**7**

Figure 8 – Examples of Water Savings

Water Savings

Examples of Water Savings Through Increased Cycles of Concentration

State	Tons	System Gallons	Chemical CoC	CHC CoC	Water/Sewer Savings	% Savings-Makeup	% Savings-Blowdown
VA	730	2,610	4.5	7.0	991,408 Gallons	18%	40%
FL	850	4,000	2.0	4.0	5,400,000 Gallons	40%	73%
ND	4,500	80,000	3.5	5.8	10,830,000 Gallons	15%	50%

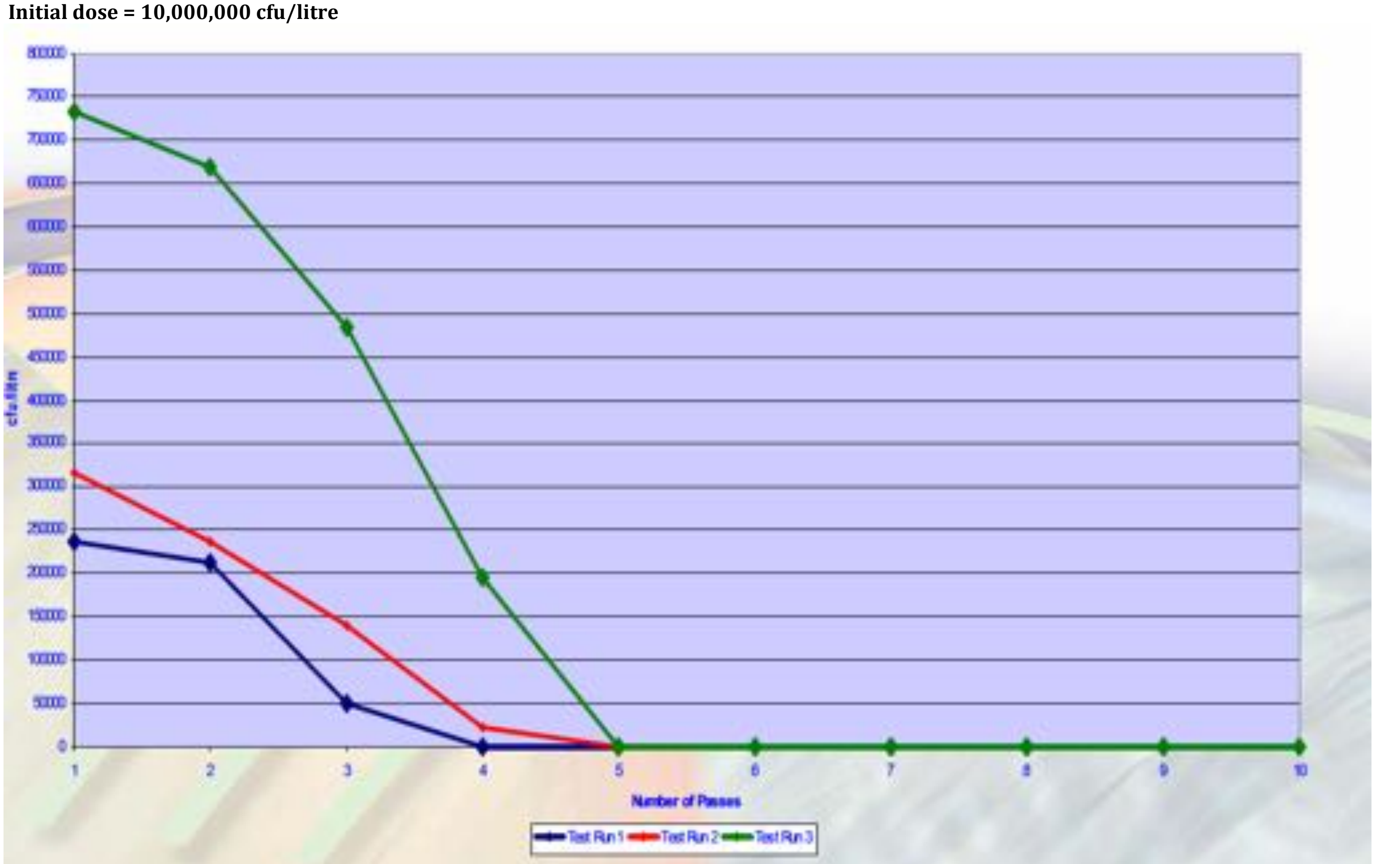
CoC = Cycles of Concentration

A Marmon Water/Berkshire Hathaway Company

Figure 9 – Legionella Counts versus passes through CHC chamber

Effect of CHC on Numbers of Legionella Pneumophilia

Initial dose = 10,000,000 cfu/litre



Data from Merican Sciences, J Usher and G. Hatchhroft and Principle Consultant Alan Edwards C.Chem MRSC from Alan Edwards and Partners, UK 2008