Case History Report
The “Dolphin” Nonchemical Device
Boilers and Cooling Tower

Device Evaluated
"The Dolphin HYTRONIC Series 1000" pulsed power water treatment device (Dolphin) manufactured by Clearwater Systems LLC, 145 Dennison Rd., P.O. Box 463, Essex, CT 06426, ph: 860-767-0850 FAX 860-767-8972 WEB www.clearwater-dolphin.com

System Data
Clearwater representatives designed systems based on the Dolphin, a non-chemical device (NCD), for treatment of boilers and cooling towers in place of typical chemical water management programs at a **new** North Central Pennsylvania hospital power house. At the time of this review, the power house had been in operation approximately thirteen months.

Boilers
The power house is equipped with three, 500 hp fire tube, gas fired boilers operating at 150 psi. Makeup water, see attached analysis report, was **not softened** per Clearwater recommendations, while a deaerator operated at 224/228 F is provided for oxygen removal. Steam is used mainly for heating loads with makeup averaging 650 gpd, one boiler on line. Dolphin units are installed on the condensate return line (two units), boiler feedwater lines (one on each of three lines), and the boiler makeup water line.

Cooling Towers
Three stainless steel construction, 500 ton capacity, BAC 3000 series cross flow cooling towers are used to provide cooling for the condensers of three freon cycle chillers. Typical load is one unit base, one unit trim, one unit in reserve with makeup averaging 9000 gpd. System metallurgy is black iron piping, copper tubes, and some brass valves. Dolphin units are installed on each chiller condenser return line (3 units) and the cooling tower makeup water line.

Claims Made
Dolphin sales literature and WEB site information claimed that the NCD "prevents mineral scale buildup - removes and eliminates existing scale - inhibits corrosion" in boiler systems. In cooling tower systems, the NCD claimed benefits are "improves system efficiency - eliminates bio-film - reduces encrustation & fouling - controls bacteria to very low levels - inhibits corrosion".

Dolphin WEB site data, 01/03, claims that Dolphin devices "impart pulsed, high frequency electromagnetic energy into flowing water".

History
The Dolphin units were installed concurrent with construction of the new power house with start-up about 12/01. Operation was continued to 01/03, date of our review, using only the installed NCD systems as treatment with untreated city water makeup.

PCT personnel visited the site twice in January, 2003, to examine an opened boiler, check the cooling towers, and obtain water samples. The site visits were at the request of hospital operating personnel as they had determined, based on their experience with the NCD systems, to return to chemical treatment in the near future. During the visits, plant personnel reported that boiler piping leaks, at threaded joints, had started within three months of start-up, with many parts of both the boiler feedwater and blowdown piping having been replaced as many as three times prior to the time of our visit.

Problems reported with the cooling towers included chunks of rust scale blocking distributor nozzles, "rusty" appearance of the cooling water at times, biological buildup in condenser heads, and excessive brushing of tubes to maintain chiller operation. A corrosion coupon rack was installed, but hospital personnel had received no results to date from Clearwater. Target conductivity, controlled by a conductivity base blowdown controller, was 1000 mmhos, giving about 4.5 cycles.

Review
Boiler #2 was opened for examination during both visits to the hospital power house as it had suffered tube/tube sheet junction leakage on a substantial number of tubes and had just been cleaned with the leaking tubes rolled.

Our examination showed what appeared to be severe oxygen pitting corrosion at the fire side tube/tube sheet junction. Examination of the boiler water side internals showed definite oxygen pitting corrosion with a substantial coating of fine red/black powder on all surfaces. Several leaking pipe joints, corrosion evident, on the condensate, feedwater, and blowdown piping were also observed. Plant operators noted that boiler #2 had logged just 1300 hours of operation.

The cooling tower system came on-line during the first visit with the cooling water observed to be very rusty, looking like tomato juice. Almost immediately, the cooling tower was seen to overflow from the distribution deck. Inspection of the deck showed that the overflow was the result of large pieces of rusted pipe scale blocking the distributor nozzles.

Samples were obtained only from the boiler system (boiler #1 on-line) as the cooling system was operating under upset conditions. Analytical results from Analytical Services, Inc., Brockway, PA, a state certified laboratory, are attached.

A Dolphin unit control box was opened and found to contain a small transformer. The transformer output, passing through an inductor coil, fed into the actual Dolphin unit. The Dolphin unit was also inspected and appeared to be nothing more than an insulated coil wound around a pipe spool. Typical power input was listed on the literature as 110 to 390 va.

Draining of Y screen traps prior to the condensate pumps, and the condensate and feedwater sample ports, resulted in a substantial amount of black and yellow red solids discharge.

Discussion

The analytical data clearly shows that the boiler system is suffering from major ferrous corrosion based on a finding of 41.8 mg/l total iron in the boiler water.
While not of the same magnitude as iron, the high level of copper, 2.9 mg/l, in the boiler water is also of concern as it indicates corrosion of yellow metals somewhere within the boiler system.

While the calcium level in the boiler water was somewhat lower than expected, no calcium scale was seen in the water side inspection of boiler #2. It appears that the calcium is bulk precipitating in the boiler water due to the substantial loss of alkalinity and the presence of some phosphate in the city makeup water. In essence, the boiler is actually operating on a combined carbonate/phosphate cycle bulk precipitation program, which explains the lack of any substantial scale deposits.

Levels of both magnesium and silicon in the boiler water are substantially lower than would be expected based on the ten (10) chloride cycles that the boiler was operating at when sampled. This indicates that magnesium silicate is also precipitating within the boiler.

While the condensate pH was lower than the desired 8.0 to 8.5 range, it was not strongly acidic and did not contain a substantial amount of iron. This can be explained given the low alkalinity of the makeup water, 15 mg/l, and the loss of alkalinity within the boiler due to calcium precipitation, which ties up carbonate preventing evolution of carbon dioxide into the steam with subsequent condensation as carbonic acid into the condensate.

Conclusions

Boiler

Based on the reported and observed leaks, and substantial iron level found in the boiler water, it is clear that the Dolphin NCD has not controlled corrosion within this boiler system.

While no calcium scale is evident in the boiler, the analytical data shows that the actual mechanism preventing scale formation is classic carbonate cycle boiler chemistry aided by the phosphate present in the city water. We can thus conclude that the Dolphin NCD has no evident effect on scale.

Cooling Tower

Based on the corrosion products observed in the cooling tower distribution basin and rusty appearance of the cooling water, it is evident that the Dolphin NCD does not control corrosion in a cooling water environment.

Looking at control of scale, operating with city water at 1000 mmhos, about 4.5 cycles of concentration, results in a saturation index of -0.35 at 95 F. Basically, under these non-scaling conditions, no scale could form, thus we cannot comment on the ability of the Dolphin unit to control scale in this cooling water application.

Literature

Review of the supplied literature and Clearwater WEB site shows no theory of operation for the Dolphin unit which is consistent with accepted scientific principles.

For instance, reference is made to Faraday's Law of Magnetic Induction (1) to "explain" how the Dolphin unit "effects surface charge and precipitation". This law concerns induction of an electrical voltage via movement of a magnetic field relative to a conductor. At no place in the equation for this law, EMF = -lambda X (dif magnetic flux/dif time), can one find an addition, or removal, of an electron to a particle, which would be required to effect surface charge.

Dolphin literature further states operation is via "The electric field effects the surface charge and precipitation behavior of charged particles--". It is a commonly accepted chemical principal that the constituents responsible for scale formation exist in water as separate, hydrated ions, not as "charged particles". Since there are no particles in the water to be "effected" by an electric field, there will be no action by the NCD.

The claimed "activation of colloidal nucleation sites" resulting in bulk water precipitation of calcium carbonate is easily explained by well known chemical processes, operating with, or without, the presence of the Dolphin NCD.

Economics

A general claim is made that NCD are less expensive to operate than traditional chemical water management programs. The hospital people stated that the equipment cost for the Dolphin units was $79,908. Based on our review of the facility, annual chemical cost would be $6,360 with an initial cost for needed control and feed equipment of about $7840.

Reducing the cost of the Dolphin installation by that of the chemical feed and control equipment gives a cost of $72,068, which results in a simple ROI of 11.4 years for replacement of the chemical water management program by the Dolphin NCD. This is an extremely poor ROI and cannot justify installation of such a NCD, even if it did work as claimed.

Please note that we did not consider the costs of such items as makeup and blowdown in the above simple ROI review as the chemical water management program would operate, in both the boiler and cooling tower systems, at substantially higher cycles than was specified for the Dolphin installation. This would effectively give a lower operating cost due to reduced makeup and blowdown, further increasing the ROI time period.

Reporter
Timothy Keister, FAIC, CWT
Chief Chemist

(1) Specific Faraday law noted in letter dated July 24, 2003, from Robinson & Cole, attorneys for Clearwater Systems, LLC.

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Boiler Water Analysis Report

Customer: NC PA Hospital

System: Power House Boiler System
Location: North Central PA

Date sampled: 01/13/03
Date reported: 01/15/03

Parameter	City makeup	Feed water	Condensate	Boiler water
pH	6.40	7.55	6.11	10.7
conductivity, mmhos	224	41	42	1970
total alkalinity, mg/l	15	2	3	42
calcium, mg/l	24.8	3.9		224
magnesium, mg/l	3.2	0.5		7.2
iron, mg/l	<0.03	0.12	0.13	41.8
copper mg/l	<0.02	0.04	0.04	2.9
silicon, mg/l	1.4			3.0
chloride, mg/l	42	20	18	420
sulfate, mg/l	16.3			21.1
sulfite, mg/l		<2		<2
OH alkalinity, mg/l				16
total phosphate, mg/l	0.44			10.3
ortho phosphate, mg/l				0.29
dissolved solids, mg/l	146	24		1268
suspended solids, mg/l		<1	<1	116
total hardness, mg/l	75.2			589.6
cycles on chloride				10

Chemical analysis by Analytical Services, Inc., Cert. Lab #33-411