CASE STUDY

Non-Phosphorus Inhibitor Reduces Water and Chemical Consumption in an Air Separation Plant

eROI[SM] by Ecolab

ANNUAL SAVINGS

WATER

Reduced water usage by 81,541 m^3

$62,237

COSTS

Reduced biocide usage by 25,200 kg

$5,047

Reduced acid usage by 9,300 kg

$6,814

TOTAL VALUE DELIVERED

$74,100

BACKGROUND

The usage of phosphate-based corrosion inhibitors has long been accepted as a general practice in industries. However, phosphorus is a critical nutrient that promotes algae growth. Thus, disposal of industrial water with phosphorus content can trigger algae bloom, which harms other organisms living in the same watershed. Based on this concern, Nalco Water developed a non-phosphate inhibitor as a better alternative for conventional phosphate-based program. As strict environmental regulation is enacted in many countries, the new non-phosphate corrosion inhibitor by Nalco Water has become a best practice water treatment solution.

Besides its environmental benefit, the non-phosphate solution offers some technical advantages. First, the program works at higher pH and reduces phosphate concentration for less acid consumption and bacteria growth in the cooling water system. Second, it contributes less microbial growth in the cooling water due to reduced phosphate concentration in the system.

An air separation plant in Southeast Asia aimed to reduce the chemical consumption in the cooling water system. The cooling water make up is supplied by an industrial estate, which has high pH conditions. The system operated with 3.5 cycles of concentration with considerable amount of hardness, alkalinity and chloride due to high biocide consumption in the system. Initially, a zinc, phosphate-based chemical was used in this plant for corrosion and scale inhibitor control.

A detailed review of the existing program showed that it required a significant amount of acid to adjust the system's pH level to avoid calcium phosphate precipitation. The second major contributor to the chemical consumption was chlorine to suppress bacterial growth. After a brief presentation about the new non-phosphate program by Nalco Water, the plant agreed to conduct a field trial.

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SOLUTION

The dosage of the non-phosphate program was determined using the Cooling Water Optimizer software from Nalco Water. Based on the result, the non-phosphate program works up to a pH level of 8.3 whereas the old program had a maximum pH level of only 7.7. However, during the plant audit, the Nalco Water team learned that the pH increase is limited to 8.0. This was due to the Direct Contact Air Cooler unit used to cool the process air, where stripping could lead to a pH level increase of 0.5. Thus, the initial pH measure of 8.3 would result in pH of 8.8 in cooling water, leading to the formation of calcium carbonate scale.

After further collaboration with Nalco Water, the plant requested a two-stage trial. The first phase was to be an initiation stage where a higher non-phosphate concentration would be used to avoid higher corrosion rates when the phosphate level is declining. This was done based on a customer concern, which might not have been an actual need. The second stage of the trial involved the program running at normal concentration.

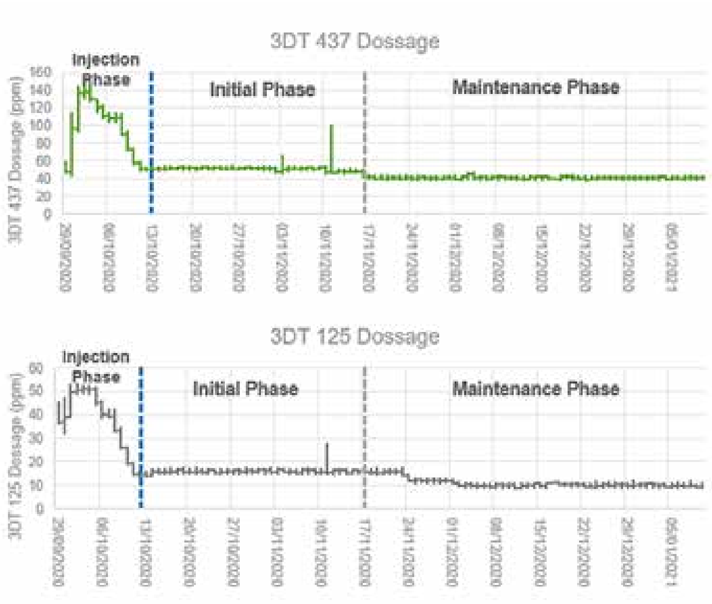

Figure 1. Non-phosphate chemical concentration as read by 3D TRASAR technology.

In the initial injection phase, the concentration of both old and new chemical is mixed up in the system, creating a high dosage value (Figure 1). However, as the old chemical is flushed out of the system, the reading is decreasing to the initial phase dosage. This initial dosage lasted for a month and then switched to the maintenance dosage. In both phases, the initial chlorine dosage was not changed to avoid microbial growth. The chlorine dosage was later revised as some new facts were discovered during the trial.

RESULTS

One of the most noticeable changes in terms of water quality after application of the non-phosphate program is the pH rise of the cooling water system. Higher pH corresponds to a reduction from the average of 1225 kg/month to 775 kg/month after the non-phosphate application. Moreover, the chloride level showed a decreasing pattern as a result of lower biocide required.

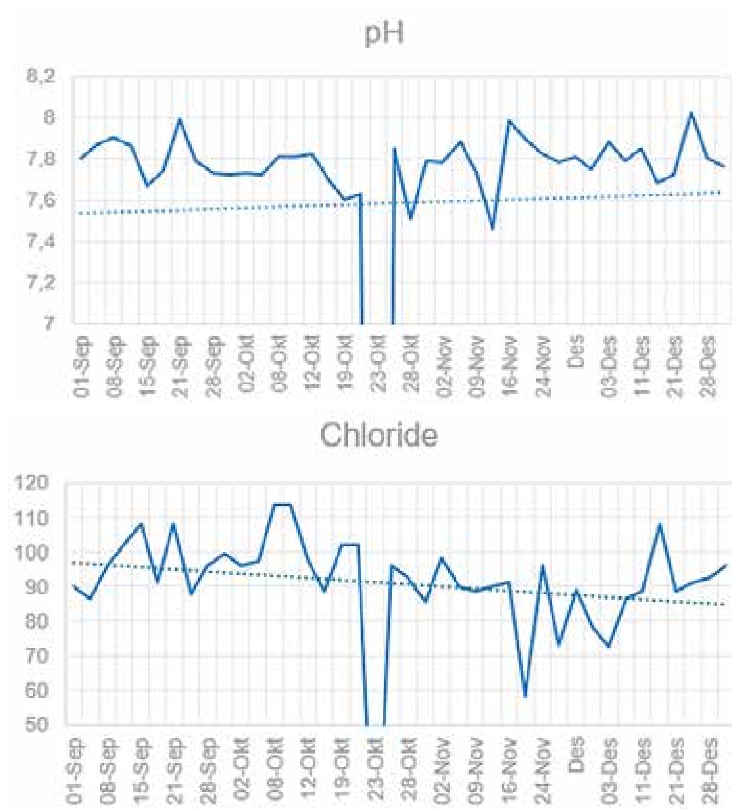

Figure 2. pH and chloride profile of cooling water during non-phosphate trial.

During the trial, the corrosion rate of the system was closely monitored in real time by analyzing the trend given by the Nalco Corrosion Monitor (NCM) for both mild steel and copper. The corrosion limit for mild steel and copper were 2 and 0.3 mpy, respectively. Overall, both mild steel and copper corrosion rates were maintained below the treatment limit.

An interesting phenomenon occurred in the copper corrosion rate trend. The initial copper corrosion rate shows a value far below the limit during the initial stage where the non-phosphate program was injected in high dosage. However, as the dosage was normalized, the corrosion rate increased. The increase in copper corrosion was thought to be due to the unchanged dosage of chlorine. Thus, the chlorine dosage was reduced to minimize the copper corrosion rate.

Figure 3. Steel and copper corrosion rate as read by the Nalco Corrosion Monitor

The chlorine dosage was reduced gradually. Initially, it was reduced to 80% of the original chlorine dosage. However, this effort failed to reduce the corrosion rate of copper. The chlorine dosage was adjusted to 60% of the original dosage to help reduce the corrosion rate.

This effort is also reflected in the Free Residual Chlorine (FRC) level. Before the chlorine dosage was dropped, the FRC value often fluctuated beyond 0.2 mg/l. As the phosphate level was declining in the cooling water system, the chlorine demand started to decline. Thus, the old dosage of chlorine would be high. Instead of attacking the bacteria, the program started to react with azole copper in the system. The system was unchanged, due to the lower chlorine demand given by the new non-phosphate inhibitor program.

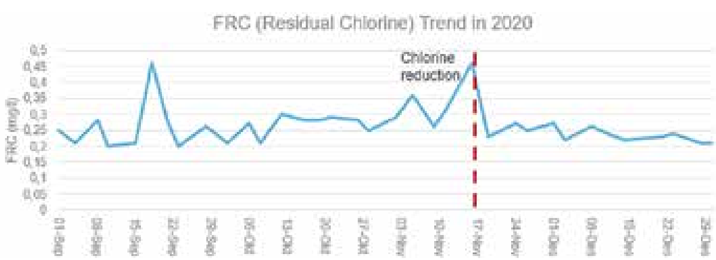

Figure 4. FRC profile during non-phosphate trial

Though the biocide dosage is lessening, the system is able to maintain adequate FRC at 0.2 ppm level. Furthermore, based on the dip slide result, the biocide population is maintained at a level below 1000 cfu/ml.

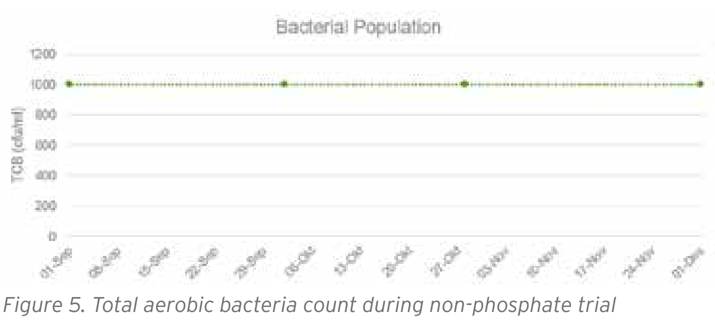

Figure 5. Total aerobic bacteria count during non-phosphate trial

In addition to the same bacteria control given by a lower dosage of chlorine in the new non-phosphate program, less chlorine also resulted in the increase of cycle of concentration. Less chlorine means the system contains less additional chloride which can operate at higher cycles before it exceeds the chloride limit of the system. As seen in Figure 4, the chloride level in the cooling tower basin was showing a declining pattern, resulting in cycles of concentration increase from 3.5 to 6.4 as shown in Figure 6.

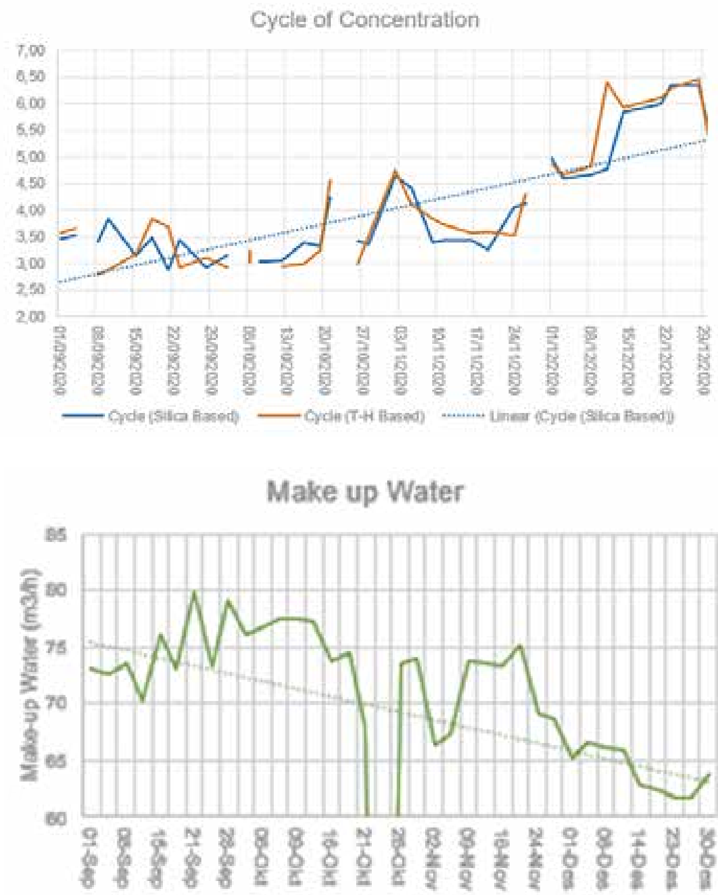

Figure 6. Cycle of concentration profile (left), and flow of makeup water (right)

Increase of cycle means lower water consumption was achieved after implementing the non-phosphate program. Higher cycles of concentration contributed to the reduction of makeup water from 73.5 to 64 m3/h, equivalent to a 14% reduction. In addition to less makeup water consumption, the cycle of concentration profile also implied that there is no excessive potential scale formation as both cycles based on silica and hardness show similar patterns. This was later confirmed by the performance of some critical intercooler in which the non-phosphate program was able to deliver a stable approach temperature for the main air compressor intercooler as shown in Figure 7.

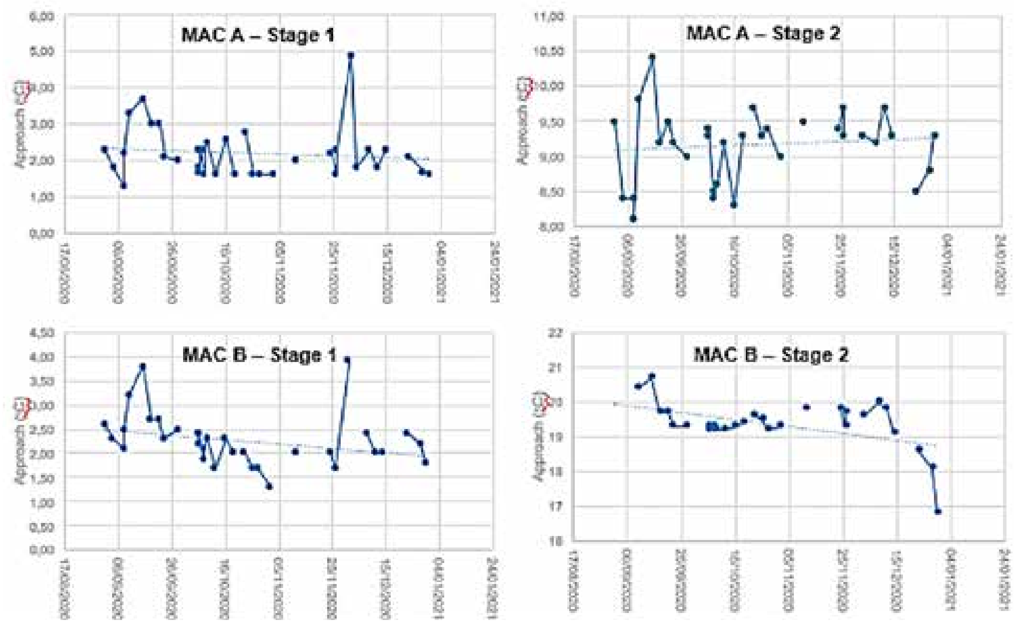

Figure 7. Approach temperature trend of MAC intercoolers

CONCLUSION

The application of a non-phosphate program addresses environmental burden by lowering phosphate discharge. The new non-phosphate program application in this air separation plant showed its capability to reduce the chlorine and acid consumption of 31 and 37%, respectively. Less chemical application leads to the possibility to operate at higher cycles, resulting in 14% annual water savings.

Nalco Water's non-phosphate chemistry showed less contribution to bacteria growth while delivering the same level of scaling control. This helped the plant to achieve stable performance in critical heat exchangers. Overall, the new non-phosphate application delivered a total of $74,100 per year and led to non-phosphate applications in other industrial sites located in Southeast Asia.

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