Best Practices in Contamination Management

Increase Operating Reliability and Reduce Total Cost of Operations in a Chemical Plant

NALCO
An Ecolab Company

CASE STUDY - CHEMICALS

CH-1896

BACKGROUND

A chemical plant located on the Colombian Atlantic Coast uses natural gas as feedstock to manufacture various nitrogen-based products that are later used to produce liquid fertilizers such as nitrogen, phosphorus and potassium and calcium carbonate.

Nalco has managed the plant's chemical programs and services at the water treatment plant, cooling towers, and boilers for more than 20 years. Nalco has implemented its Creating and Maintaining Value (CMV) business model to ensure that the chemical applications, services, and the best technologies available are designed and used in agreement with the customer's expectations, impacting their key business drivers.

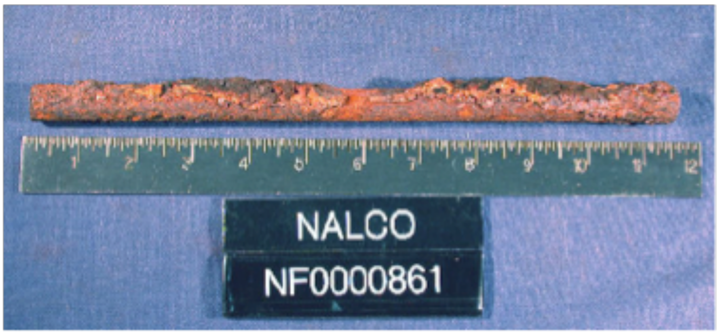
Due to the nature of the process, an environment rich in ammonia, nitric acid, and nitrosous vapors exist at this plant. Contaminations of this component can generate problems in the control of the cooling water chemical program, jeopardizing operation reliability and increasing the total cost of operations due to failures in the compressors' coolers, stress corrosion cracking in the inox metallurgies, fouling, and under-deposit corrosion in the low flow velocity heat exchangers.

SITUATION

One of the interstage coolers of a carbon steel compressor that handles syntes gas (H_2 and N_2) in the tubes and cooling water in the shell, experienced a failure after only 7 months in operation. 20 out of 70 tubes leaked during the hydrostatic test. The metallographic analysis conducted to one of the tubes concluded that the failure was due to under deposit corrosion which produces low oxygen zones that are converted into anodic areas and accelerate the corrosion reactions, in addition to the presence of high levels of corrosive chlorides ions. The under deposit corrosion problems are agravated at low flow velocities (<1 m/s).

Customer Impact	eROI℠	Economic Results
Reduction of chemical usage due to ACTI-BROM™ optimization	SAFETY	US$20,000/year
Reduction in cleaning and maintenance overhauls from 13 to zero per year	ASSETS	US$128,000/year

eROI is our exponential value: the combined outcomes of improved performance, operational efficiency and sustainable impact delivered through our services and programs.



Heat Exchangers Sample Tube sent to laboratory showing high under-deposit corrosion

Deposit composition on the tube external surface.

Table 1

Element	Weight Percent
Iron (as Fe_3O_4)	78
Chlorine (as Cl)	4
Silicon (as SiO_2)	2
Sodium (as Na_2O)	2
Phosphorus (as P_2O_5)	1
Sulfur (as SO3)	1
Zinc (as ZnO)	1
Total from XRF	90

A multidisciplinary team from the customer and Nalco was created to investigate the failures related to the situation and propose a cost-effective solution in order to recover operating reliability.

The audit revealed that the root cause of the problem was high microbiological activity due to the ammonia contaminations experienced in the process equipment. (Figure 1). Contamination problems are attributed to:

1. Reduction of the chlorine gas effectiveness as it reacts with the ammonia forming chloroamines, which have lower biocide power compared with the hipochlorous ion, making the system vulnerable to microbio contaminations, and consequently producing high fouling conditions with the microbio metabolism residuals.
2. The growth of Nitrifying Bacterias, such as Nitrobacter, which convert the ammonia into nitrite (NO_2), producing corrosive acid conditions in the system. This type of corrosion is accelerated by localized low pHs and the presence of Nitrobacter.
3. High pH (pH>9.0) localized zones (ammonia leaks in specific equipment) which produced unexpected precipitation of scale forming salts in the system.
4. Increase of chloride levels in the cooling water due to a higher chlorine gas consumption to counteract the effectiveness lost and limiting the cycles of concentration in order to maintain the chloride levels < 200 ppm as Cl in the presence of SS304 metallurgy.

In Figure 2, bacteria counts increased during the ammonia peaks in the cooling water.

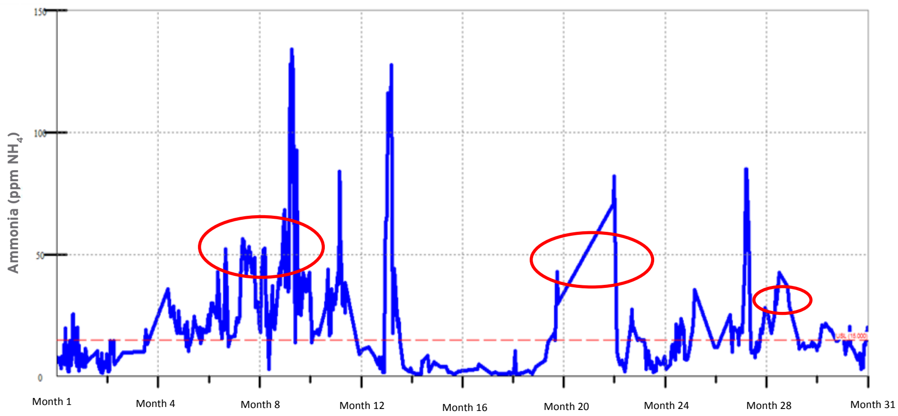


Figure 1 – *Ammonia in Cooling Water*

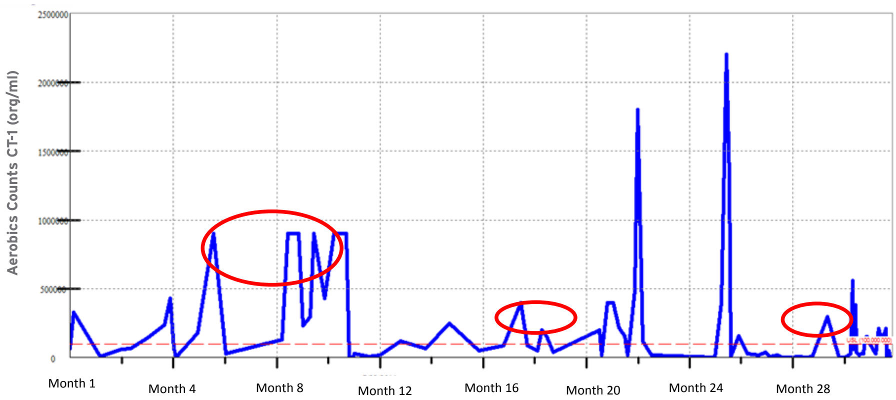


Figure 2 – *Bacteria Count in the Cooling Water*

Permanent injections of large amounts of chlorine and soda become necessary under these conditions to achieve minimal control and then chlorides exceed maximum permissible levels. See Figure 3.

SOLUTION

Using the Nalco engineering approach (Mechanical-Operational-Chemical) the following recommendations were proposed:

1. Backwashing all the heat exchangers that have this type of system available.
2. Identify and repair all equipment with ammonia leakage in order to reduce the ammonia levels <15 ppm in the cooling water.
3. Improve flow conditions in order to avoid areas or equipment with low flow velocities that promote deposit formation.
4. In order to counteract the ammonia contaminations in the cooling water system and the cooling tower, Nalco recommended a sanitization and de-contamination program using a non-oxidizing biocide and biodispersant that will also allow the chlorine gas performance recovery as the primary microbio control agent. This program should be maintained while the ammonia contaminations exists.
5. Implementing an oxidant chlorine-bromine program (ACTI-BROM) to improve the microbio control effectiveness.

RESULTS

After ACTI-BROM implementation at a ratio of 4:1 (Cl:Br ratio) the ORP was increased to average readings of 350 mV as a consequence of a lower microbio activity. It was also reported a higher chlorine free residual and lower bacteria counts as observed in Figures 4, 5 and 6.:

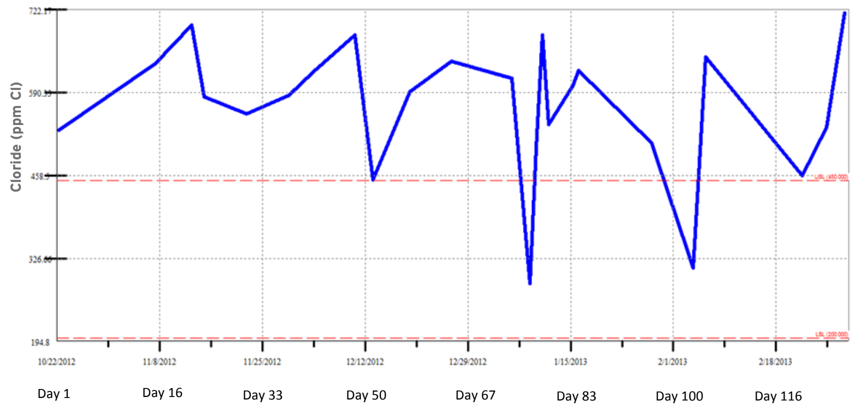


Figure 3 - *Chloride in the Cooling Water*

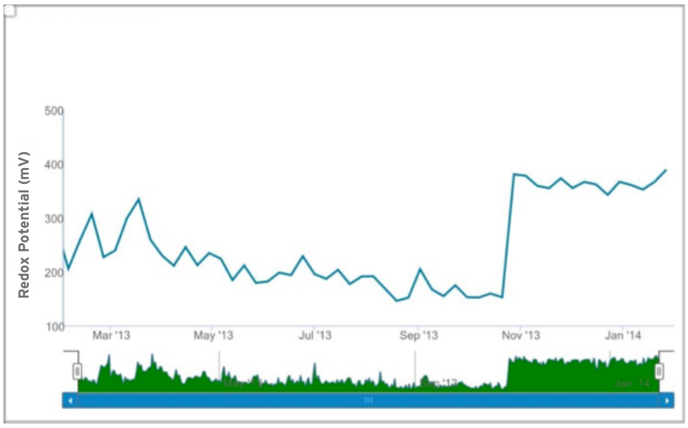


Figure 4 - *ORP reading after ACTI-BROM*

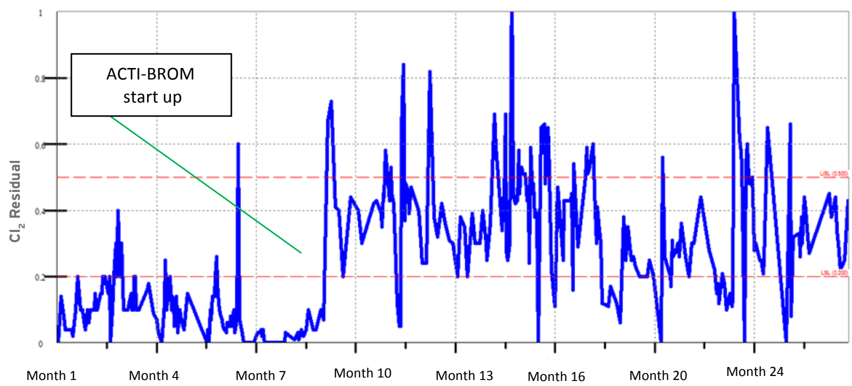


Figure 5 - *Free Chlorine Residual after ACTI-BROM*

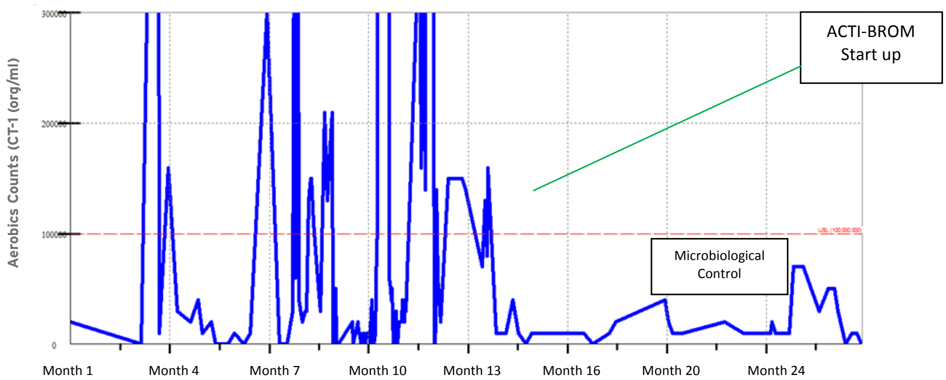


Figure 6 - *Bacteria Count in the Cooling Water After ACTI-BROM*

After the implementation of ACTI-BROM, the activity of Nitrosome bacteria, which converts ammonium into nitrite, and Nitrobacter, which converts nitrite to nitrate, was reduced to a minimum. Figure 7.

Another identified benefit of better microbio control was the reduction of chlorine gas and caustic soda consumptions, which impacted, cooling water conductivity, reducing it from 4,200 uS down to 2,700 uS. This lower conductivity reduces the water corrosivity. Figure 8 showed the conductivity reduction after Nalco recommendations were implemented.

Chlorides were reduced by 60% decreasing potential failures of stainless steel equipment.

The corrosion velocity for mild steel and copper was under control, resulting in readings well below the maximum targets of 3 mpy for the mild steel, and 0.3 mpy for the copper, respectively.

Significant savings were achieved in the chemical program using ACTI-BROM, and total costs of operations are summarized below:

1. Reduction of approximately 60% in gas chlorine consumption and chloride content in the cooling water
2. Reduction of approximately 35% in the cooling water conductivity due to lower gas chlorine and caustic soda usage, resulting in a less corrosive water.
3. Excellent microbiological control in the cooling water systems at the ammonia, nitric acid, and power plants, even with high contaminations of ammonia and nitrous gases.

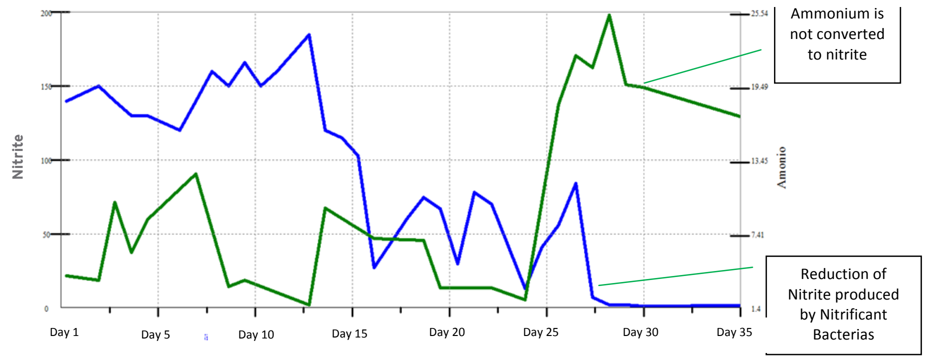


Figure 7 – *Bacteria Count in the Cooling Water After ACTI-BROM*

Figure 8 – *Cooling Water Conductivity*

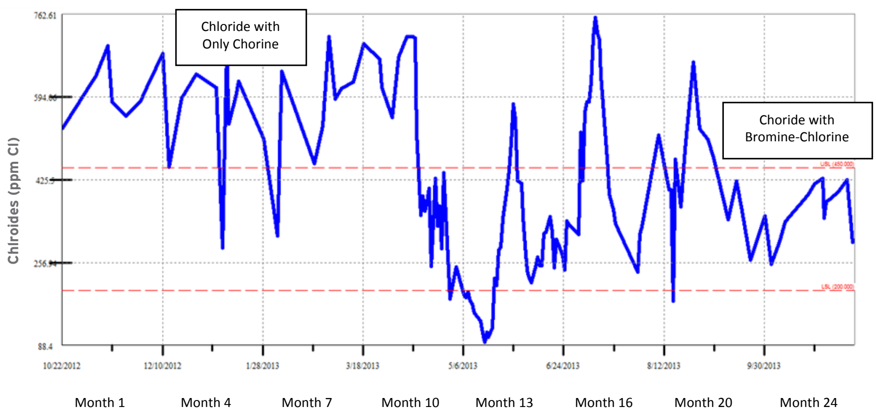


Figure 9 – *Cooling Water Chloride*

4. Reduction of 21% on chemicals used for water treatment with a total impact of US$20,000 USD/year.
5. Reduction in total annual failures in the compressors coolers with a significant impact in maintenance and production costs for the plant of 128,000 USD/year

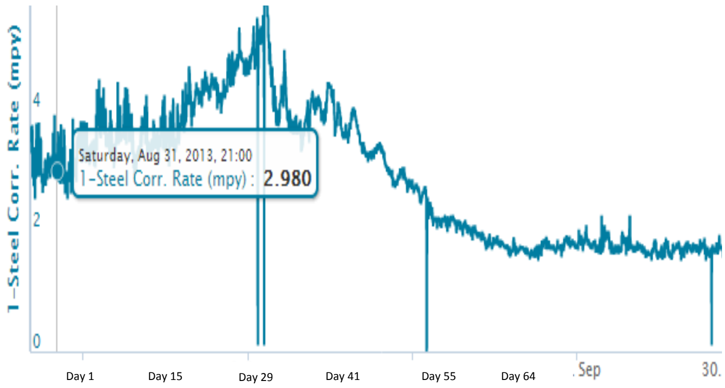


Figure 10 – *Corrosion Velocity: Mild Steele*

Nalco, an Ecolab Company
North America: ***Headquarters*** – 1601 West Diehl Road • Naperville, Illinois 60563 • USA
Nalco Champion – 7705 Highway 90-A • Sugar Land, Texas 77478 • USA
Europe: Richtistrasse 7 • 8304 Wallisellen • Switzerland
Asia Pacific: 2 International Business Park • #02-20 The Strategy Tower 2 • Singapore 609930
Latin America: Av. das Nações Unidas 17.891 • 6° andar • São Paulo • SP • Brazil • CEP 04795-100

nalco.ecolab.com