Hydrosol System
Furnace Cooling Water Cleaning
Case Study: North American Stainless

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I. Subject

Controlling piping system scaling and/or fouling due to contaminants within reheat furnace cooling water piping, and similar systems ensure efficient operation of cooling water systems thereby eliminating costly equipment repair and production downtime. Customized high velocity pipe system cleaning and preventative maintenance can improve and maintain cooling efficiency of these water systems. In this technical brief we will discuss how fouling occurs, the effects of foreign contaminant buildup on piping system thermal conductivity, and how the implementation of a regular preventative cleaning will maintain an efficient thermal conductive system thereby optimizing your cooling system.

II. Piping System – Scale Buildup and Monitoring

Although not the same phenomenon, in general scaling and fouling is defined as the deposition of undesired contaminants on heat transfer surfaces. Both have a cumulative negative impact on the thermal and mechanical performance of cooling water piping systems, heat exchangers, and similar components. Beyond a reduction in thermal transfer efficiency of the piping system, a reduction in fluid flow and an increase in rate of corrosion occur thereby further causing an indirect however growing reduction in heat transfer within the system.

The mechanisms of scale buildup and fouling on cooling surface walls occurs in two ways 1) by **impurities** within the cooling fluid precipitating out (as water is heated and evaporates in a cooling system vapor is lost and dissolved solids continually concentrate in the remaining water, this concentration builds within the system until the contaminant forms deposits on hotter surfaces of the furnace piping system) and 2) by **corrosion** particles building up within the water until they adhere or settle within the walls of the system components. With time, these contaminants harden while the continuous buildup results in an accumulative effect resulting in the erosion of thermal transfer capabilities of the cooling system where the cooling media does not carry away as much heat as desired thereby the heat stays in the piping.

Beyond the potential for reduced thermal conductivity and reduced fluid flow due contaminant buildup, an additional concern is the formation of hot spots which could result in a catastrophic failure of the pipe wall due to local overheating. Local scale buildup on pipe walls can occur at hot spots within a piping system further compounding the challenge of cooling these local areas. With the passage of time the reduced cooling will result in extreme hot spots which are an area of potential failure, resulting in leakage, of the pipe if the scale is not removed.

Common contaminants found in the scaling of cooling water systems include calcium, silica, and iron. As these contaminants precipitate they form solid deposits on the piping system walls and insulate the metal surface from the cooling water, restricting heat transfer and fluid flow. Common compositions and thermal conductivities alongside that of the Steel base metal are shown in Table 1.

Material	Thermal conductivity - kcal/m2.h per degree C
Steel	15
$CaSO_4$	1 - 2
$CaCO_3$	0.5 - 1
Iron Oxide	0.5

Table 1: Common composition of pipe wall contaminants

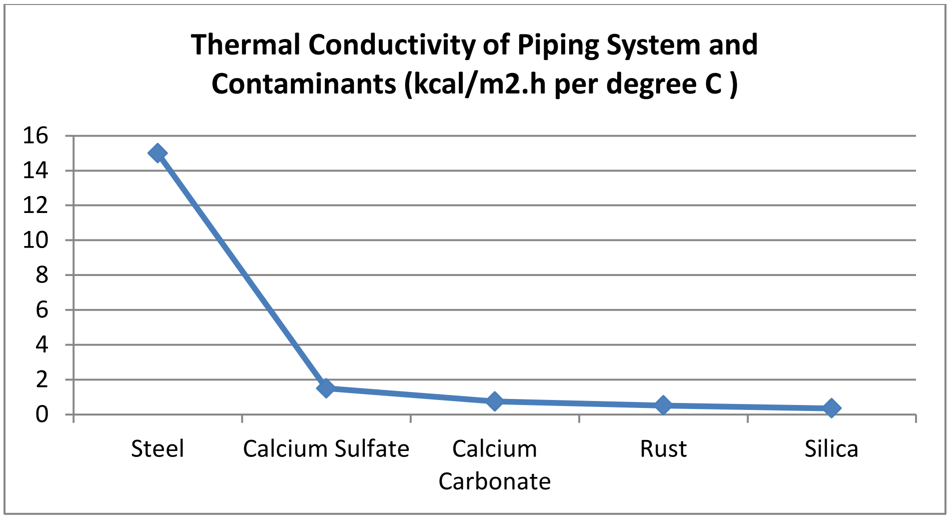

Figure 1: Thermal conductivity of steel and water contaminant buildups

Common scaling buildup contaminants and their identification:

Calcium **sulphate deposit** crystals are small and fit together tightly forming a hard and dense surface. Calcium sulphate deposit is brittle, and its interaction with acid will produce calcium chloride and hydrogen sulfate; however its removal by chemical cleaning can pose a challenge via traditional methods.

Calcium **carbonate deposit** is often porous and loosely packed and the scale looks dense, uniform, and white in color. When the deposit interacts with the acid solution it becomes calcium chloride which stays in solution and carbon dioxide gas is released causing the solution to bubble and the gas escapes.

Iron deposits originate from either corrosion in the system or iron in the cooling water and are dark color. Iron deposits are soluble in hot acid and turn the acid solution a dark brown color.

Silica crystals are very small therefore the deposit is very hard which results in an impervious scale on the pipe surface. The scale is extremely brittle and is light in color and its removal by chemical cleaning can pose a challenge via traditional methods.

Monitoring

Corrosion and contaminant buildup can be monitored by periodic measurement and visual inspection of coupons placed within the system. Coupon weight loss provides a quantitative measure of the corrosion rate and the visual appearance of the coupon provides an assessment of the type of corrosion and the amount of deposition in the system. Hydrosol System offers the service of performing a periodic review of the coupons to assist in creating a cleaning schedule and process.

III. Cleaning Process – NAS Reheat Furnace

Prior to project execution, Hydrosol System performed pre-job engineering in coordination with the NAS to ensure a smooth and efficient system cleaning; critical variables are looping, valving, and any specific issues being observed. This knowledge was used by Hydrosol System to engineer a custom cleaning process.

Hydrosol System arrived at the jobsite with tooling, pumping, tanks, connection hoses, chemical, and highly trained chemical cleaning personnel including one project supervisor. Upon arrival Hydrosol System temporarily places their cleaning system in series with the cooling water loop, this pump system was used to circulate and inject cleaning fluids. Careful consideration is performed in the pre-engineering to ensure each leg of the system can be isolated to create flow velocity and allow Hydrosol so concentrate on "trouble spots" within the cooling water system. Likewise proper valving and looping assists technicians in proper system flushing and cleanout.

Phase one of the cleaning process is the circulation of water and inspection of the entire piping system to ensure no leaks exist. Upon successful inspection of cooling water system, Phase two begins with injection of Hydrochloric Acid (HCL) with corrosion inhibitor added to protect the system from corrosion. The inhibited HCL is circulated in the system and begins removal of scaling. Hydrosol System technicians closely monitors the ratio of HCL within the system by performing on-site testing. As the HCL removes scaling it either becomes tied up within cleaning solution or heavy particles fall into the baffled cleaning tank. This results in rises and falls in the ration of HCL in the cleaning solution. Circulation continued around the clock until a level of equilibrium is attained for an extended period of flushing time, this indicates scaling is no longer being removed from the pipe system and therefore an acceptable level of cleanliness has been achieved. An example graph of this cleaning cycle is observed in Figure 2.

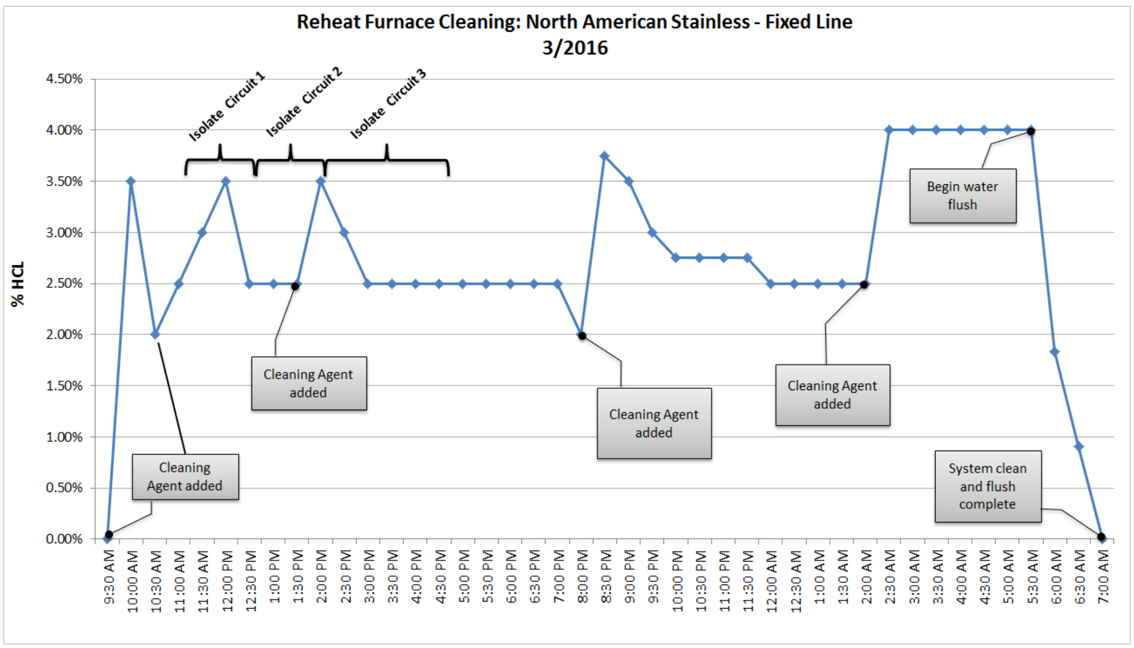

Figure 2: Graph of cleaning process for Cooling Water System, NAS

IV. Results

As described previously, pre-job process engineering is an important variable to ensure the success of the project. Hydrosols' understanding of the system and issues being observed assist in the engineering a suitable process. In execution of the project, Hydrosols' continuous monitoring of the cleaning process allows them to use the pre-engineering knowledge combined with real-time observed chemical reactions to properly focus on specific portions of the system as results indicate.

A third indicator of cleaning progress is the volume of sludge deposited in the baffled mixing tank. The NAS Reheat flush was performed for a period just under 24 hours and resulted in the removal of approximately 10 ft^3 of scale sludge within a piping system of approximately 600 gallons which amounts to several hundred pounds.

V. **Conclusions**

Heat exchanging systems are critical components in many manufacturing industries and require consistent monitoring and maintenance to preserve their thermal efficiencies which will result in avoided downtime and costly repairs. Contaminant buildup has a major impact on cooling efficiency as shown in Figure 1 and is resultant of either corrosion in the system or from contaminants in the cooling media itself both of which bond to the walls of the piping in the cooling system. The subject of scale buildup is complex and the type of scaling is unique to each system requiring trained chemical cleaning technicians to evaluate each system for development of a specific cleaning process and schedule.

With proper maintenance, your most critical assets can be protected for decades of high performance and peace of mind.