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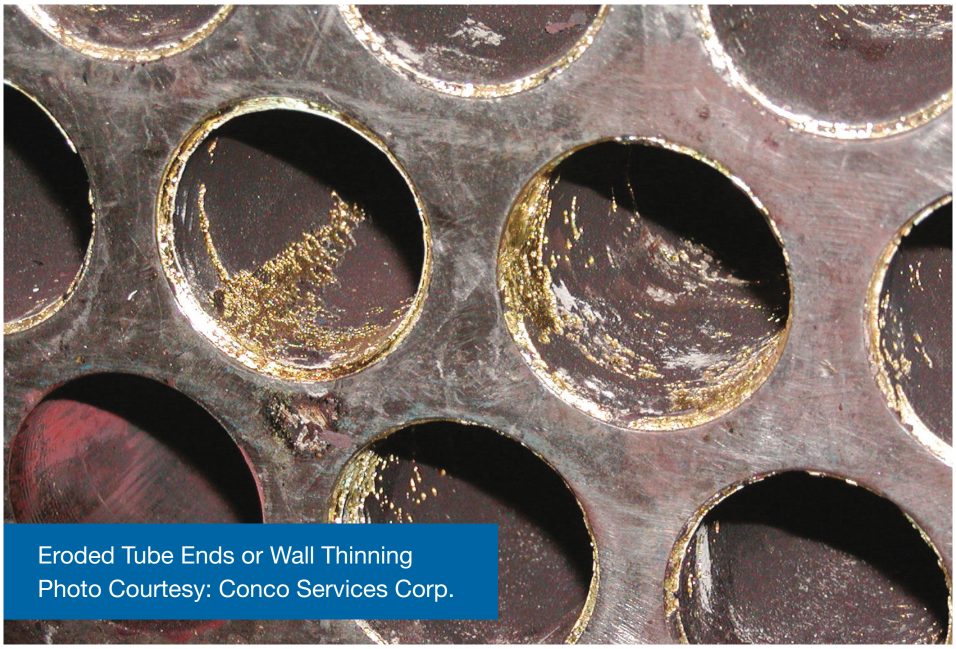
A Journey to Improve Condenser Performance

BY BARRY VAN NAME

While there is an industry-wide understanding that compromised condenser tubes reduce unit performance in the short term, the long-term effects of this neglect can be detrimental, forcing unplanned outages and loss of revenue.

"In our work with engineers and project managers on site, we often see that these people have so much on their plates, so much responsibility," said George E. Saxon, President of International Markets at Conco. "The sense of relief is palpable when we formulate a plan to get their unit condensers and heat exchangers back up and running, working at close to specification again. It's a dynamic process and very rewarding for everyone involved."



Eroded Tube Ends or Wall Thinning
Photo Courtesy: Conco Services Corp.

Saxon noted that when a unit is struggling to meet megawatt demand, a thorough condenser analysis and cleaning can have very dramatic results.

Recovered megawatts in the condensers can mean hundreds of thousands of dollars recouped for just that unit in a very short time, usually weeks or months. "Most advantageous for the power generation plants," said Saxon, "is that the expected results can be quantified and the return on investment can be calculated prior to a contract being signed or a technician setting foot on site."

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So why is it so important for condenser tubes to be cleaned and inspected? Over time, as condenser tubes become fouled with deposits, heat is not transferred efficiently, the cooling process is compromised and there is a noticeable reduction in unit output. In addition, under-deposit corrosion can occur in condenser tubes as the deposition material causes damage to the tube wall. A breach or tube leak can cause damage to other components in the unit system. An unfortunate but common scenario is for cooling water to enter the condensate and travel through the boiler and into the turbine.

THE INSIDE OF FOULING

The contaminants that build up and damage condenser tubes over time run the gamut from soft and sticky to extremely hard, and often depend on the geographic location and cooling water source of the plant.

In power generation plants in the Midwest U.S., for instance, condenser tubes are often filled with calcium carbonate deposits, whereas in coastal southeastern U.S. plants, microbiological, particulate and sediment are the frequent culprits.

Plants obtain all-important cooling water from either fresh, brackish or seawater sources, and the unique chemistry of a water source presents a unique set of fouling problems. Particulate fouling is the process of debris from water sources settling on to the surface of a condenser tube. Particulate matter can be natural sediment or bio-growth, and this fouling is often the result of low-flow conditions in the condenser. If left unaddressed, particulate fouling will cause damage to condenser tubes and adjacent components.

When the saturation point of dissolved constituents in the cooling water is exceeded, another type of fouling called scaling or crystallization occurs. Scale deposits, such as calcium carbonate, are known to be some of the most tenacious condenser tube fouling issues.

Scale deposits are also more likely to form in high temperature conditions, and in condenser tubes this buildup of scale is detrimental to heat transfer. Like other types of fouling, scale deposition can cause under-deposit corrosion and even erosion-corrosion around the scale itself. Removal of the scale is necessary to return the condenser to optimum efficiency.

Mechanical tube cleaners with precision cutting blades have been engineered to break through the hard shell-like coating, while safeguarding the valuable tube wall.

Microbiological fouling is caused by high bacteria content in the cooling water and low velocity flow. This type of fouling can result in substantial particulate deposition as fine matter adheres to the sticky biofilm coating of bacteria on the tube wall. Worse yet, the thickening deposits produce corrosive bacterial by-products that can eat through the base metal of the condenser tubes.

A condenser's inlet tube sheet is the entry point into the thousands of condenser tubes that comprise a unit. Debris and macrofouling of this important gateway can cause condenser efficiency problems. Depending on the plant's water source, debris can include sea grass, mud, leaves, sticks and even large particulates from the cooling tower. When sea water is used for cooling, the most frequent culprits of macrofouling are aquatic wildlife and shellfish. While filters are in place at most plants, debris often makes its way to the tube sheet, causing partial blockages and reduced flow through the condenser tubes.

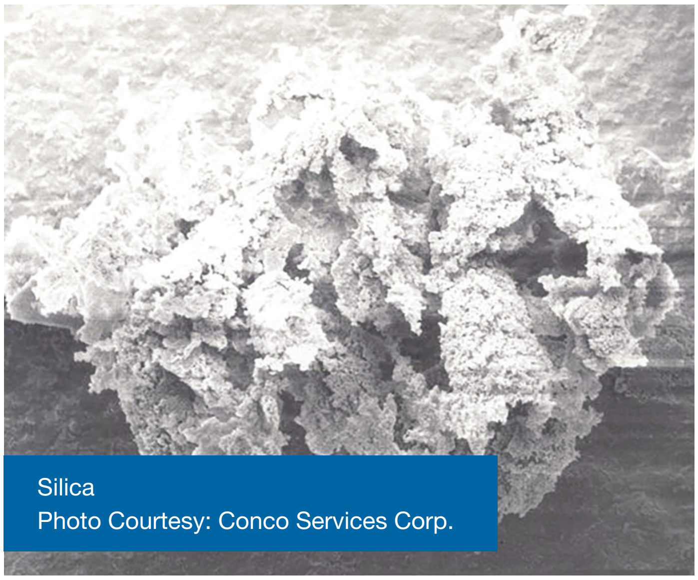
The resulting partial flow blockage will allow particulates to accumulate and local flow around the deposits may cause erosion-corrosion. To ensure that the tube sheet is free and clear to operate, debris screens and filters should be inspected and cleaned on a regular basis.

Not all condenser tubes are alike. Knowing what they are made of provides a necessary understanding of why some condenser tubes are more prone to fouling. The three most common materials used for power plant condenser tubes are: copper, stainless steel and titanium.

Copper is a natural antimicrobial material, and while copper condenser tubes disrupt the growth of some microbes, they are also prone to the formation of a hair-like oxide deposition that will disrupt heat transfer if left unattended. Stainless steel tubes are prevalent in midwestern U.S. power plants and are generally considered high-performing tubes. The most important consideration for stainless steel tube maintenance is keeping them clear of slime and microbiological deposits. Titanium condenser tubes are a more recent addition in condenser production.

Titanium has good heat transfer characteristics, the tubes do not corrode, and there is a longer incubation period before the first cleaning is needed, after which, fouling will occur at the same rate as stainless steel tubes.


Under Deposit Corrosion
(Pitting Due to Manganese)
Photo Courtesy: Horizon Image Sciences


Silica
Photo Courtesy: Conco Services Corp.

THE CONSEQUENCES OF FOULING

Unfortunately, there are serious economic consequences to be endured by power generation plants when condenser tube fouling progresses and tube perform-

Conco Cal-Buster and Calcium Scale
Photo Courtesy: Conco Services Corp.

Stainless Steel Condenser Tube
with Calcium
Photo Courtesy: Conco Services Corp.

ance is impaired. Increased turbine back pressure, increased unit heat rate, increased losses to cooling water, increased $C0_2$, and increased N0X emissions can lead to dramatic losses in unit output, unit availability and, undeniably, revenue.

Fouling that is severe enough to cause tube failure can also lead to damage in other unit equipment as contaminants enter the condensate. Because the stakes are so high, effective diagnostic testing to determine the nature and severity of tube fouling conditions must be done.

Deposit sampling, fouling monitors, computer-based performance analysis and borescopic examination are effective diagnostic approaches that pinpoint and clarify fouling conditions.

THE IMPORTANCE OF CLEANING

Once analysis has yielded important data on the nature and severity of fouling, cleaning the tubes is the next step.

There are four primary cleaning approaches to cleaning fouled tubes: chemical dissolution, hydrolancing, continuous online cleaning systems and mechanical tube cleaning.

Use of chemicals can be complicated. While each fouling scenario will require a unique chemical cleaning strategy, there can be economic costs associated with disposal of used chemical agents and legal restrictions on what can be used and where because of valid environmental concerns. When chemicals are used, the use of high volume water to flush the chemical out of the tube may remove residual deposits, and avoid acid degradation of the tube metal.

The effectiveness of hydrolance cleaning is dependent upon the random lance travel speed, the nozzle used, and of course, the deposit and fouling conditions of the tubes.

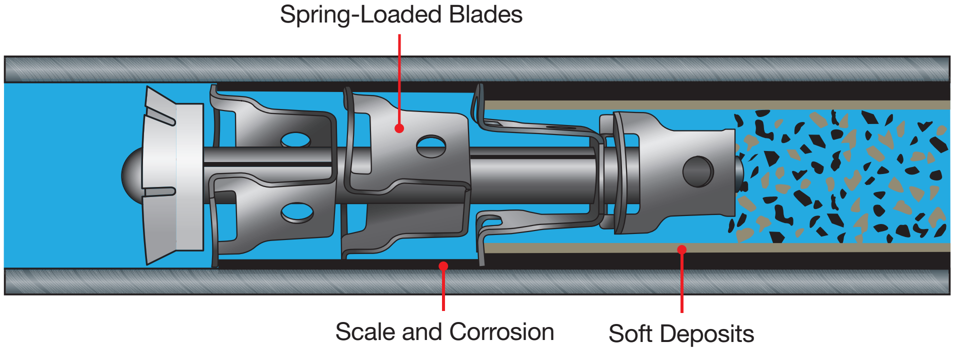
When hydrolancing, water travels at 20,000 psi or more. The hydrolance method can be dangerous for wall thinning and tube-to-tubesheet joints, and cannot be used if tube coatings are in place.

In drought-stricken regions where water conservation is paramount, consider that hydrolancing a unit with 5,000 tubes will consume well over two million gallons of water.

By contrast, mechanical tube cleaning the same unit would consume less than nine thousand gallons of water.

Some plants opt for online cleaning systems. While they work to a general extent, there are several shortcomings. Most notably, not all tubes in the condenser are effectively cleaned by the online system because there is a random, uneven distribution of cleaning balls, allowing deposits to continue to accumulate in a portion of tubes. Moreover, the balls do not remove obstructions, and they can become lodged within the tube, becoming an even greater obstruction than the deposition related to source water.

When online ball systems are installed, online cleaning and offline mechanical



Industry Standard Metal Tube Cleaner in Tube
Photo Courtesy: Conco Services Corp.

cleaning should be viewed as complementary technologies, each achieving specific objectives: restoring cleanliness and maintaining cleanliness.

A complete analysis of return on investment should take place when considering an online cleaning system. Online ball cleaning systems are expensive and operating costs are high, requiring maintenance, consumables and spare parts that, combined, can equal the cost of two mechanical cleanings.

Technicians Shooting Condenser
Photo Courtesy: Conco Services Corp.

Mechanical condenser tube cleaning is the option most frequently chosen by power generation plants in the U.S. Mechanical cleaning is generally applicable in most situations because it is fast, effective, very safe and easy to use. Most importantly, it improves heat transfer and provides protection from under-deposit corrosion.

Once tubes are cleaned with mechanical cleaners, water flow will be restored and the condenser returned to an as-new state.

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Compared to other cleaning methods, mechanical cleaning minimizes unit downtime during the cleaning process because a typical team of technicians can clean 5,000 tubes during a ten-hour shift.

It is often the case that a unit can be cleaned over a weekend and brought back online by the following Monday morning, generating megawatts and revenue.

There are numerous cleaning strategies available that are safe and effective on all types of deposits.

In selecting the best cleaning strategy with the appropriate mechanical cleaner, fouling deposits, corrosion products, physical obstructions and tube surface roughness will be removed quickly. An effective strategy can be formulated before a technician arrives on site and before a unit goes offline, by trial cleaning of a unit's tube sample.

In figuring your return on investment with mechanical tube cleaning, consider cleaning 24,000 1" O.D. x 20 BWG tubes in a typical 625 MW unit.

The estimated cost to clean these tubes is $32,400. We know from industry reports that the cost of fuel for a rise of 0.3 Hg in backpressure in a 600 MW unit would be $562,500. With a cash flow out of $32,400 and cash flow in of $562,500 there is a net present value of $530,100.

This calculation reflects a +1,636% return on investment. A comparable return on investment is achievable with your own plant's condenser cleaning.

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