Find Condenser Tube Leaks with Ultrasound

By Allan Rienstra, SDT Ultrasound Solutions

Executive Summary

Power Generation facilities aim to run at maximum output during uptime and manage downtime such that it has a minimal effect on efficiency.

Turbine efficiency is negatively impacted by tube leaks in the condenser. Leaks cause contamination of pure water used for steam. When contaminant counts reach alarm states pressure must be lowered reducing output. The turbine continues to run in a low capacity mode until the leaks are found and isolated.

Results Engineers must choose between:

- Treating the symptons with a system flush or
- Fixing the problem by finding leaking tubes and plugging them, thereby removing them from service.

Often the system flush is chosen as a fast path to restoring optimal output in the shortest length of time. However with ultrasound technology locating tube leaks is quick and safe. It`s now a clear choice to fix the problem properly instead of applying a bandaid.

The benefits to use ultrasound include:

- Reduced time required to find leaking tubes.
- Worker safety is improved.
- Fewer personnel required reduces labour costs.
- Less coal is consumed, therefore less CO2 and less ash produced for a lighter environmental impact.

Case Study – AB Brown Power Plant, Mt. Vernon, Indiana

Data and situational contributions by Bill Phipps, Production Manager, Vectren Corporation

Author’s Bio

Allan Rienstra is the President of SDT North America and Director of International Business Development at SDT International. During his 25 years involved with ultrasound he has helped thousands of companies create world-class ultrasound programs. SDT’s clients are supported by a global team spanning 40 countries, 4 continents, and countless languages.

You may contact the author directly: allan@sdthearmore.com

Introduction

Heat exchangers come in many shapes, sizes, and configurations. Their purpose; to efficiently transfer heat energy from one medium to another while keeping those media separate.

Sometimes called “surface condensers”, these installations are used in a variety of industrial applications. We find them in refineries, water and wastewater treatment facilities, food processing, and power generation to name just a few.

Shell and tube heat exchangers consist of a bundle of steel tubes entombed in a shell. For the installation to perform effectively both bundle and shell must be leak free.

Two fluids of different temperature flow freely through and around the tubes. Separated by only the thinnest of steel, the transfer of heat energy is completed without the mingling of a single molecule.

Heat exchangers function under extreme high pressures and temperatures; conditions which, over time, contribute to failure modes that impact the installation’s integrity. A common cause of failure is corrosion. The corresponding effect is tube leaks.

In fact the bundles consist of thousands of tubes; which provides excess capacity to accommodate leaks. Corroded and leaking tubes only need be plugged to effectively remove them from active duty. The exchanger can continue to function so long as a sufficient number of functional tubes remain. The leaking ones are by-passed.

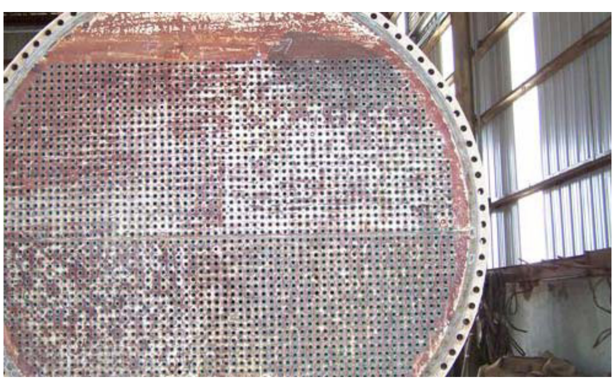

Figure 1 - Condensers May Consist of 1000s of Tubes

There are systems in place to notify operators of the increasing presence of tube leaks. Tube corrosion can be attributed to increasing levels of contaminants like sulfates, organic acids, and chlorides.

One method used to identify contamination is to measure condensate samples for cation conductivity. Cation conductivity measures the electrolytic conductivity of a water sample and reports it in micro Siemens per centimetre (uS/cm).

Silica and sodium levels are monitored constantly. When they exceed acceptable levels (measured in parts per billion (PPB)) it’s time for action. If not, silica deposits on the tube walls and creates scaling.

Corroded leaking tubes allow the two separated media to merge. Contamination of highly pure steam and water transfers downstream to other system components.

Formations on turbine blades, pump vanes and valves diminishes their efficiency, creates imbalance, and forces drive components to work harder just to maintain output.

Figure 2 - Scaling Creates Vibration and Imbalance

Increased vibration levels accelerate component deterioration. Originally, tube leaks were caused by corrosion. Add in the juddering and jarring from vibration and new leaks appear in the form of cracked tubes.

Two Action Paths to Consider

Results Engineers have two paths of action when silica and sodium level are high. With either choice, the station is forced to run at a lower output capacity for the duration of the maintenance.

Simple action is non-intrusive and fast. It involves valving off one side of the condenser and flushing the system. Acceptable sodium and silica levels are quickly restored and the generator unit is back to full capacity fast.

In human terms, it's a detox. A detox is temporary. It treats the symptoms, but doesn't address the problem. In the human example, bad diet and lifestyle is the culprit. In the condenser example its leaking tubes.

Flushing the tubes has environmental consequences. Old water must be disposed and replaced with new. The unit runs at reduced power, burning more coal, while producing less megawatts.

The leaks haven't been repaired. Levels of sodium and silica will rise again. Another flush will be necessary soon.

The other action choice is to identify the leaking tubes and plug them; effectively removing the leakers from service. This is the better solution because it treats the cause. But it too carries a downside.

Figure 3 - Leaking Tubes are Plugged Out of Service

Looking for leaks can be unpredictably more time consuming than a system flush. Depending on the tools used for leak detection, you can be looking at a few hours, a day, or even longer. This needs to be communicated clearly so enough time is budgeted to do the job properly.

Safety is an issue always. Inspectors are exposed to confined spaces and high levels of heat and humidity. The condenser is at or near operating temperature. They must work in teams; never alone. Personal hydration is paramount.

Case Study – AB Brown Power Plant, Mt. Vernon, Indiana

Bill Phipps is Production Manager at the AB Brown Power Plant in Mt. Vernon, Indiana. Located on the northern bank of the Ohio River, AB Brown is a four-unit, 700MW power generating facility.

Figure 4 - AB Brown Power Plant, Indiana

Two of the units are coal fired and the other two are gas. The coal units depend on leak-free condensers to operate efficiently. Water from the cooling tower passes through the inside of the tubes. Steam exhausted by the turbine passes over the tubes and is transformed back into condensate as ultrapure water. The water is returned to the boiler and converted back to steam.

The steam side of the tubes maintains 27 inHg (inches of mercury) vacuum. Any tube leak allows the water from the cooling tower to pass through and foul the ultrapure water with sodium and silica. Condenser tube leaks increase the silica and sodium counts in the boiler water and steam. Once the silica and sodium in the boiler water reach 750 ppb they are forced to lower pressure on the Unit and lose Megawatt production.

January 2015 – Silica and Sodium Levels are Rising

The next image shows a graph trending higher silica and sodium levels in the cooling tower water on Unit One. The presence of contaminants is below the 750 ppb threshold but it puts Phipps' team on notice.

On 01/14/2015 his team isolated and drained the half of the condenser (Unit 1, 216) with the leak.

The green line represents the sodium levels and it immediately dropped, however it takes a while for the silica levels to respond to the flush. The red line shows the gradual drop in silica. These levels will eventually rise again unless the tube leaks are found and isolated.

Rising sodium and silica levels in Unit 1 indicate small tube leaks. After the condenser was flushed on 01/14/2015 normal levels were restored... for now.

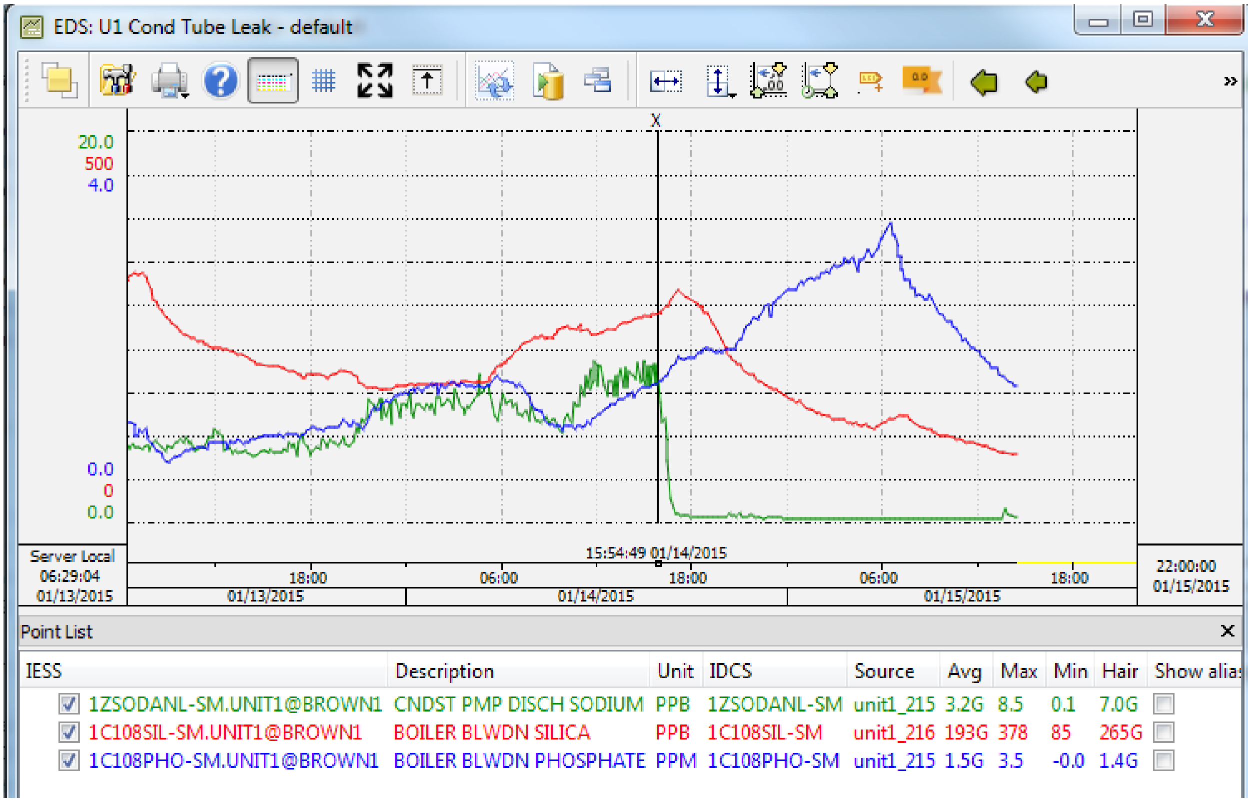

Figure 5 - Gradual increases in Sodiam (Green) and Silica (Red) indicate leaking tubes.

Meanwhile, sensors also indicated high levels of sodium and silica in Unit 2. With valves they isolated and drained the half of the condenser with the leak. See the next graphic.

They knew they had a tube leak in Unit 2's condenser. During a planned outage they did a dye hydro on it to locate the tube leak. This graph of Unit 2 shows the difference in the silica and the sodium when a tube leak is present. Disregard the area between 1/9 and 1/12 as this was the area that the Unit was offline and the condenser tube side was filled with water and dye. Just look at the

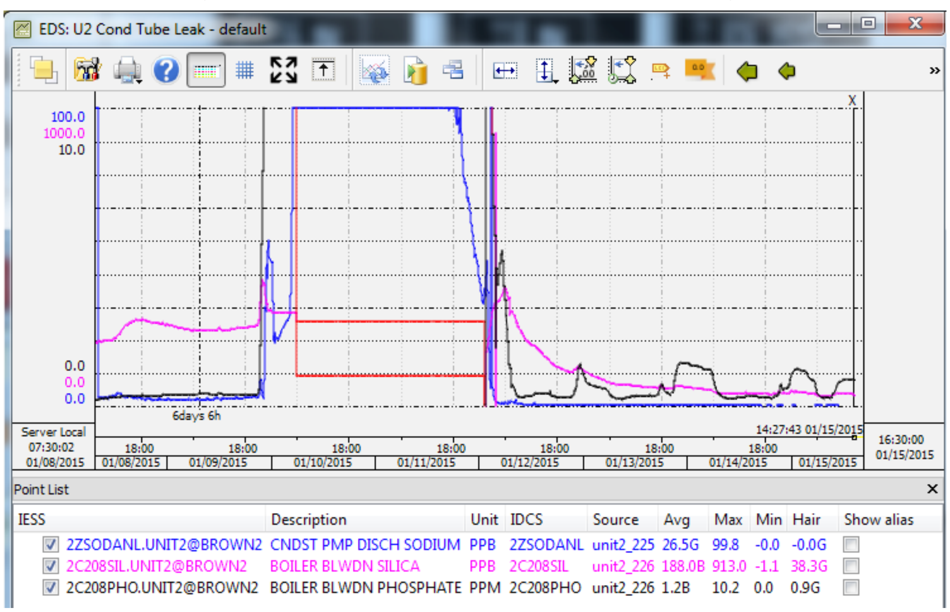

Figure 6 - Spike above 1000ppb in Unit 2 is a leak that needs immediate attention

difference in the "pink" (Silica) amplitude before and after.

A significant tube leak on Unit 2 caused reduction in output. The Unit was shut down on 1/10 and 1/11 for a dye test. Leaks were found and isolated. Silica levels restored to normal by 1/13 and 1/14.

Phipps and his team are experienced at battling condenser tube leaks.

"We usually helium leak test for Condenser Tube Leaks." Says Phipps. "The water side (inside) of the tubes are drained – the outside of the tubes (Shell) is under vacuum. The helium detector inlet is inserted into the vacuum pump exhaust. Helium is sprayed around on the water side of the tubes. We have a box fabricated that allows us to narrow the area of a condenser tube leak down so that we shoot areas of the tube sheet instead of shooting each individual tube. Once the general area is located, then individual tubes have helium shot in them.

"We had helium leak checked this half of the condenser 3 times, but determined that the leak was so small we could not find it. It requires half of the condenser to be taken out of service to leak check. This has a negative effect on heat rate, as well as during the summer months – Generator Output due to the backpressure created on the low pressure turbine."

"We have the equipment and trained personnel to perform the Helium leak check. Since none of us had ever "heard" a condenser tube leak using the Ultrasound equipment, and when the leak increased to a point that we thought we could locate it, the half of the condenser was again isolated."

"A helium leak check was then performed and the two leaking tubes identified using Helium. I had instructed the Results Engineer and Maintenance crew that if they could find the tube leak using helium, I then wanted them to use the SDT270 unit to "listen" to what a tube leak sounded like. When performing a Helium Leak Check the time involved is at least a day per condenser half. We hoped to reduce that time using the ultrasound."

"Once the two tubes were identified – the Results Engineer took the SDT270 Unit into the Condenser. He started in an area that the helium had not identified a leak. He did not use the precision tip but just "scanned" the area. He said he heard nothing in the areas where the helium had not detected a leak. However when he waived the SDT270's airborne sensor in the area where the tube leaks were known to exist, he started hearing noise. As he continued scanning over the tubes that were leaking he could hear a "psssst" then nothing as he moved away from the tube. He then put the precision tip on and started checking each individual tube in about a 5 tube by 5 tube area. He said when he checked the leaking tubes – he actually had to turn the sensitivity down on the SDT Unit."

"In all – he scanned approximately 18,000 tubes in 30 minutes with the SDT270 compared to a whole day with Helium Tracer Gas. The SDT270 Unit narrowed the leak(s) down to a small area."

"It is the Results Engineer's opinion that we should use the SDT Unit for finding Condenser Tube leaks in that

1. He believes smaller leaks can be identified with the SDT270 Unit where they cannot be detected with helium
2. He knows that he can find the leaks faster with the SDT270 Unit using the scanning method first.
3. It will be cheaper in that Helium Gas will not have to be purchased
4. It will also return the Unit to full load capacity faster by reducing significantly the time that it takes to find leaks."

"He may still use the helium to verify the leak, but the SDT Unit will be the first tool used. His confidence in the ultrasound has grown with each inspection. He states, "If you can't find it with the SDT270 Unit, you will not find it with the helium."

Figure 7 - Finding Tube Leaks with SDT Ultrasound

"There was a time when Phipps used a contractor to helium leak check condensers. This came with an average cost of about $10,000 per visit so they purchased the helium leak check equipment and trained their own operators."

"The ultrasound equipment from SDT is more than justified on this cost savings alone. And since investing in ultrasound they added additional attachments and purchased a software upgrade for the SDT270. "We will expand the program in the hopes of identifying air leaks, valves leaking through, bearing lubrication and other issues that are in the capability of the SDT Unit," states Phipps.

Figure 8 - SDT270 is the most sensitive ultrasound instrument in its class

April 2015 – Furthering Their Confidence in SDT

In May I revisited with Bill Phipps to check on his progress. He was pleased to share his new success. On April 13th, 2015 another leak was reported.

Silica levels spiked in the cooling tower blowdown water at 3:15pm. Looking at the graphic below, the control room was alerted when blowdown silica spiked to 1000 ppb (parts per billion).

This graphic points out the source of the spike too. Unit2_226 tells them which side of the condenser to valve out. The turbine can keep running, albeit at reduced capacity, while the ultrasound team heads in to find the leak.

The SDT270 ultrasound equipment was used to rapidly identify the tubes and the area. The leak was massive and required the plugging of 39 tubes. As a secondary check, and to follow procedure, the leaking tubes were then verified with Helium.

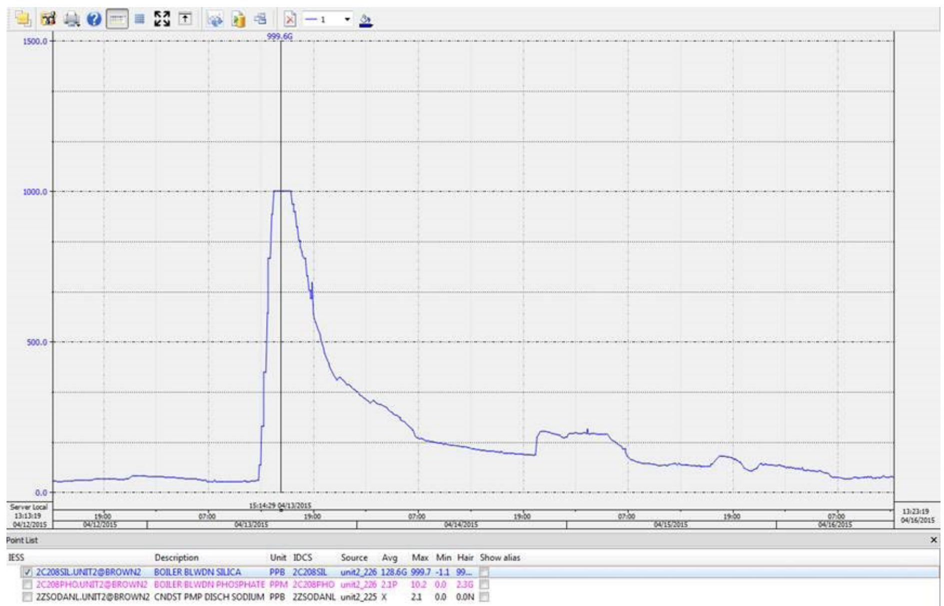

Figure 9 - Blowdown silica spiked to 1000ppb; 39 tubes were plugged from service

As Phipps' team continues to have success with ultrasound he expects they will fully eliminate the helium verification altogether.

Summary

Most reliability departments recognize the significant versatility of Ultrasound as an asset condition management technology. For those pursuing world-class reliability standards, implementing ultrasound testing for all its virtues is a necessity.

The case study shared with us by Mr. Phipps at AB Brown is another fine example. Clever, out of the box thinking makes ultrasound testing indispensable.

There is no shortage of reasons to invest in an ultrasound program. Use it for on-condition lubrication, compressed air leak management, steam trap testing, vacuum leak detection, low speed bearing and gearbox analysis, valve passing, electrical inspections, or finding tube leaks in condensers. Just use it.

Visit SDT North America (www.sdthearmore.com) to hear more interesting ways to put your ultrasound technology to use.