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BOILERS

TROUBLESHOOTING OF CONDENSATE CONTAMINATION

In a well maintained, properly operating boiler system, condensate is relatively high purity water with low conductivity and minimal dissolved solids. Condensate contamination can be caused by heat exchanger leaks or boiler carryover, and can be a perplexing problem. If approached logically, you will be able to find the source of the contamination.

Consider the analogy of a tree with the boiler being the trunk and the steam/condensate system being the branches. When condensate contamination occurs, you should start at the trunk and work your way out one branch at a time until the source is found. Figure 1 illustrates a typical steam/condensate system tree.

A good boiler water management program should include regular condensate testing by both the boiler operators and the contracted water management specialist. When condensate contamination is found, the following steps will lead you to the source. Table A summarizes these steps.

1. How is the boiler operating? Is the boiler operating within normal operational parameters? Is the steam load fluctuating significantly? If the boiler is over cycled, treatment chemicals are overfed, or alkalinity is too high, carryover may occur. Improper boiler water levels are a common problem. Fire tube boilers are more prone to carryover than water tube boilers because they

typically have less steam separation equipment.

Boiler carryover is just as likely to have a mechanical cause, as it is a chemical cause. Mechanical carryover causes include:

- Excessive movement of water in the steam drum.
- Spray or mist carryover from fine water droplets. This usually occurs when separation devices are missing or damaged.
- Steam production in excess of design rating.
- Sudden swings in steam load.
- High water level.
- Low water level.
- Changing boiler pressures.

2. What is the contaminant? Use the testing tools on-hand to determine the nature of the contaminant. Typical parameters you should be able to easily check are conductivity, pH, hardness, orthophosphate, molybdate, nitrite, chlorides, and iron.

3. Are any of the contaminants unique

to any of the steam uses in the plant? Hardness can come from a leaking hot water heat exchanger. Orthophosphate can come from a leaking heat exchanger in a phosphoric acid bath or boiler carryover if the internal treatment chemistry includes phosphate. Nitrite can come from a leaking heat exchanger in a closed hot water loop. Elevated pH may be attributed to an over feed of neutralizing amine, the in-leakage of caustic from a heated bath, or boiler carryover. Increased conductivity can be caused by any of the above. If you are lucky, the uniqueness of the contaminant will lead you directly to the source.

4. Check the condensate quality of the steam header as close to the boiler as possible and before any other possible contamination sources (including the neutralizing amine feed). You may be able to get a sample off the steam header's steam trap. If you find contamination here, you most likely have boiler carryover occurring. This boiler carryover may either be the *cause* of the condensate contamination you see or be a *result* of it. Remember that drip legs off steam headers are there to take out carryover though.

TABLE A
Troubleshooting Checks

Check	Description	Examples
Boiler Operation	Review boiler operation and confirm if carryover is occurring. If it is occurring, eliminate it.	Carryover can have mechanical causes, chemical causes, or both.
Contaminants	Determine what the contaminants are. If they are unique to a particular system, tracking down the source will be much easier.	Contamination can take the form of elevated conductivity, hardness, pH, orthophosphate, molybdate, nitrite, chlorides, iron, etc.
Condensate Survey	Once boiler carryover is eliminated if it was occurring and the condensate system has had time to flush out, begin testing the condensate system to find the source of the contamination.	Contamination can enter the condensate system through leaking hot water heat exchangers, leaking chemical bath heat exchangers, open condensate receiver tanks, etc.

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5. If you believe you have boiler carryover occurring, this must be corrected before you can further investigate the source of the contamination. Boiler carryover will contaminate the entire condensate system, making any other condensate sampling a fruitless endeavor. Work with the boiler operators to correct the problem. Dump all incoming condensate, if possible, to clear the contamination from the system in the shortest period of time.

6. After any carryover is under control and the condensate system has had time to clear itself of the carryover contamination, start testing the condensate return system for the contamination. Start first with the condensate receivers closest to the boilers. When you find one that's contaminated, work your way upstream from there. With any luck, you may be able to quickly find the source of the contamination. Table B lists recommended condensate survey tools.

Finding contamination sources can be tough sometimes. The offending piece of equipment may only operate sporadically. By the time the condensate contamination is seen back at the boiler, the leaking piece of equipment may already be offline and any contaminated condensate flushed from its nearest condensate receiver.

Heated baths are often temperature controlled. When the bath reaches the set temperature, steam flow through the heat exchanger is turned off. The steam remaining inside the heat exchanger condenses and can form a negative pressure. If the heat exchanger has a leak, the outside liquid is sucked into the heat exchanger. When steam flow is returned to the heat exchanger, a slug of contamination is sent back to the boiler system via the condensate. This can be an especially frustrating contamination source to find, but can sometimes be easily spotted by a bubbling bath. If you see a heated bath bubbling near the heat exchanger, you most likely have steam leaking out of the heat exchanger. You should take a sample after the system has been down and is then being reheated to catch the contamination if it is occurring.

Case Study 1

The boiler supervisor at a hospital kept a very close eye on the parameters of his boiler system. Boiler tests were conducted like clockwork, steam rates

**TABLE B
Condensate Survey Tools**

<i>Tool</i>	<i>Comments</i>
Sample cooler with bucket	A low-tech sample cooler can be made by coiling tubing around in a bucket.
Conductivity meter	Contaminants are typically ionic and will increase conductivity.
pH meter	A cooled sample is important for accurate pH determination.
Sample bottles & tongs	For collecting the samples for immediate analysis or to bring a sample back for later analysis.
Notepad	Take notes about location of sample, tests conducted, appearance of sample, smells, etc.
Test reagents	Total hardness, orthophosphate, molybdate, nitrite, molybdate, iron, etc. For most of these tests, all you care is if the contaminant is present, not how much is in there.
Casserole dish & stirring rod	For conducting water analysis.
Personal protective equipment	Gloves, safety glasses, etc.
Infrared temperature gun	Knowing whether lines and equipment are hotter or colder than expected can help trace down the contamination source.
Paper towels	You will get wet.
Hand tools	Pliers, wrenches, and so forth may be required to open sight glasses, valves, unions, etc.

were graphed, makeup rates were measured, and deionization unit service runs were calculated. These were the type of operators that everyone would like in their boiler room. They knew the boilers like the back of their hands. The supervisor noticed that the makeup rate had dropped while the steam loads, makeup water quality, and boiler operation had not changed. He also noticed that the amount of neutralizing amine required to maintain condensate pH had increase significantly and that phosphate levels in the boiler had dropped slightly. From his knowledge of boiler operation and his gut feeling, the supervisor felt he had an in-leakage of water somewhere out in the condensate system. He just didn't know how to find it.

The supervisor discussed this with his water treatment company to confirm his suspicions and to trace down the source of the leak. The water treatment professional examined the boiler logs and supporting data and came to the same conclusion. The in-leakage was estimated to be around 1.4 gpm on average. A condensate survey was conducted immediately. Knowing the system, the in-leakage was expected to show up as hardness or increased con-

ductivity because the source was most likely straight city water or softened city water. Conductivity and total hardness tests were conducted at each condensate receiver, and condensate flowrates were noted.

On the first visit, the in-leakage was not found. Perhaps the problem was intermittent and not happening at the time of the testing. The boiler operators were instructed to keep a close eye on total hardness and conductivity readings for the total condensate sample being collected. If hardness showed up or conductivity increased, a condensate survey should be conducted immediately. The problem was that the total condensate return was so large compared to the 1.4 gallons per minute (gpm) in-leakage, that any effects it had on conductivity or total hardness were greatly diluted and almost unnoticeable in the total condensate sample.

A week later, the water treatment professional returned and conducted another condensate survey. This time elevated conductivity, a trace of hardness, and a good size flowrate was found coming from a heat exchanger. This was the most likely source of the leak. The condensate from this heat

exchanger was rerouted down the drain. As a result, boiler makeup rates, amine dosages, and phosphate levels returned to normal. When the heat exchanger was finally replaced, tubes were found to be cracked where they intersected with the tube sheet.

The condensate contamination from the heat exchanger in-leakage revealed itself in several ways.

Makeup rate decrease. Because the boiler had a large percent of condensate return and good quality feedwater, the 1.4 gpm of in-leakage had a significant effect on the amount of makeup water recorded at the boiler pretreatment equipment.

Neutralizing amine increase. Because the boiler system used dealcalizers for pretreatment, the in-leakage introduced more alkalinity into the boiler than was normal. As this alkalinity broke down in the boiler to form carbon dioxide, more neutralizing amine was required to neutralize the carbon dioxide when it formed carbonic acid in the condensed steam.

Phosphate drop. Because the in-leakage contained hardness, phosphate levels were seen to slightly drop in the boiler as it formed calcium phosphate sludge and was blown down from the boiler.

Case Study 2

An animal food facility used fire tube boilers with reverse osmosis makeup to supply steam to their plant. Periodically, the boilers would have level control problems due to foaming. The boiler conductivities and chemical levels were all within normal operating parameters. Knowing the system and the plant, it was felt that the most likely source of this foaming was from fat getting into the condensate system. Since the boiler foaming was a somewhat random event, this wasn't an easy contaminant to track down. A condensate survey was conducted with nothing found. The boiler operators decided to route one condensate system at a time to the drain to see if this would eliminate the problem.

With a little patience and time, the source of the fat contamination was finally found. A small condensate receiver tank was located on the floor in the corner of a meat processing room. There was a 2-inch hole in the top of the tank where a fitting used to be but was gone now. When the meat processing

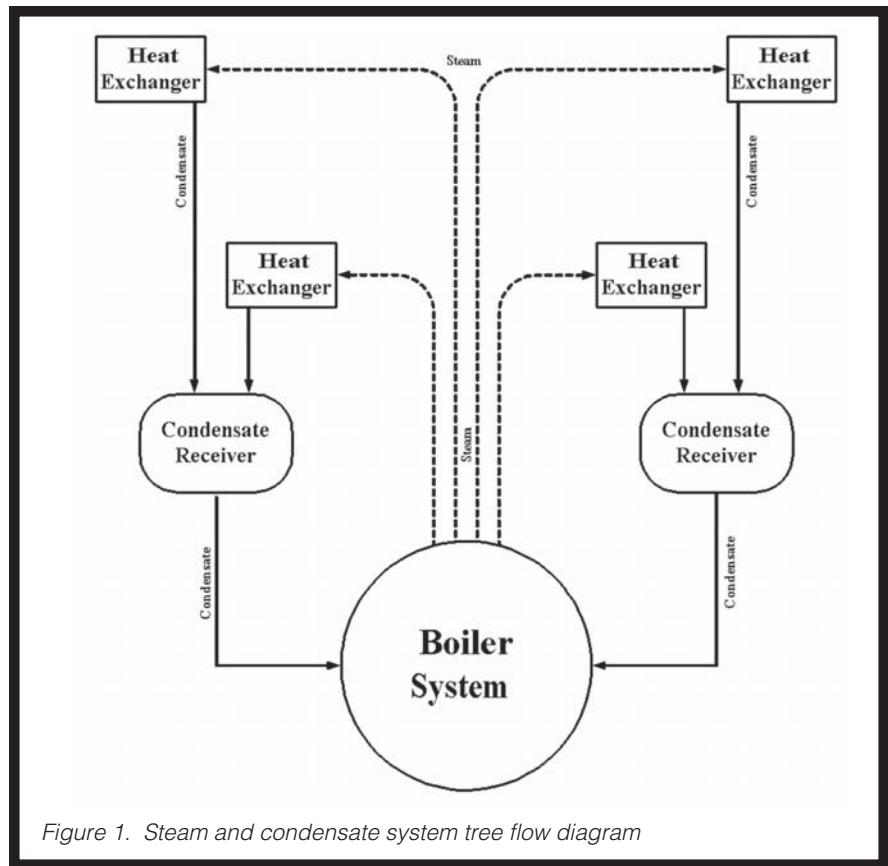


Figure 1. Steam and condensate system tree flow diagram

room would be washed down, fats would be splashed up on the condensate receiver tank and into this hole sometimes. From there, it was a short trip to the boilers where foaming would then occur.

Case Study 3

An automotive facility had four large water tube boilers supplying steam to the automotive plant for heating baths, space heating, and driving turbines. Elevated conductivities were noticed in the total returned condensate from the plant. The boilers were operating normally and no carryover was believed to be occurring.

More information was desired about the characteristics of the contamination besides the fact that it raised conductivity. The gamut of tests that were on-hand were run on the condensate and phosphate was found. Since phosphate was not used in the boiler water treatment program, this also confirmed that boiler carryover was not the root cause. A condensate survey was then conducted to track down the source of the contamination.

Luckily, the powerhouse had the ability to test the condensate being returned from each department of the plant sep-

arately. Testing each department's condensate for conductivity and phosphate revealed which department was the source of the contamination. Then, the individual condensate receivers in the department were tested and, once again, conductivity and phosphate tests revealed which condensate receiver was the contaminant source. Next, the processes that returned condensate to this condensate receiver had to be determined. Plant piping drawings were referenced and it was discovered that the only source of phosphate in the area that returned condensate to this receiver was a heated phosphoric acid bath tank.

Further investigation of the phosphoric acid tank revealed that hard water makeup was used in the tank. When calcium phosphate scale would build up enough on the steam coil to significantly inhibit heat transfer, the maintenance personal would "beat" the scale off with a hammer and return it to service. As a result, the coil developed leaks. It was recommended that the coil be repaired or replaced and that softened makeup water be considered as makeup to the phosphoric acid tank to eliminate the scale formation.

Conclusions

Condensate contamination can have negative effects on the condensate and boiler system by increasing corrosion rates, contributing to scale, causing carryover, etc. In order to prevent these negative effects from happening, a good testing program needs to be in place to detect condensate contamination up front. When contamination does happen, a logical approach needs to be taken to find the source of the problem.

- Is boiler carryover happening?
- If boiler carryover is happening, eliminate it.
- What is the contaminant?
- Is the contaminant unique to any systems?
- If condensate contamination is still detected, conduct a plant-wide condensate survey to find the source.■

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