Agilent Technologies

Detecting Leaks in Power Generation Steam Condensers

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Leak Detection
Seminar Outline

Problem Definition
Challenges in Condenser Leak Testing
Agilent’s Harsh Environment Probe & VS Leak Detector
Case Study: Covanta SEMASS
Cost Savings
Links to more information
Q & A
Problems Caused by Air In-Leakage

Turbine efficiency is dictated by the pressure gradient across the turbine and condensing system. When the design specification vacuum level deteriorates due to air in-leakage the efficiency of the entire system can decline rapidly.

Even small amounts of non-condensable gas (air) can inhibit heat transfer in the condenser and adversely affect performance. Large amounts can virtually block the condensation process, which of course will cause a substantial rise in back pressure.

To prevent excessive accumulation, most power plants use steam jet air ejectors and/or liquid ring vacuum pumps to remove the non-condensable gases. When these methods cannot keep pace with the rate of air in-leakage then the leaks must be found and repaired.
Why Helium Leak Testing?

Helium Leak Testing Offers:

- Excellent sensitivity
- Totally inert
- Good response time
- Ability to pinpoint the leak
- Equipment is easy to use
- Can easily apply helium to all parts of the system
- Allows immediate repair and retest
- Not subject to false indications

It is the most widely accepted method to identify air in-leakage

What are the limitations?
Challenges in Condenser Leak Testing

Size

• Power plants are massive facilities
• Can be difficult to test when you cannot see the detector
• Helium sample is small so sensitivity is limited
• If not sampled properly, leaks can be missed
• Response slowed by plant piping & distance
Challenges in Condenser Leak Testing

Complexity of...

• The condenser
  - Where to connect to the system?
  - How to improve sensitivity?
  - How to sample in the vacuum region?

• The equipment
  - Previous generation leak detectors were more difficult to set up and operate
  - Can be difficult to discern a leak from background helium
Challenges in Condenser Leak Testing

It is difficult to separate the steam when sampling for helium.

Separation methods can be complex, costly, and are not foolproof.

High temperature can pose a problem.

Water vapor destroys leak detector pumps, valves, and spectrometers.
Methods of Trapping Steam

Bucket of ice and flask or cooling pipe
  - Inconvenient
  - Cumbersome to move around
  - Requires supply of ice
  - Not foolproof, can still ingest water

Dedicated Dryer
  - Expensive
  - Not portable
  - Can get saturated

Sacrificial pump
  - Costly over time
  - Requires power and hinders portability
Agilent VS Leak Detector & Harsh Environment (HE) Probe

Agilent has developed an innovative leak test solution for power generation. The HE Probe is easy to use, very sensitive, highly robust and solves one of the most difficult leak testing problems...how to keep water vapor from damaging the leak detector.
Agilent Harsh Environment (HE) Probe

- Probe consists of a helium-permeable composite membrane brazed into a stainless steel tube.
- Permits helium through probe while blocking water, chemicals, etc.
- Connects directly to the leak detector inlet
- High temperature tolerance
- Inert & resists nearly all chemicals
- High resistance to impact, tearing & delamination
- Is “non-stick”, so will not become coated over time by condensates
Sampling in Viscous Flow Pipes

Limited leak response in large pipe in viscous flow

- Zero flow at wall
- Maximum flow at central axis
- Minimal gas flow in lateral test port with limited helium migration to leak detector
- Leak detector
- Membrane trapped between flanges
- Primary gas flow near central axis of pipe
- Other gas molecules
- Helium atoms with a mean free path of E-4 centimeters.
Sampling in Viscous Flow Pipes

Plant piping necks down to a manageable size in front of system pump(s)

In 12-inch pipe, ~10x improvement in sensitivity and response time

HE Probe installed directly in primary gas flow for high sensitivity & fast response. Can be adjusted for various size pipes.
Additional Advantages

**Graphic Display**
- VS Graphic Display mode makes leak identification and time-tracking easy

**Wireless Remote**
- Monitors test results up to 100m from detector

**Data Collection**
- Leak Test Data Wizard software enables data collection and analysis
Advantage of the Wireless Remote
We used our leak tester and found the leak on the rupture disk of the turbine and repaired it. I believe we easily gained 0.5”HgA on that unit. But that was an easy leak to find. We have found harder leaks under insulation that only helium would have led us to.

Kevin Crimi, Operations Manager, Covanta SEMASS

ACTUAL RESULTS

Covanta SEMASS Facility
West Wareham, MA
Probe installed at the wall of condenser piping

Slow response and gradual change in helium signal makes it difficult to identify leaks
Probe installed in the center of condenser piping

Sudden change clearly identifies a leak
Quick Payback

**Savings Analysis**

It is well within reason to assume that leaks are causing an increase in condenser vacuum of 0.016 bar (0.5" HgA). If this is the case, here are the potential savings:

Each plant has different operating characteristics, but calculating the answer is simply a matter of gathering some data and multiplying*.

1. In your "Turbine Data File" there should be a graph or table that shows Turbine Efficiency Improvement as a function of turbine back pressure [condenser absolute pressure]. For this example the improvement is assumed to be 0.3%, from 0.08 bar to 0.07 bar (2.5" HgA to 2.0" HgA).

2. Determine the Turbine Heat Rate, which is the BTU input to the turbine required to produce a kilowatt of electricity. A typical value is about 8500 Btu/kW.

3. Determine the cost of fuel. A recent spot price for natural gas was $3.00 per million BTUs.

Use the following calculation:

\[ \left[0.003\right] \left[8500 \text{ Btu/kW-hr}\right] \left[\$3.00/10^6 \text{ Btu}\right] = 7.65 \times 10^{-5} \text{ $/kW} \]

This appears to be insignificant until we factor in the amount of power produced over an entire year. If the plant is rated at 500 megawatts (500,000 kW) and it operates 8000 hours per year:

\[ \left[7.65 \times 10^{-5} \text{ $/kW}\right] \left[5.0 \times 10^6 \text{ kW}\right] \left[8 \times 10^3 \text{ hr}\right] = \$306,000 \text{ per year} \]

Detecting and stopping leaks with the VS Leak Detector and HE Probe delivers an outstanding return on your investment and potentially pays for itself on the first use. For more information contact Agilent Technologies Vacuum Products Division at 800.882.7426, or www.agilent.com/chem/leakdetection.

* All of this depends on the conditions at your particular plant. Use the above formula to calculate your own potential savings. Calculation courtesy of Dekker Vacuum Technologies, Inc.
HE Probe Summary

Features

- Permeable membrane technology – ZERO risk of leak detector damage
- Easy to use - Simple system connection
- Can be inserted directly into the center of the pipe - Faster response time and better sensitivity
- Extremely robust - Withstands hot, wet, corrosive environments
- No maintenance or adjustments
- Economical - Less expensive than dryers and repeated purchases of sacrificial pumps
- Can be used at atmospheric pressure or in a vacuum
  - Liquid ring pump exhaust
  - Inside condenser
Want More Information?

Power Gen Resource:
  • http://tinyurl.com/HEProbeReference

Full Covanta SEMASS Video is on the Agilent YouTube Channel:
  • http://tinyurl.com/HEProbeVideo

Have more questions? Like to arrange a demo? Contact John McLaren:
  • john.mclaren@agilent.com
  • (781) 860-5461
Thank you for attending!