Agilent

Trusted Answers

# Detecting Leaks in Power Generation Steam Condensers

The Agilent Solution

# Problem Definition

Power plant efficiency is dictated by the pressure gradient across the turbine and condensing system. When the vacuum level of a condensing system deteriorates due to air in-leakage the efficiency of the entire system will decline. Even small amounts of non-condensable gas 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.

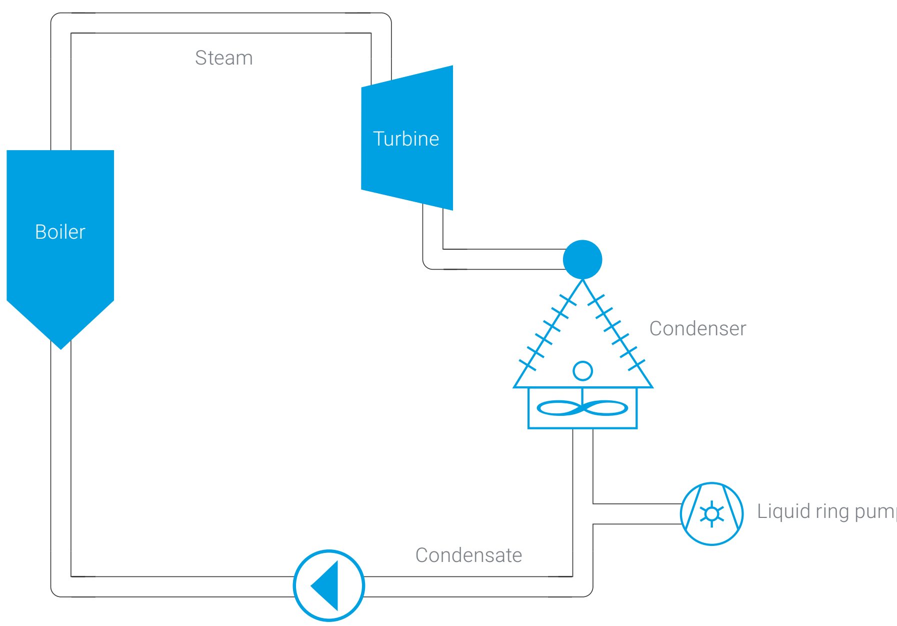
## Finding the leaks in a power plant condenser presents several unique challenges

- Size: Power plants are massive facilities and it can be difficult to test when you cannot see the leak detector
- If the test is not performed properly leaks can be missed
- Sensitivity and response time can be adversely affected by plant piping and distance
- The biggest obstacle is the condenser environment itself. Water vapor and other compounds can destroy a helium mass spectrometer leak detector.

### Challenges with Steam

Finding leaks in a water vapor (steam) environment presents several challenges:

- Water vapor can quickly destroy the leak detector pumps, valves and spectrometer
- It is difficult to separate the steam when sampling for helium
- Separation methods can be complex, costly and can fail
- Equipment often cannot tolerate high temperature



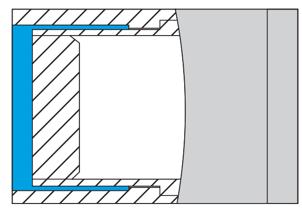

**The Plant Cycle**
A typical Rankine cycle. When air in-leakage of non-condensable gases exceeds the capacity of the liquid ring pump(s), plant efficiency declines significantly and leak testing is required.

# The Agilent Solution

To address the challenges of leak testing power plant condensers, Agilent has developed an innovative leak test solution for power generation plants that includes a specialized sampling probe and leak detector tailored to these requirements.

## Agilent Harsh Environment Probe

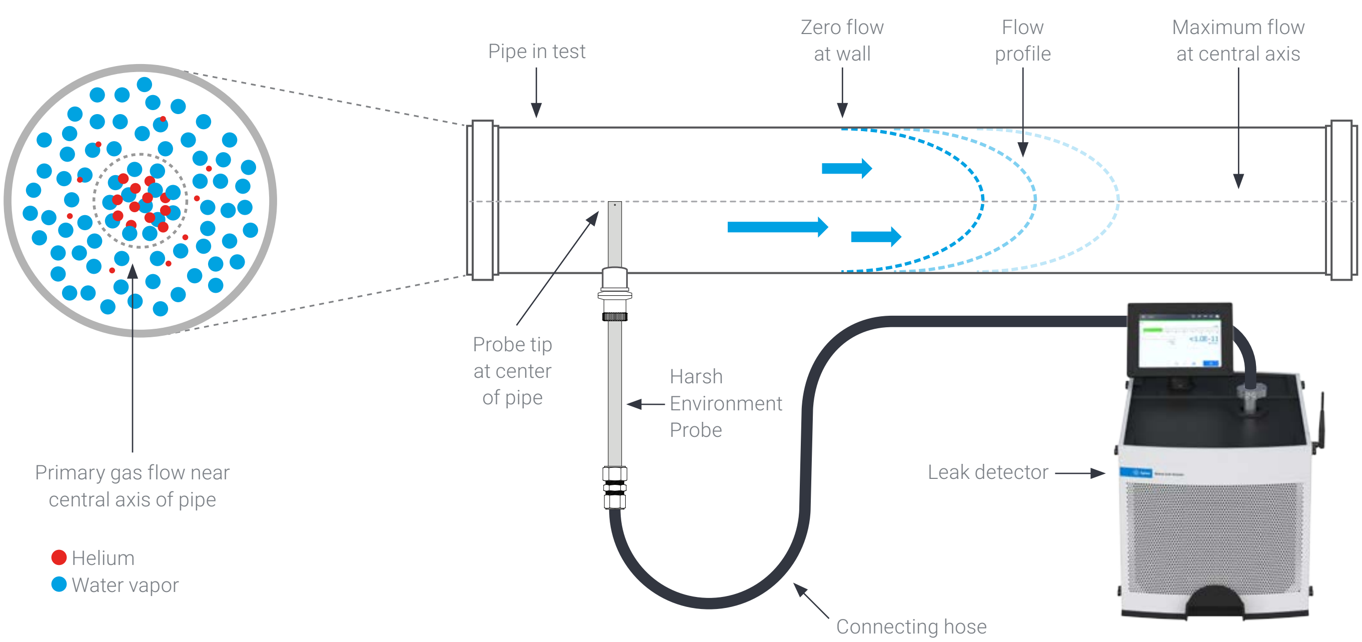
The Harsh Environment Probe is easy to use, very sensitive, highly robust and solves one of the most difficult leak testing problems: How to keep water vapor from damaging a leak detector? It is designed to withstand the water vapor and high temperatures inside condenser piping without dryers, chillers, a secondary vacuum pump, or throttling valves. The probe can be positioned in the exhaust of a liquid ring pump on the condenser system, or flange-mounted directly into the low-pressure side of the condenser.



**Composite Permeable Membrane**
The probe consists of a helium-permeable composite membrane (shown in blue) brazed into a stainless steel tube which permits helium through the probe while blocking water and chemicals.

## Sampling in Viscous Flow Pipes

Equipment damage or failure due to corrosion or water in the leak detector or roughing pump is eliminated. The Agilent HE Probe will withstand water and amines, and operate at temperatures up to 95 °C (200 °F). The probe connects directly to the HLD leak detector with no additional water trapping or auxiliary pumping required.




**How the Harsh Environment Probe is Used**
Even when a leak is present helium will not readily reach the test connection. This condition is portrayed in the graphic above. Maximum flow through a pipe is at its center and flow is near zero at the wall. This greatly inhibits detection of helium. The Harsh Environment Probe can be inserted in the pipe for faster detection and greater sensitivity. Alternatively it can sample at a vacuum pump exhaust or steam ejector.

# Savings Analysis

How much can you save by finding and repairing leaks? Even a small amount of air in-leakage can cause a measurable loss of efficiency resulting in consumption of significantly more fuel over the course of a year. For this analysis we'll assume that repairing several leaks in a condenser results in an improvement in condenser pressure of 0.017 bar (0.5" HgA).

## Potential Savings

Every plant is different but calculating fuel cost is relatively straightforward:

1. Typically, a plant's turbine data file should have a graph or table of turbine efficiency improvement as a function of turbine back pressure (condenser absolute pressure). For this example, we'll assume that the stated improvement in condenser pressure of 0.017 bar (0.5" HgA) results in a turbine efficiency improvement of **0.3%**.
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 **10,300Btu/kW**.
3. Determine the cost of fuel. Natural gas can be a volatile commodity, but over the past few years it's reasonable to accept an average spot price for natural gas of **$2.00 per million Btu's**.

### Return on investment

Detecting and stopping leaks with the Agilent HLD Leak Detector and HE Probe delivers an outstanding return on your investment and potentially pays for itself on the first use.

**Note.** Potential savings depend on the conditions at your facility. Use the formulas below to calculate your own potential savings.

### Use the following calculations:

$$\underbrace{[0.003]}_{\text{Efficiency improvement}}\ \underbrace{[10{,}300\ \text{Btu/kWh}]}_{\text{Turbine heat rate}}\ \underbrace{[\$2.00/10^{6}\ \text{Btu}]}_{\text{Fuel cost}} = \underbrace{6.18 \times 10^{-5}\ \$/\text{kWh}}_{\text{Savings per kilowatt-hour}}$$

This seems insignificant until we factor in the amount of power produced over an entire year. For a plant rated at 600 megawatts and operating 8000 hours per year:

$$\underbrace{[6.18 \times 10^{-5}\ \$/\text{kWh}]}_{\text{Savings per kilowatt-hour}}\ \underbrace{[6.0 \times 10^{5}\text{kW}]}_{\text{Plant rating in kilowatts}}\ \underbrace{[8 \times 10^{3}\ \text{hr/yr}]}_{\text{Hours of operation per year}} = \underbrace{\$296{,}640\ \text{per year}}_{\text{Annual savings}}$$

# An Innovative Leak Test Solution

### Agilent Helium Leak Detector

The Agilent HLD Leak Detector uses a mass spectrometer tuned to detect helium, which is used as a tracer gas to locate and/or measure very small leaks in enclosed devices or systems. The mobile HLD is both a precise instrument and a robust workhorse, featuring an easy-to-use touch screen interface and menu structure that quickly connect users to powerful leak detection capabilities.

### Advantages of a Wireless Remote

The Agilent HLD is available with a wireless remote control that permits an operator to work up to 100 meters from the leak detector. The wireless remote gives a single operator the freedom to spray helium and monitor the detector for a response without having to be in front of the instrument.

### Agilent Harsh Environment Probe

The probe consists of a corrosion resistant 316L stainless steel tube with a composite permeable membrane at its tip. The membrane readily permeates helium tracer gas while protecting the leak detector from water vapor that would destroy the pumps, valves, and spectrometer. Its design allows it to be positioned in the center of the pipe. This guarantees the probe tip is in the maximum helium flow for the best sensitivity.

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