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FOCUS ON O&M

PREVENTIVE MAINTENANCE

Stop valves from leaking money

Testing valves for leakage costs little but can save a lot. Energy drops across many valves exceed 1,250 Btu/lb, and leakage rates can be higher than 1,000 lb/hr. In a plant burning fuel priced at $5 to $10 per million Btu, a single valve with a modest leak (Figure 1) can account for $50,000 to $100,000 in lost fuel costs annually. That's at least an order of magnitude greater than the $3,000 to $6,000 cost to replace it.

The losses multiply quickly in a typical power plant, which may have hundreds or thousands of valves. By wasting precious fuel, leaks can raise a generating unit's heat rate by as much as 1% to 3%. Another penalty is the cost of producing the makeup water that literally goes down the drain.

First measure, then control

Most power plants consider a certain level of energy losses and leakage acceptable. Traditionally, detecting leakage losses has been challenging and time-consuming, and leakage rates have been nearly impossible to pin down. A relatively new technique, ultrasonic emissions testing (UET), can detect and quantify energy losses by relating the characteristics of sounds produced by leaking valves to their leakage volume or rate. As steam, saturated steam, or water moves from a high-pressure line through a leaking valve into a lower-pressure line, it produces turbulence. The nature and the level of turbulence correlate with a measurable and unique ultrasonic signal from the valve seat or area with a leak surface.

Deriving the leakage rate from the amplitude of the signal is analogous to calculating the flow rate through an orifice or constriction using the Reynolds Number. The same variables on which orifice flow calculations depend influence the relationship between the sound signature and the leakage flow rate. These variables include the pressure differential across a valve or orifice, its geometry, and the properties of the fluid being controlled.

In practice, the level of the acoustic signal is measured against background noise to isolate the sound energy associated with the leakage. Measured levels and known values of variables are entered into knowledge-based software that compares the inputs with numbers in an extensive database. The database, developed over the past decade, contains all relevant parameters, including signal levels and laboratory-measured leakage rates for many valves operating under different conditions. The software correlates the test data to the lab data and calculates

1. Look familiar? Over one year, the cost in wasted fuel of ignoring a leaking isolation valve is typically many times the cost of replacing it. *Courtesy: Valvtechnologies*

2. Probing the pipe. Ultrasonic emissions testing is nondestructive, intrinsically safe, and nonintrusive to normal plant operations. *Courtesy: Valvtechnologies*

the leakage rate of the valve under scrutiny with proven accuracy.

Comparing measurement methods

Another technique for detecting and quantifying valve leakage is thermography. Like "night vision" cameras and goggles, thermography uses infrared imaging to measure the heat energy emitted by an object. It can detect even small surface temperature variations inside a pipe.

Testing for leakage requires making several measurements upstream and downstream of a valve and across its body. If the conditions in a pipe are known, the surface temperature gradient can be used as a model to predict the heat flux or the temperature gradient inside it. Heat-transfer programs correlate the level of heat flux to the energy loss or leakage of the valve.

Although thermographic testing is far more common than UET, there are situations where thermographic results must be carefully interpreted:

- An elevated downstream temperature could be produced by residual heat from a recent cycling of the valve. In this case, thermographic data could be misleading.
- UET identifies the leakage at the source and measures it against background noise. With thermography, it is far more difficult to isolate valve leakage from other potential heat sources.
- A leaking valve will always emit an ultrasonic signature. But if the leak is in a saturated environment, it may not produce a temperature rise downstream.
- Thermographic testing may require removing large amounts of insulation from multiple locations along a pipe. UET only requires drilling a few, easily pluggable 1/2-inch holes in the pipe's aluminum jacket to accommodate a 3/8-inch-diameter probe to make contact with the valve and the adjacent pipe (Figure 2).
- UET gives immediate results, but thermographic measurements must be mathematically or computationally modeled to determine leakage rates.

Theory into practice

AES Red Oak (Figure 3) is an 832-MW gas-fired 3 x 1 combined-cycle plant in Sayreville, N.J., that entered commercial service in September 2002. An energy trading company buys power from the plant under a 20-year tolling agreement that includes incentives for improving its heat rate.

3. Do it yourself. The AES Red Oak plant in New Jersey found that top-quality shutoff valves often weren't installed under its turnkey contract. An ultrasonic testing and valve replacement program paid immediate dividends in the form of lower unit heat rates. *Courtesy: AES*

4. Time well spent. More than 50 valves were ultrasonically checked during a half-day of testing. *Courtesy: Valvtechnologies*

At the plant, which was built under a fixed-price contract, operators soon became painfully aware that many of its isolation valves were of low quality and prone to leaks. Among the concerns that the leaks raised were excessive plant heat rate and the possibility of water induction to the steam turbine.

Marc Hain of AES Red Oak and Tony Glembocki of the valve designer and manufacturer Valvtechnologies (www.valv.com) teamed up to test those valves suspected of leaking. The two men targeted 50 valves for UET testing over the course of a half-day (Figure 4). "During the test, we opened and closed the targeted valves and adjacent block valves. When we compared the sets of readings, it was clear that we were getting meaningful results," recalls Hain.

Although the plant's time and budget constraints didn't allow for a complete valve replacement program, the testing did isolate the leakiest valves, which then were moved to the top of the O&M department's list for repair or replacement. Testing also identified the "good" valves, which were sealing tightly.

AES Red Oak then replaced the faulty valves with Valvtechnologies' "absolute zero leakage" metal-seat ball valves. According to Hain, the result was dramatic: "an overall improvement in plant heat rate of 20 to 40 BTU/kW-hr."

*—Contributed by **Marc Hain** of AES Red Oak and **Michael Flaherty** and **Tony Glembocki** of Valvtechnologies.*