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Combat surging energy costs

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Surging energy costs have facility engineers, managers and maintenance supervisors looking for ways to make plants more efficient. The most logical place to start is with the boiler system to get control of the Steamer, one of three energy-wasting villains called the D-Energizers.

BioIndustrial fuel bills can amount to between \$1 million and \$3 million per year, eating up a large percentage of operating budgets. Surging energy costs have facility engineers, managers and maintenance supervisors looking for ways to make plants more efficient. In many cases, the most logical place to start is with the boiler system. You might think of it as getting control of the Steamer, one of three archetype energy-wasting villains – the D-Energizers – introduced in our May cover story (www.plantservices.com/articles/2007/105.html).

The reason? Eight out of 10 boilers are more than 30 years old. They run less efficiently, often are unreliable and might even be in violation of U.S. federal pollution standards. There are still 400 counties in the United States that are considered U.S. EPA non-attainment zones, meaning they don't achieve current air quality standards. And while the EPA is the highest-ranking regulator of boiler emissions, many state and local governments are enforcing even stricter regulations.

One way to find out whether the boiler in your facility is efficient is to perform a steam audit: a comprehensive analysis of energy used within a facility, process or equipment, including recommendations for energy conservation measures. A steam auditor can work much like a super hero to apprehend the Steamer and eliminate his wasteful effects on your boiler and steam system.

Scope, cost and deliverables

There are two types of steam audits: a simple boiler system audit and a complete facility audit. In a simple audit, a professional evaluates the boiler room, boiler and accessory support equipment, possibly extending the evaluation somewhat into the facility. With a complete site audit, auditors evaluate the boiler system as well as components throughout a facility, including steam traps, piping, valves and steam users.

A simple boiler system audit costs about \$1,000, whereas a complete site audit, depending on the number of steam traps, other equipment and the size of the plant, could cost a few thousand dollars. The essential steps are:

- Data acquisition: Identify where and how a facility, process or equipment uses energy, along with costs and utility issues affecting the energy consumption.
- Data analysis: Identify energy conservation measures to make energy use more efficient, less expensive and more environmentally friendly.
- Recommendations: A final report details what was found, a list of areas that need improvement, and recommended actions, usually accompanied by some type of economic justification.

About the auditing process

If your facility recently replaced the boiler system, more than likely a steam audit isn't needed.

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A steam audit can take several days to complete, depending on the type of audit and the size of the facility. A facility need not shut down for the procedure; it's better that it continue as usual so the auditor can easily spot steam leaks and other anomalies during daily operations.

During a boiler room audit, your mild-mannered auditor will check the boiler controls, the boiler, blowdown and feedwater conditioning to identify inefficiency issues. Auditors use their uncanny abilities to do an inventory of key equipment, looking for:

- Energy-saving methods
- Areas to implement better engineering practices
- Health and safety concerns

In a complete facility audit, an inspector not only checks the inventory of key equipment in the boiler room, but also focuses on potential improvements throughout the energy-using facility, effectively putting the cuffs on the Steamer to bring him under control. The evaluator inspects the boiler, steam flow, pressures, temperatures, air handling, steam trapping, piping ancillaries including valving and insulation, condensate handling and heat recovery. Energy savings are sought through:

- Locating steam leaks
- Heat recovery
- Conservation of flash steam
- Return of condensate

Start at the boiler

One of the first things an auditor needs to determine is the condition of the boiler system (Figure 1). The decision to replace a boiler shouldn't be based solely on the boiler's age. Some boilers, even at 70 years old, remain in good condition. However, if the boiler is leaking, heavily scaled, or has outdated burners and controls, it's probably time to replace it and oust the Steamer from your plant.

If the boiler is in good shape, it might only need efficiency retrofits such as an updated burner or combustion control system, which can save 50% on capital costs compared to a new boiler unit and provide significant fuel savings at least equal to the retrofit cost during the first year.

Auditors also investigate whether the boiler has been overheating. If the boiler overheats, there might be problems with either the boiler's insulation or gasketing, which could lead to damaged and unsafe equipment. The cost of repairs to correct these types of problems are relatively nominal when compared to the consequences of letting the Steamer flex his energy-sapping muscles unchecked, causing conditions to exist that result in serious safety or mechanical repair issues.

The auditor will perform a combustion test using stack gas analysis equipment to quantify boiler efficiency. This could lead to the recommendation of an oxygen sensor/transmitter in the exhaust gas.

The sensor/transmitter continuously senses oxygen content and provides a signal to the controller, which adjusts the air damper and gas valve, maintaining a consistent oxygen concentration in the flue. This minimizes excess air while optimizing the air-to-fuel ratio and puts the Steamer on the run.

Oxygen trim systems typically increase efficiency by 1% to 2%, which, if you're looking at energy bills in the millions, means saving \$10,000 or more each year.

How is steam applied?

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The next step in a process is to determine what the steam is used for, how it's applied and if it's possible to reduce the operating pressure to reduce the sensible heat required to produce a pound of steam.

To determine this, the heating process is reviewed along with the existing piping layout to see whether the diameters of the piping, controls, steam traps and control valves allow operation at lower pressure, knowing velocities and pressure differentials will be changing.

If it's concluded that the pressure can be reduced, fewer BTUs per hour will be used in the process, saving the facility those energy dollars.

Minimize stack temperature

Stack temperature also is something to consider when looking for ways to be more efficient. A well-tuned boiler should operate between 50° to 100° above saturated steam temperature. If it operates at higher levels, fixing the problem begins with maintenance and cleaning.

From an efficiency standpoint, every 40°F in temperature reduction results in a 1% fuel savings and much frustration for the Steamer.

Sometimes, the stack temperature is higher because there's soot on the fireside surfaces caused by improper air/fuel ratio control. This means the burner was operating with excess fuel (rich), causing fine black particles, chiefly composed of carbon, to form on the heat transfer surfaces. This slows heat transfer, causing considerable energy loss.

Soot can be mechanically removed with a flue brush. Once the soot is gone, a professional will be needed to recalibrate the burner. The return on your investment to reduce stack temperature is quick, usually in less than one year.

Another cause of elevated stack temperature is scale formation on the waterside surfaces of the boiler caused by improper water treatment. The remedy might be either acid cleaning or tube replacement, depending on the severity of the scaling condition. In either case, the fix, though more expensive than cleaning the fireside, is often paid back through energy savings in a year or less, depending on boiler size.

Survey piping

In complete facility site audits, auditors survey the steam piping for energy losses through radiation and steam leaks. These manifestations of the Steamer are identifiable to the naked eye.

Cutting down on steam loss through radiation is as simple as insulating the distribution system. More than half of process plants lack pipe insulation or the insulation has deteriorated to the point of uselessness. The larger the pipe diameter and greater the length, the more insulation can help in saving energy.

Reducing steam leaks caused by piping corrosion and compromised flanging can be another significant energy saver. The leaks appear as wisps of condensed steam, and, once secured, result in considerable dollars saved (Table 1).

Other opportunities to reduce energy costs with piping include ensuring steam mains are laid out, sized, drained and vented properly, according to the U.S. Department of Energy (DOE). An auditor

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drops; that it's adequately supported, guided and anchored; and that appropriate allowances are made for pipe expansion at operating temperatures.

Investigate feedwater and condensate

During a complete facility audit, the auditor also will investigate how the feedwater supply and condensate returns are being handled. They check to see if the water sent directly into the boiler is free of dissolved gases such as oxygen and carbon dioxide, which can cause destructive corrosion to the boiler and condensate lines.

To avoid these conditions, one thing an auditor might recommend is installing a deaerator (Figure 2) for removing dissolved oxygen and carbon dioxide from the feedwater.

Auditors also will check to ensure the facility is using a water softener and that it's working properly. Without a water softener, scale builds up in the heat exchanger, and it doesn't take much scale to cause fuel usage to skyrocket: A quarter-inch of scale increases fuel use as much as 15%.

They also will examine condensate return. For many years, condensate was dumped down the drain. In the past few years, cost pressures and environmental concerns have forced facility engineers, managers and supervisors to rethink how they handle condensate.

Because condensate has already been through the steam system, it takes far less heat and fuel to turn it back into steam than it would to produce steam from an equal quantity of cold water. That's why steam users should return the condensate back to the boiler, where the whole process starts over again. This reuse can lead to hundreds of thousands of dollars in savings, depending on the size of the boiler and its operating hours.

Raise feedwater temperature

Facilities also can reduce their energy bills by taking a look at how much they spend on heating feedwater (Figure 3). An auditor will probably suggest an economizer if your facility hasn't already invested in one, because an economizer can reduce the steam boiler's fuel requirements, frustrating the Steamer by transferring heat from the flue gas to incoming feedwater.

By recovering waste heat, an economizer can often reduce fuel requirements by 5% to 10%, and if you're looking at \$1 million to \$3 million in annual energy costs, this retrofit can save \$50,000 to \$300,000 a year.

To determine if an economizer should be used, the auditor considers the boiler size (200 hp or larger is a likely candidate), the operating pressure of the boiler, the degree of burner modulation, and the feedwater temperature. A payback analysis can then be made based on the size, pressure, modulation and temperature conditions combined with hours of operation and fuel costs.

Alternative fuel?

Fuel alternatives are assessed during an audit, because adding the capability to burn a second fuel may result in a lower primary fuel burning cost.

For example, by retrofitting a boiler's burner to handle No. 2 oil, facility management can then negotiate with the local gas utility for a better rate because it can burn oil during peak gas usage

▶ **Navigate**

Audit steam traps for health and safety

Steam traps are typically part of a complete facility site audit. Auditors look for traps that pressurize the condensate line (“blowing through”), causing waterlogging and inefficient process performance. Traps are normally checked using heat-sensitive or ultrasonic instrumentation.

The other critical issue the auditor is looking for is evidence of the Steamer swinging his water hammer. In steam systems, water hammer most often occurs when some of the steam condenses into water in a horizontal section of the steam piping, usually caused by poor condensation drainage. Subsequently, steam picks up the water, forms a slug and hurls it at high velocity into a pipe elbow or other restrictive device, creating a loud hammering noise and greatly stressing the pipe.

Imagine a filled 8-in. pipe, 8 in. long. It weighs about 15 pounds, or the same as a bowling ball. Now put 100 psi of pressure behind the ball and roll it at 60 mph: That’s the level of force when water hammer is occurring. It can cause pipes to break or even disintegrate if the pressure is high enough, potentially scalding or severely injuring employees in the vicinity. Clearly, this is a problem that needs to be fixed.

A steam trap auditor will gather information on the number of steam traps in the facility, test and tag the steam traps, record findings, and calculate energy-saving measures and potential ROI.

Maintain a boiler log

To maximize the audit process and help keep boilers running optimally at all times, all facilities should keep a boiler room log. The log serves as a guide to a comprehensive maintenance program. By helping to evaluate performance and spot trends that may affect operating pressure (steam boiler), operating temperature (hot water boiler) and stack temperature, boiler logs help to determine when to clean the boiler, adjust the combustion, repair or maintain the refractory or insulation, and adjust water treatment. It also helps with timing on replacing safety devices, fuel filters or gaskets, stopping the Steamer in his tracks. Because the log keeps track of issues with the boiler, the auditor will know what to look for up front.

For everyday safety, the log should also include standard operating procedures, which allow it to serve as a “how to” reference book for employees. Not knowing the proper procedures when an issue arises can lead to boiler outages and accidents.

Calculate returns on investments

Facilities that invest in steam audits learn a lot about their boiler systems and why the energy bills may be going through the roof. They also learn a lot about how they might proceed to conserve energy, reduce cost, increase reliability and improve safety.

The last key component of a steam audit is what you can expect of ROI for the suggested improvements and maintenance. Opportunities vary from simple cleaning procedures to replacing equipment, and have paybacks that begin immediately, one of the most important being keeping employees safe. By incorporating your super auditor’s energy efficiency suggestions, facilities may save hundreds of thousands of dollars over the next few years and force the Steamer to take his D-Energizing bag of tricks elsewhere.

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▶ [Navigate](#)

More resources at www.PlantServices.com/thismonth

The DOE has an entire webpage devoted to helping companies become energy efficient:

www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12530

Perform steam surveys with clamp-on flowmeters:

www.PlantServices.com/wp_downloads/gic_sensing.html

Save energy with high-turndown boilers: www.PlantServices.com/wp_downloads/mra_steam.html

The Steam Challenge: www.PlantServices.com/articles/2006/232.html

DOE boiler software is a hot way to save energy: www.PlantServices.com/articles/2006/247.html

For more, search www.PlantServices.com using the keywords boiler, steam and energy.

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