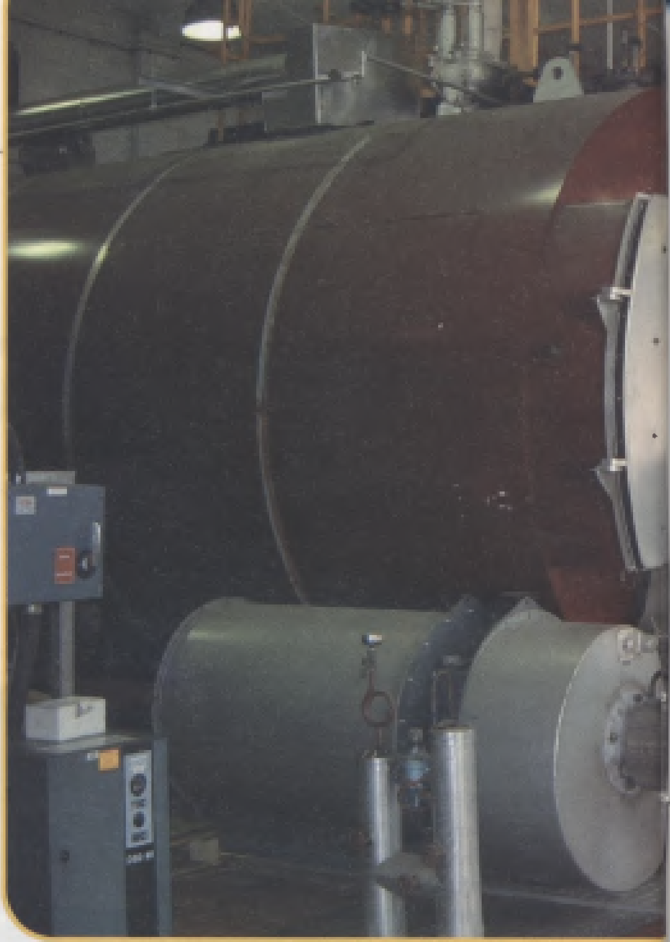
Beating boiler failure



More than 70% of all steam boiler failures are attributable to inadequate water treatment, but who is at fault? Chris Reid examines the issues

Design and manufacturing requirements for shell boilers are covered by BS2790:1992 and water tube boilers by BS1113:1992, while the recommendations for treatment of water for steam and hot water boilers are detailed in BS2486:1997. So, if boilers are built to the standard and their water treatment carried out likewise, why do they still fail?

BS2486 gives recommendations for the control of water-side conditions for steam boilers and for feed water. In section 1.2.1, it states that the objectives are: to contribute to the overall safety of operation of the boiler or water heater; to assist in the maintenance of high heat-transfer efficiency in the boiler or water heater by preventing deposition of scale or other debris and preventing corrosion or deterioration of surfaces in contact with water; and to maintain the quality of generated steam or hot water. It also notes that failure to maintain suitable water conditions could compromise the in-service integrity of pressure parts and lead to danger from release of stored energy or steam.

So the recommendations reflect good operating and design experience. But while much is made of combustion controls, water feed and TDS (total dissolved solid) issues, little attention is paid to the detail of chemical dosing. Custom and practice have it that boiler water should be manually tested daily and corrective adjustments made.

However, BS2486 states under section 2.5, Sampling and Testing: 'As a minimum, boiler water, feed water and condensate should be tested once per day and the ion exchange plant should be tested three times a day'. So, if custom and practice are correct, why are more than 70% of all recorded boiler failures attributed to incorrect water treatment?

The answer lies in the fact that the rule of thumb governing boiler water testing stems from the days when the Lancashire Boiler reigned supreme – but boilers have changed a lot. Today, they are designed to deliver far more dry steam for a given size and are fully automatic. If they have controls that comply with Health & Safety Guidance Note PM5 or Sated 3, they can operate without manual intervention, save for the weekly evaporation test to ensure that safety alarm systems are operating. Yet, when it comes to water treatment, we still rely on practice established more than 60 years ago.

Back to basics

So let's investigate further. The efficiency of any heat exchanger is governed by the cleanliness of the primary and secondary surfaces. The maximum steam output of a boiler at any pressure is governed by the rate at which heat can be supplied and transferred. If steam demand exceeds the rate of heat transfer, the pressure falls; and, if the fall is sufficient, carryover and instability result.

Chemical deposits or scale restrict heat transfer, boiler efficiency falls and the possibility of failure increases as the metal surfaces overheat. So boiler feedwater is treated to prevent scale forming and water-side corrosion. However, overdosing can lead to a reduction in efficiency, an increase in blowdown

and energy wastage, while underdosing leads to premature failure.

Looking at boiler feedwater temperature, the lower it is, the greater the dissolved oxygen content and propensity to cause corrosion – so the more oxygen scavenging chemicals are required. Typically, at 60°C, the requirement is 5mg/litre, whereas at 95°C it falls to 1mg/litre. Untreated, oxygen reacts with iron in the boiler to form rust, with every 3mg of oxygen able to remove about 7mg of iron. Think of the damage that 5,000 litres per hour of poorly treated feed water at 80°C can do to a boiler operating for 10 hours a day for, say, 200 days per year. What's more, that damage is not uniform – instead characterised as localised pitting, quickly leading to tube failure or problems in the steam and condensate lines.

However, some oxygen scavengers raise the TDS of the boiler, so over-treating is also a problem. With commonly used sodium sulphite, for example, it takes 8mg to neutralise 1mg of dissolved oxygen – raising TDS of the feed water by at least 8mg/litre. So, if we combat oxygen damage by dosing for worst-case conditions, we incur higher rates of surface blowdown, with the attendant energy and water losses. Hence we need to balance dosing according to feedwater temperature.

But even with a high proportion of hot condensate being returned to the feedwater tank, fitted with a direct steam injection heating system, it is difficult to achieve an even feedwater temperature. Whether you have a daily start-up or operate 24/7, the feedwater temperature varies. On start-up, or with an increased load, the balance between steam flow and condensate return will change and the feedwater tank level falls. Cold make-up water is then required, so the temperature falls and dissolved gas content increases.

After a couple of hours, the system settles down and, with a combination of cold water, returning condensate and direct steam injection heating system, a steady tank is achieved. If it is a closed loop system with no vents, then all is well. But most systems collect condensate in vented receivers and pump it back to the feed tank. On a system with all steam traps working correctly, there will be a flash steam loss of 10–15%, based on operating steam pressure. That has to be made up by cold water, the flowrate of which is controlled by an on/off control system supplying a high volume in a very short time – which depresses the temperature of the tank.

Clearly, testing once a day, at about the same time, will probably give similar results – but they are not representative of real operating conditions. So at what temperature do you set your chemical dosing regime? Dosing chemicals based on an estimated temperature, or one sample per day, plainly contributes greatly to problems in the boiler, which reduce efficiency and increase operating costs.

Wouldn't it make sense to monitor the feedwater flowrate and the dissolved oxygen level, or temperature, and to design a dosing algorithm based on these critical factors? It would then be possible to adjust the chemical dosing rate accurately in real time, according to changing feedwater demand. Aquanet has been supplying automatic control systems to the marine industry for a number of years and many of the gas tankers, FPSOs (floating production storage and offloading) and large cruise vessels such as Queen Mary II, Princess Cruises and Holland America Lines, install the equipment as standard. So why has the land-based industrial sector missed out?

Much the same arguments apply to the way we monitor and control the chemical composition, and dissolved and suspended solids content, of boiler water. The plain fact is that the reason for 70% of all recorded boiler failures being attributable, in one way or another, to chemical treatment is our use of outdated practices for treating boiler feedwater.

This is the age of the computer. With modern instrumentation almost anything is possible – certainly reducing the failure rate of boilers. If you want to compare your dosing regime against an automatic system, go to www.controls4steam.co.uk and click on the calculation link. PE

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Pointers

- The efficiency of any heat exchanger is governed by the cleanliness of the primary and secondary surfaces
- The maximum steam output of a boiler at any pressure is governed by the rate at which heat can be supplied and transferred
- If steam demand exceeds the rate of heat transfer, the pressure falls; and, if the fall is sufficient, carryover and instability result
- If water treatment custom and practice are correct, why are more than 70% of all recorded boiler failures attributed to incorrect water treatment?