Steam Boiler failure: Are you doing enough? Annual failure rates suggest not

It is the line of least resistance to do a job by rule of thumb or just follow instructions. But often things happen that cannot be put right by rules and require someone who knows "Why" as well as "How"? Here, Chris Reid of Controls4Steam explains why water treatment demands close attention

That statement is as relevant today as it was in 1945 when it appeared in "The Stoker's Manual" prepared under the directions of the Fuel Efficiency Committee of the Ministry of Fuel and Power.

The book contained information that would help the stoker 'operate the boiler plant in the best possible way', and recognised the important role the Stoker could play in saving coal.
Yet today, boiler water treatment is still based on a 'Rule of Thumb' that was conceived when the 'Lancashire Boiler' was at its peak. At that time it was recognised that controlling the pH value was sufficient to prevent corrosion on low pressure boilers with low heat-flux and employing internal chemical treatment.

70 years ago it was left to the Boilerman to test the feed and boiler water once or twice a shift and manually adjust the rate at which the chemicals were dosed. With modern boiler plant conforming to CEA/SAFED BG01 operating unattended for 72 hours, who carries out the daily water tests? Are you doing enough?

Compared to their predecessors, modern 3-pass wet back boilers contain probably less than a third the amount of water for the equivalent steam generation capacity with the furnace tube having a considerably higher heat-flux rate.

Maintaining the combustion efficiency over the lifetime of any boiler is dependent upon the rate of heat transfer from flame to water; fouling of the furnace and boiler tubes retards boiler efficiency. With over 70% of all recorded boiler failures related to incorrect or no chemical dosage, is it not time to disregard the "Rule of Thumb" of a daily water test and give water treatment chemical dosing the prominence it deserves?

To maintain efficiency throughout the boiler's working life we need to ensure that the heat transfer surfaces remain scale and corrosion free, accurately control the surface blowdown at the recommended TDS level and prevent excessive sludge build up by minimising chemical dosage and regular operation of the bottom blowdown valve.

Good corrosion control requires a high boiler water pH, the formation of a dense thin magnetite layer on the metal surfaces and the total absence of oxygen in the feed water throughout the boiler's working life. Relying on daily water tests and manually adjusting the dosing pumps cannot possibly be the most efficient and effective way to protect the boiler from damage.

Effective boiler feed water chemical control systems are essential to maintain boilers at peak operating efficiency

Any company that has suffered boiler failure or has had to have their boiler retubed or chemically cleaned will appreciate the need to improve boiler feedwater chemical control.

Passivation

The internals of new boilers and boilers that have been opened for their annual insurance test should always be passivated as an essential part of set to work. It is often set aside or forgotten, particularly with the common misconception that oxygen scavengers promote the formation of magnetite during normal boiler operation. The reality is that Sodium Sulphite, the most widely used oxygen scavenger, does not promote magnetite formation.

Scale formation

All scale deposits have a much lower thermal conductivity than the furnace and boiler tubes and must when present reduce the thermal efficiency of the boiler. At best the scale will hinder the heat transfer process; worst case scenario would result in the hot spots weakening the metal. The metal will then be distorted by the boiler pressure and may collapse. A reduction of 2-3% of heat transfer per 1mm of scale is itself significant. With a monthly fuel bill of £30,000 the reduction in efficiency can cost from £750/ month upwards.

Reduced heat transfer also results in high metal temperatures at the entrance to the first tube pass which can cause cracking of the tube plate ligaments and cracking of welds and tube ends at the tube plate attachments.

Oxygen corrosion

Water with a temperature below 100°C will absorb oxygen, which unless removed by suitable treatment reacts with the metal inside the boiler and steam system causing corrosion. The lower the feedwater temperature the greater the amount of dissolved oxygen it contains and therefore proportionally more oxygen scavenging chemicals are required to prevent damage.

Oxygen damage is characterised as localised pitting so it does not take too much before a tube failure occurs or problems start to appear in the steam and condensate lines.

Neutralising the oxygen before it enters the boiler is obviously vital but this is not without its downside – Sodium Sulphite, which is commonly used on land boilers requires approximately 8-10mg of product to neutralise 1mg of dissolved oxygen thus raising the TDS of the feed water by at least 8mg/litre, so if your philosophy to combat oxygen damage is to overdose the chemical for the worst case condition you introduce other problems like higher rate of surface blowdown with the attendant energy and water loss.

Whether you have a daily start-up or operate 24seven the feedwater temperature will vary throughout the course of the day each and every day. Ascertaining the correct dosage of Oxygen Scavenging chemicals is based on calculation: on start-up or with an increase in load, the natural balance between steam flow and condensate return will change and the feedwater tank level will fall. Cold make-up water is required to correct the imbalance. The tank temperature will be depressed and dissolved gas content will increase.

Testing once a day, at about the same time will probably give you similar results. But the results are not representative of actual operating conditions throughout the day.

Dosing chemicals based on an estimated temperature or one sample per day contributes considerably to problems in the boiler which ultimately reduces efficiency and increases operating costs throughout the lifetime of the boiler.

At a temperature of 80°C there is 3mg/l of dissolved oxygen in the water being fed to the boiler. At 95°C the Oxygen content will be 1mg/l reducing the sulphite requirement by approximately 65%.

Taking into account the large increase in dissolved solids contributed by the Sulphite, monitoring and maintaining the highest possible feed temperature will not only reduce the dissolved oxygen, it will provide a reduction in dissolved solids. This means less blowdown is required which gives savings in water and energy.

Another common misconception is that heating the feed water using inline heaters or economisers reduces the dissolved oxygen. The reality is that it does not because unlike an atmospherically vented feed tank, the oxygen has nowhere to escape.

Given, therefore, the uncertainty of the stored feedwater temperature and the boiler demand it makes sense to monitor the feed rate and the dissolved oxygen level (or feed water temperature) and to design your dosing algorithm based on these factors.

It would then be possible to accurately adjust the dosing rate in real time, according to the amount of dissolved oxygen in the feed water and the boiler demand. Not too much, not too little but just the right amount, saving chemicals and energy by reducing the need to blow down the boiler.

Dissolved and suspended solids content

As we generate steam, the water in the boiler evaporates and the concentration of dissolved and suspended solids increases. How quickly they increase depends on the quality and condition of the feedwater. If we do nothing about this, the Dissolved Solids level will increase until we get foaming and priming with consequent problems within the boiler and the steam distribution system. It is essential therefore, that the dissolved solids level within steam boilers is not allowed to rise above a specified concentration.

The majority of modern boilers have automatic controls which monitor and regulate the solids content to within the boiler manufacturers specified limits to prevent foaming and carry over. However, the majority of controllers installed rely on a fixed temperature input to calculate the solids level. Since conductivity varies with temperature at approximately 2% per °C, accurate control can only be achieved when temperature compensation is automatically applied.

Some suspended solids, will fall to the bottom of the boiler forming sludge. This should be controlled by manual or automatic operation of the bottom blowdown valve. The most effective and economic way is to open the valve quickly but for short periods of 3 to 5 seconds duration. The object being to disturb the sludge at the bottom of the boiler and draw it out through the valve, short sharp operation has over time proved the best method.

To summarise, the chemical requirement of a 10 bar 10 tonne/hr boiler can vary by as much as x6 between low load and high load. During make-up, feed tank temperatures can fall by 20°C or more.

To be effective boiler feedwater control needs to be automatic and available 24seven.

Controls 4 Steam knows “Why and How”? to maintain the correct feed and boiler water chemical balance. If you want to compare your dosing regime and cost of steam against an automatic system email: **chris.reid@controls4steam.co.uk** and request a copy of the ‘Boiler Model’ or visit the web site **www.controls4steam.co.uk** and watch the video.