Water treatment approaches for boiler applications

A basic look at how hardness reduces performance for this common C/I application.

By Mario C. Uy

To fully appreciate the importance of softened water for steam boiler applications, one needs to look at the steam boiler as a production process.

In a steam boiler process, the product is steam. One raw material is water, and the machinery is the boiler itself.

Just like any other production process, to produce a quality product, the quality of the raw materials must be good, consistent and reliable.

In the case of boiler applications, hard water can result in increased production cost and decreased product quality for your C/I customers.

Water as raw material

Water is a major ingredient in the steam production process, and it should meet certain specifications.

One of the most important specifications is the level of mineral hardness.

The water must be free from mineral hardness to ensure efficiency.

Otherwise, production costs will increase and product quality will decrease.

The lower the hardness level, the better the water quality for a steam boiler process.

Inverse solubility

The hardness minerals are inversely soluble to temperature. As the temperature rises (such as in a boiler process), their solubility decreases, eventually causing the minerals to precipitate as scale.

The minerals will precipitate first on the heat transfer surfaces (i.e., boiler tubes) because these surfaces have the highest temperature.

Saturation

In addition to the inverse solubility problem, the precipitation problem is compounded by the saturation of the minerals.

As the boiler water evaporates, it leaves the minerals behind, increasing their concentration. Over time, the minerals will saturate and precipitate as scale.

The speed at which saturation is reached also depends on the rate of condensate return. The less condensate is returned, the more water is made-up, the more minerals are introduced, and the faster the saturation point will be reached.

Low mineral hardness in water becomes even more crucial in low-condensate-return applications, such as humidification, or other direct steam injections.

Efficiency loss

Scale deposits will insulate the heat transfer surfaces, decreasing the heat transfer efficiency, and increasing energy cost.

The table titled "Efficiency loss from scale build-up" shows the effect of this process.

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Thermal stress

In addition to the efficiency loss, the boiler is subjected to a higher stack temperature, due to poor heat recovery.

The heat transfer surfaces are also subjected to higher temperature, due to poor heat transfer.

Both increase thermal loading, which

Efficiency loss from scale build-up

Scale Thickness (inch)	Efficiency Loss (%)
1/64	4
1/32	7
1/16	11
1/8	18
3/8	48
1/4	38
3/8	48
1/2	60
5/8	74
3/4	90

add more stress on the boiler, eventually reducing its life expectancy.

Chemical treatment

The mineral hardness can be mitigated by chemical treatment, but only to a point.

Chemical treatment does not remove the hardness, but converts it to another manageable form, i.e. sludge instead of hard scale.

The sludge will then have to be discarded through expensive blowdowns. In high make-up applications, the blowdowns may not even keep up with the sludge formation.

Relying solely on chemical treatment is akin to allowing mud to enter your house and relying on chemical cleaners to keep the house clean.

Obviously, the best way to keep a house clean is to prevent the mud from entering it in the first place.

Conclusion

Similarly, the best prevention of scale is to prevent the mineral hardness from entering the steam boilers.

There are several ways to do this. Among them are lime softening, zeolite (ion-exchange) softening, deionization, reverse osmosis, distillation, etc.

As you improve raw material water, you will improve steam production costs for your C/I customers. In this way, water softening begins to pay for itself. □

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