



The Importance of Softened Water for Steam Boiler Applications

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Steam Boiler as a Production Process

To fully appreciate the importance of softened water for steam boiler applications, one needs to look at the steam boiler as a production process. A production process is the act of producing a product, from some raw materials, using some machinery. 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. Some of the raw materials can be used directly while others require some refinement to meet certain specifications. A raw material that does not meet specifications will increase production cost and decrease product quality.

Water as Raw Material

A boiler operation is no different. Water is a major ingredient in the steam production process. As a raw material, we must ensure that it meets 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, they will increase production costs and decrease product quality. 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, 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.

Below is a table, courtesy of Raypak, showing the respective Efficiency Loss from Scale Build-up.

Scale Thickness (inch)	Efficiency Loss (%)
1/64	4
1/32	7
1/16	11
1/8	18
3/16	27
1/4	38
3/8	48
1/2	60
5/8	74
3/4	90

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

Chemical Treatment

The mineral hardness can be mitigated by chemical treatment, to a point. Chemical treatment does not remove the hardness. It only converts them (the hardness) to other 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. The most popular method is zeolite softening. This article will not discuss the methodologies nor the economics of the different methods. Rather, its objective is to inspire you to look at Water from a Raw Material standpoint. As you improve your raw material Water, you will improve your steam production costs. For more information, please refer to our other technical publications on the specific methods of softening.