Clean Boiler Waterside Heat Transfer Surfaces

Best Practice Tip 105

The prevention of scale formation in firetube boilers can result in substantial energy savings. Scale deposits occur when calcium, magnesium, and silica, commonly found in most water supplies, react to form a continuous layer of material on the waterside of the boiler heat exchange tubes.

Scale creates a problem because it typically possesses a thermal conductivity, an order of magnitude less than the corresponding value for bare steel. Even thin layers of scale serve as an effective insulator and retard heat transfer. The result is overheating of boiler tube metal, tube failures, and loss of energy efficiency. Fuel consumption may increase by up to 5% in firetube boilers because of scale. The boilers steam production may be reduced if the firing rate cannot be increased to compensate for the decrease in combustion efficiency. Energy losses as a function of scale thickness and composition are given in the table below.

Energy Loss Due to Scale Deposits*

Scale Thickness, Inches	Fuel Loss, % of Total Use		
	Scale Type		
	"Normal"	High Iron	Iron Plus Silica
1/64	1.0	1.6	3.5
1/32	2.0	3.1	7.0
3/64	3.0	4.7	--
1/16	3.9	6.2	--

Note 1: "Normal" scale is usually encountered in low-pressure applications. The high iron and iron plus silica scale composition results from high-pressure service conditions.
Note 2: These energy losses are for firetube boilers that are not equipped with stack gas heat recovery equipment such as feedwater economizers or combustion air preheaters.
*Extracted from National Institute of Standards and Technology Handbook 115, Supplement 1. On well-designed natural gas-fired systems, an excess air level of 10% is attainable. An often stated rule of thumb is that boiler efficiency can be increased by 1% for each 15% reduction in excess air or 40°F reduction in the stack gas temperature.

Example

A firetube boiler annually uses 450,000 million Btu (MMBtu) of fuel while operating for 8,000 hours at its rated capacity of 45,000 pounds per hour (lb/hr) of 150 pounds per square inch gauge (psig) steam. If scale 1/32nd of an inch thick is allowed to form on the boiler tubes, and the scale is of "normal" composition, the table indicates a fuel loss of 2%.The increase in operating costs, assuming energy is priced at $8.00 per million Btu ($8.00/MMBtu), is:

Annual Operating Cost Increase = 450,000 MMBtu/yr x $8.00/MMBtu x 0.02
= $72,000

Best Practice Tip Sheet information is adapted from information provided by the Industrial Energy Extension Service of Georgia Tech and reviewed by the DOE Best Practices Steam Technical Subcommittee. For additional information on industrial steam system efficiency, contact the EERE Information Center

Suggested Actions

Any scale in a boiler is undesirable. The best way to deal with scale is not to let it form in the first place. Prevent scale formation by:

- Pretreating of boiler make-up water (using water softeners, demineralizers, and reverse osmosis to remove scaleforming minerals)
- Injecting chemicals into the boiler feedwater
- Adopting proper boiler blowdown practices

Monitor Flue Gas Temperature

Scale or deposits serve as insulation and reduce the rate of heat transfer across boiler tubes. Increased scale thickness results in a decrease in boiler efficiency because of an increase in flue gas temperature. Trending of stack gas temperature over time—at a constant firing rate and excess oxygen concentration—can provide a good indication of scale buildup. Energy losses caused by increased stack gas temperature are reduced in firetube boilers that are equipped with heat recovery equipment, such as feedwater economizers, condensing economizers, or air preheaters.

Perform Visual Inspections

Visually inspect boiler tubes when the unit is shut down for maintenance. Scale removal can be achieved by mechanical means or acid cleaning. If scale is present, consult with your local water treatment specialist and consider modifying your feedwater treatment or chemical additives schedule.

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