The Cost of Improper Water Treatment

It's easy to underestimate the importance of your water treatment program, whether you manage it in-house or rely on an outside water treatment supplier. That's because the effects of water treatment go well beyond maintaining satisfactory performance in HVAC systems. Water treatment has a profound impact on utility and maintenance costs, equipment life, worker safety, regulatory compliance, and more.

This chart reflects the percentages of the average facility's utility budget spent on lighting, water, cooling and heating, water treatment chemicals, and other miscellaneous expenses. Expenditures for water treatment are only a very small portion of the total cost — yet proper water treatment can produce far-reaching improvements in other cost areas.

Energy Costs in Air Conditioning Operation

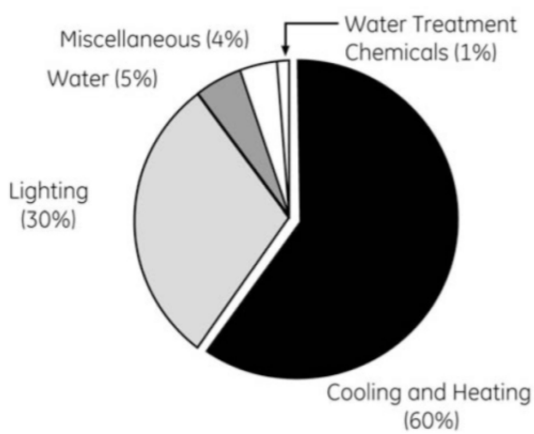

FIGURE 1: TYPICAL UTILITY BUDGET PERCENTAGES REVEAL THAT WATER TREATMENT REPRESENTS ONE OF THE SMALLEST EXPENDITURES DESPITE ITS TREMENDOUS FINANCIAL EFFECTS IN OTHER UTILITY AREAS

A sound water treatment program can help achieve both of these critical air conditioning objectives, keeping your system running reliably and minimizing your operating costs. It will also help avoid unbudgeted capital expenditures resulting from premature equipment failure.

Improved Air Conditioning System Efficiency

A well-designed water treatment program that reduces fouling, scale, and corrosion can dramatically improve system performance.

Most of the energy consumed by the typical air conditioning system is used to operate the compressor; therefore, improved compressor efficiency yields substantial cost reductions. The compressor is designed to produce a given pressure rise for a given load, and a greater-than specified pressure rise can cause an inability to meet cooling load demand or even cause an emergency shutdown. Moreover, higher discharge (head) pressure increases power consumption. High head pressure often occurs because of fouling or scale formation in the condenser tubes. Since fouling and scale resist heat transfer, the compressor must increase the condensing pressure and its associated temperature. This increase in temperature difference between the refrigerant and the cooling water is needed to force the required transfer of heat. The increased energy consumption depends on the type of compressor used, the actual operating head pressure, and the percentage of full load at which the system is running.

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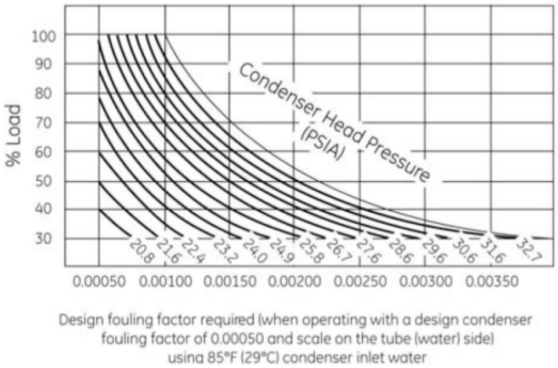

FIGURE 2: AS SCALE INCREASES, SO DOES CONDENSER HEAD PRESSURE.

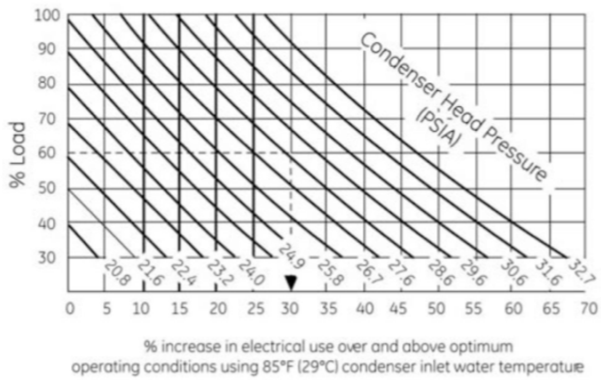

FIGURE 3: HIGHER HEAD PRESSURE CAUSED BY SCALE OR FOULING INCREASES POWER CONSUMPTION.

Centrifugal Chiller System Savings

According to the U.S. Department of Energy, commercial cooling equipment is the second largest consumer of electricity in a typical commercial or institutional property — second only to lighting.

Newer centrifugal chiller systems are designed to run economically, provided there is little or no scale and fouling. Without proper water treatment, chiller performance can degrade quickly.To see the magnitude of costs associated with air conditioning operation, it's useful to consider a centrifugal chiller system in a typical 1.2 million ft2 (111,484 m2) building. In this example, proper water treatment results in US$72,000 of savings through the condenser (US$63,360 in savings) and evaporator (US$8,640 in savings).

A typical centrifugal chiller system in a 1.2 million ft2 (111,484 m2) building and operating under optimal conditions has the following characteristics:

- Total chiller capacity: 3,000 tons (3,048 metric tons) (generally provided by two or more centrifugal chillers)
- Ideal "clean state" energy efficiency: 0.6 kW/ton
- Energy cost: US$0.10/kW-hr
- Equivalent full load hours of operation (EECH) = 1,600 hrs
- Annual energy requirement = 3,000 tons US$0.10/kW-hr x 0.6kW/ton x 1,600 EFLH/ton of chiller equipment = US$288,000 per yr or US$96 per yr/ton

Improving Condenser Heat Exchange

Even the smallest amount of scale in a typical chiller condenser can increase utility costs by US$63,360 per year -- US$34,560 resulting from scale and US$28,800 because of microbiological fouling.

Most don't realize the effect that a small amount of scale on condenser tubes can have on utility costs.
Just 1/16 in. of scale on a 5/8-in. copper tube has the same heat transfer rate as a steel pipe with walls 2 inch thick. What does that amount to in dollars?

Scale transfers heat at a rate that is 500 times less than that of the tube's copper walls. In fact, scale with a thickness of 1/64 in. will result in an increase of power consumption of 12%! That means for our typical centrifugal chiller system, utility costs will increase US$34,560!

A layer of microbiological growth or slime can impede the ability of the condenser tubes to reject refrigerant heat, raising the temperature and pressure in the condenser. The formation of biofilm in the cooling tower can also interfere with proper evaporative heat transfer by reducing the filming that normally occurs on the tower fill. A 1/16 in. layer of biofilm can result in

an increase in power consumption of 10%! Our typical chiller will, therefore, experience an increase in utility costs of
US$28,800!

Improving Evaporator Heat Exchange

The term "evaporator" refers to evaporating refrigerant. The refrigerant is "boiled" at low temperature and pressure by absorbing heat from a chilled water return loop. Since the water itself is closed loop and non-evaporative, there is little chance of scale formation.

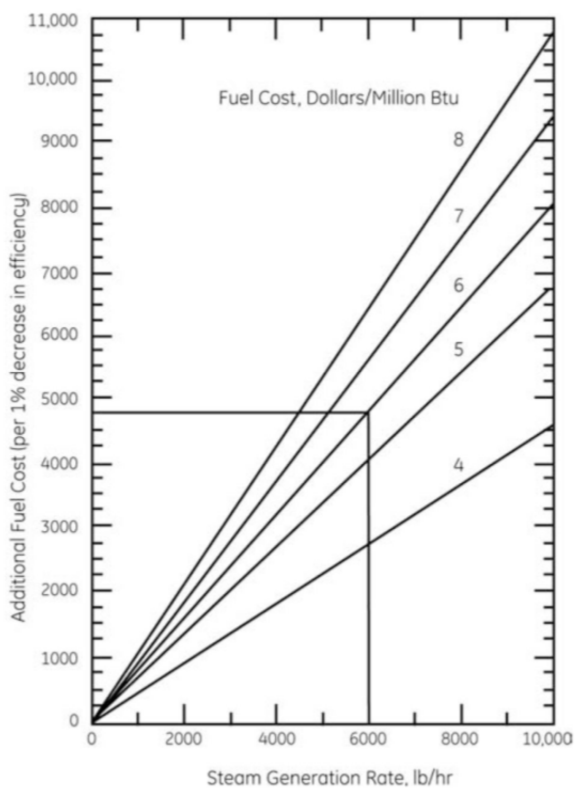

FIGURE 4: A SMALL LOSS OF BOILER EFFICIENCY CAN RESULT IN SUBSTANTIAL INCREASES IN FUEL CONSUMPTION

Fouling, however, is not uncommon. Experience has shown that evaporator fouling can lower evaporating refrigerant temperatures by 2 degrees, resulting in a 3% increase in overall chiller operating costs. Our typical chiller would then experience an increase of US$8,640 with just this slight increase in temperature!

Maintaining proper condenser heat exchange can help avoid these additional costs and save US$72,000 in a typical centrifugal chiller system.

Energy Costs in Boiler Operation

To see the cost of inefficient boiler operation, consider the graph in Figure 4.

It plots steam generation rate (in lb/hr) against annual fuel costs (in dollars), and shows the additional fuel costs caused by a 1% decrease in boiler efficiency.

Five vital factors can result in serious energy and fuel losses in boilers:

- Unnecessary water loss from the boiler
- Reduced heat transfer as a result of deposits
- Loss of steam and condensate through leaks in piping, valves and fittings
- Increased make-up water costs (and possibly sewer costs)
- Improper or incomplete combustion.

Minimizing these facts is well within the ability of qualified water treatment specialists. To see how these factors work together to reduce boiler efficiency, let's consider one boiler in detail.

Boiler Savings

The Department of Energy reports that heating equipment is the largest consumer of natural gas in commercial properties! Premier Water & Energy Technology, Inc. works to reduce customer's energy costs by improving overall boiler system water treatment and operating practices as well. Making minor adjustments can save this boiler system US $13,875.50 per year in utility costs by scale and deposit control and by reducing blow down.

Our subject boiler produces 300,000 lb (136.078 kg) of steam/day and has the following characteristics:

- Steam production = 300,000 lb/day x 1,184.6 Btu/lb = 355.38 million Btu/day
- Boiler operating pressure = 75 psig (5.2 bar)
- Boiler efficiency = 80%
- Fuel source = Natural gas at US$4.50/1,000 ft^3 and 1,000 Btu/ ft^3
- Condensate return = 80% at 200°F (93.3°C)
- Current blow down rate = 10%
- Operating season = 150 days/yr
- Water cost/1,000 gal (3784 L)= US$3.00

Reducing Blow Down

Making minor adjustments can save this typical boiler system US$13,875.50/yr - US$4,835.50 by reducing blow down and US$9,040.00 by reducing scale and improving fuel-to-steam efficiency

Boiler blow down is simply the loss of water that is already heated, which means a loss of both energy and water. Reducing blow down from 10% to 5% by improved water treatment will reduce energy costs as follows:

Water Savings-
2,104 gal (7962 L) water/day = US $6.31/day| 315,537 gal (1,194,537 L) water/day = US $946.50/yr

Energy (natural gas) Savings-
5,658 ft_3 (160 m3)/day = US$25.93/day
848,685 ft_3 (24,032 m3/day = US$3,889.00/yr

Total Savings: US$4,835.50/yr

It's important to know that while boiler water and feedwater have the same concentration of impurities before the boiler is fired, concentrations in boiler water increase rapidly as the boiler water is evaporated into steam. The "concentration factor" is the number of times your boiler water can be evaporated before reaching the maximum permissible concentration. That number is called "cycles of concentration". Blow down removes "cycled" water and replaces it with fresh water.
By improving and monitoring the quality of your feedwater - and by increasing your boiler cycles - a sound water treatment program can go a long way toward reducing operating costs and increasing plant profitability.

Reducing Scale to Improve Efficiency

Scale formation is a chief enemy of fuel-to-steam efficiency and can be reduced and maintained at a low level by appropriate water treatment.

A 500-hp boiler producing steam at a rate of 16.74 million Btu/hour at 75% efficiency and operating for 8,000 hrs/yr requires an energy input of:

- 16.74 million Btu/hr
- 100,440 million Btu/year (16.74 x 8,000 x 0.75)

If scale 1/32 in. thick forms on the tubes, depending on the composition of the scale, expect an energy loss of 2%-7%.

- Annual energy loss at 2%
- 2,009 million Btu/year (100,440 x 0.02)

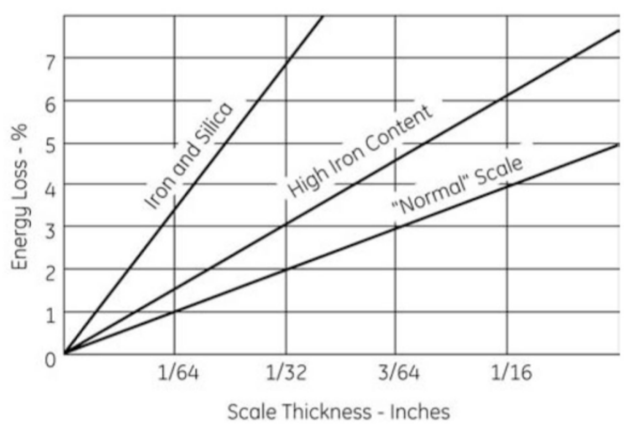

FIGURE 5: EVEN NORMAL SCALE INCREASES ENERGY LOSS DRAMATICALLY.

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If the gas in use has a heating value of 1,000 Btu/ft3 and costs $4.50/1,000 ft^3 (305 m), removing that scale and preventing new deposits results in yearly cost savings of:

- 2,009 million Btu/year
- US$9,040/yr (2,009 million Btu/year x 1 ft^3/1,000 Btu x US$4.50/ 1,000 ft^3)

The Role of Water Treatment

Your water treatment program can go a long way toward achieving this kind of energy savings. For example, improving the quality of feedwater and using effective dispersants can substantially reduce blow down required to control the concentration of impurities in boiler water.

Scale formation is a chief enemy of fuel-to-steam efficiency, and can be reduced and maintained at a low level by appropriate water treatment.

Both scale and sludge can decrease boiler efficiency, and a good water treatment program must control both. Following a complete water analysis of your system, your water treatment specialist will be able to establish a treatment program for your boiler and cooling system.

Protecting Your Capital Equipment

The Hartford Steam Boiler Inspection and Insurance Company has analyzed 2,462 boiler accidents and determined that on average, 23% of all boiler failures studied occurred as a result of poor water treatment.

In boilers with up to 4,000 ft$_2$ of heating surface, 36% of failures had to do with such problems as scale and sediment. Another 8% were the result of corrosion and erosion.

When corrosion attacks metal components of the boiler or air conditioning system, it not only weakens the metal itself, but produces an insulating effect that can cause overheating and eventual breaks and failures. The buildup of corrosion products decreases heat transfer ability and reduces system efficiency.

The cost of an ongoing water treatment program to reduce scale, corrosion and fouling is small compared with the energy costs caused by lack of treatment or incorrect treatment.

The Costs of Compliance

This section might be more appropriately called "The Costs of Noncompliance." After all, even though meeting the myriad of local and regional regulations governing the treatment and disposal of water in your facility can be expensive, not meeting them can cost even more.

Ideally, your water treatment supplier should go beyond the essentials dictated by law and help you reduce costs while meeting environmental objectives. At Premier environmental compliance are perfectly compatible goals.

Talk with your Premier representative today to find out how you can reduce costs and improve system operations.

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