



WATER
QUALITY
RESEARCH
COUNCIL

Water Softeners as Energy Conserving Investments

RESEARCH REPORT

**"Softened Water Energy Saving
Study-Controlled Experimental Testing
Program on Household Water Heaters"**
New Mexico State University

PURPOSE

The purpose of this study was to measure and quantify differences, if any, in energy consumption of household water heaters installed and operated on hard versus softened water supplies. The objectives were to determine if softening water saves energy in gas and electric hot water heaters, and to determine how accumulated scale and sediment in heaters affects energy consumption.

TESTING

The NMSU study was performed in the laboratory on 16 water heaters: four new heaters and 12 heaters removed from actual households in the Las Cruces, New Mexico area. Used heaters were selected to obtain a broad range of in-service-time, from five to 15 years, and varying amounts of sediment-scale deposits. The test groups were chosen so that half of each group had been operated exclusively on the area's untreated hard water; and the other half of each group had been operated exclusively on water from the same water source but which was first softened by home water softeners to remove hardness minerals. The energy consumed by each water heater was monitored at the NMSU labs for 14 days under typical residential hot water usage patterns.

RESULTS

Gas Water Heaters - in terms of additional energy consumed, the group of used heaters on hard water took 29.57% more Btu's than the group on softened water to provide the same amount of hot water.

Electric Water Heaters - In terms of additional energy consumed, the group of used heaters on hard water took 21.68% more Btu's than the group on softened water to provide the same amount of hot water.



ENERGY CONSUMPTION OF GAS WATER
HEATERS OPERATED ON UNTREATED
HARD VS. SOFTENED WATER



UNTREATED HARD WATER



SOFTENED WATER

29.57% MORE BTUS CONSUMED BY THE
GAS WATER HEATERS THAT HAD BEEN
OPERATED AND TESTED ON HARD WATER



ENERGY CONSUMPTION OF ELECTRIC
WATER HEATERS OPERATED ON
UNTREATED HARD VS. SOFTENED WATER



UNTREATED HARD WATER



SOFTENED WATER

21.68% MORE BTUS CONSUMED BY THE
ELECTRIC WATER HEATERS THAT HAD BEEN
OPERATED AND TESTED ON HARD WATER

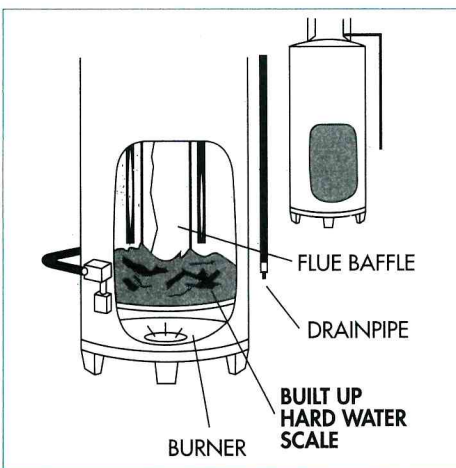
OBSERVATIONS

The major reason cited by the NMSU researchers for the energy usage differences is simply the application of the principle of insulation...but in reverse. In this case, hard water can contribute to the buildup of a

layer of insulation (in the form of scale) between the water and the heat source. Scale acts as an insulator and is a poor conductor of heat.

The problem this poses for water heaters is that when such a scale and sediment builds up in the heater tank, it insulates the water from the heat source being used to heat it [see illustration to left].

In order to heat the water in such a situation, it is first necessary to heat the scale that has built up in the tank. The energy used in heating this scale is largely wasted. As a result, water heaters with such a scale build up work harder and use more energy to deliver a given amount of hot water than heaters which do not have the handicap of this unwanted hard water scale.



The researchers at NMSU removed and weighed the sediment and scale that had accumulated in the used water heaters. In the water heaters that had been operated only on "soft water," the amount of scale removed varied from 1.09 to 4.27 pounds. In the "hard water" gas water heaters, the amount removed varied from 3.86 pounds in a six year old unit, to almost 40 pounds in a 10 year old unit. The amount removed from the electric water heaters varied from 15 to 39 pounds.

After removing the scale from the units, NMSU researchers retested them for energy consumption. Although the efficiency improved somewhat, the units which had been operated and tested on hard water still consumed more energy than those units which had been operated and tested on softened water. The "hard water" units still consumed 24.55% more Btu's than their "soft water" counterparts. The "hard water" electric units consumed 7.23% more Btu's than the "soft water" units. Thus, the removal of scale from the heaters affected an average reduction in energy consumption of 5.02% for the gas heaters and 14.45% for the electric units.

Since not all of the energy consumption differences between the "hard" and "soft" water heaters could be accounted for by the scale removal, the researchers theorized that the use of hard water caused, by a yet unknown mechanism, some permanent effect on the performance of the water heaters.

When water heaters are first installed and operated on a given water supply, they demonstrate a certain initial average energy efficiency. That is, over a period of time, the unit will deliver a certain amount of energy in the form of hot water for every unit of energy it consumes. Some of the energy consumed by the heater will not be delivered in the form of heated water, but will be lost in the heating process.

For example, some energy may go up and out into the environment through the flue in a gas heater. Likewise, some energy may pass out through the jacket or fitting in an electric heater. The design of the heater and the type of energy used, among other factors, will determine the initial average energy efficiency of any given water heater.

The NMSU tests conclusively demonstrated that a buildup of hard water scale in a water heater tank interferes with the heat transfer process and will reduce the average energy efficiency of that appliance. The tests showed that the removal of built up scale will significantly improve the heater's average efficiency. Removing or reducing the buildup of that scale will not make the unit perform better than its original design will permit, but it will work to control significant losses in average efficiency due to scale formation.

*...a properly designed water softener
will either eliminate or very greatly reduce
the buildup of hard water scale...*

While consumers could, as the NMSU researchers did, periodically disconnect their water heaters and remove built up scale, by far the easiest and most effective way to control scale buildup is to remove the hardness minerals from the water before it reaches the water heater. This can and is accomplished every day in the millions of homes and commercial establishments that have installed ion exchange water softeners. Water softeners remove calcium and magnesium from water. These are the principle minerals that form hard water scale. In most applications, the operation of a properly designed water softener will either eliminate or very greatly reduce the buildup of hard water scale, as the NMSU tests showed.

IMPORTANT NOTE

The following facts and qualifications should be taken into consideration when interpreting these research results:

- All findings are based on the units used and on the hard water supply available in the Las Cruces, New Mexico area during the operation and test period. The testing groups' average water hardness ranged from 9.4 to 14.3 grains per gallon.
- In addition to the level of water hardness, there are a number of factors which combine to determine if scale will form in a heater tank and at what rate it will build up. These also include water temperature, pH, and total dissolved solids (TDS). These factors vary from water supply to water supply and may even vary over time within a single water system.

FOR MORE INFORMATION

The complete 137 - page
Research Report, Order No.
R14 may be purchased from:
Water Quality Association
4151 Naperville Road
Lisle, Illinois 60532