ECOWATER SYSTEMS®

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ENERGY SAVINGS WITH SOFTENED WATER

COMPLETE WATER SOLUTIONS

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Contents

I. Introduction

The purpose of this publication is to provide support data and basic information on how a water softener saves on energy consumption when water is heated by various methods, to serve or satisfy a particular need. As the cost of energy escalates, all of us become even more aware of the rising cost of the fuel consumed to perform the necessary water heating requirements. The primary concerns are to conserve on energy and to improve the efficiency of the water heating process.

This information will be of use and of interest to you if you are concerned about the efficiency of a water heating system, or would like to keep better control of the cost of operating a plant or specific process using hot water. You may be involved in the design, operation, maintenance or purchasing of equipment, and need to justify the cost of new or replacement components or a complete system. All water using and heating appliances or systems are affected by the quality of the water being supplied for their use or processing.

Up until the recent past, the need to be concerned about the quality of water we were using was left to someone else. Unless we could visually see a problem, or smell or taste something in the water, we would naturally take it for granted that the quality of the water was very adequate for our use. Some of you knew better and were very aware of the need for water treatment or conditioning. You were aware of the added expenses involved in maintaining and operating equipment when the water caused problems, when the water was not taken care of by water conditioning. We now have some added support data to show that your concerns were right and that you can save energy and operating costs by improving the efficiency of a water heating system. This can be done by using soft water.

II. Summary Comments

The application of a water softener to eliminate the formation of the hardness scale reduces fuel consumption. Tests conducted at the New Mexico State University have shown that gas fired heaters consumed 29.6% more BTU's and electric heaters consumed 21.7% more BTU's when operated on hard water than they did when operated on softened water.

The water softening process removes the hardness or scale forming minerals, which are calcium and magnesium and, in some cases, clear water or ferrous iron. These hard minerals react or are affected by heating of the water. When heated, these minerals have a tendency to precipitate or fall out of solution and form a hardness scale. You may have seen this scale in plumbing, hot water tanks, on low water cut-offs, heater elements, pumps, or possibly in the water or kettle on the old stove top. The scale looks like, and basically is, limestone which has some substantial insulating properties. The hardness scale formation interferes with the heat exchange process and drastically lowers the fuel efficiency of the water heater.

We can conserve by lowering the temperature of the heated water to the lower limit of the heated water usage. We will also eliminate waste of heated water by fixing leaks and closer monitoring of the hot water or steam system and insulating lines as well as holding tanks.

To improve the efficiency of the water heating process, the elimination or removal of scale forming minerals from the water supply is very important. This is accomplished by a water softener.

The accumulative effect of improving the efficiency of the water heating process is very significant. Checking with the Minnesota State Energy Commission revealed that over 60% of the energy consumed in commercial and institutional buildings is used to heat water.

III. Water As a Resource

To better understand the total aspects of water and why we should be concerned about how it is used and treated, let's take a few minutes to discuss water in our environment.

As a resource, no other compound is more important to man than water. In addition to its daily chore of sustaining all life, water provides man with a building block for social development and even possesses religious and legendary value.

Water is a valuable resource and its availability is crucial to our existence. Our vast oceans alone would lead us to believe water is an inexhaustible resource — after all, roughly two thirds of our planet is submerged by these very oceans. For those who delight in statistics, water — as oceans, rivers, lakes, or ice-caps, total an unbelievable 324,030,000 cubic miles of water on the earth's surface There are another 2,000,000 cubic miles of water beneath the surface of the earth. In terms of gallons this comes to a number too staggering to mention.

This total has not changed since the earth was a barren planet, millions of years ago. Why then do we concern ourselves with the availability of this ever present gift? Facts are that only just over three-tenths of one percent of this supply is available as fresh water that can be used for drinking and countless other domestic and industrial purposes. One now begins to understand the meaning of "Water, water everywhere, and not a drop to drink."

Studies have shown that an American will use an average of 60 gallons of water per day. That 60 GPD multiplied by our 250,000,000+ population is only a fraction of the water our country uses daily. Where does the rest go? To agriculture for irrigation, to power plants for electricity generation and to industry for processing. These factors increase our per capita water use more than a thousand fold.

While the significance of these facts is more important than actual numbers, it is interesting to note that it takes:

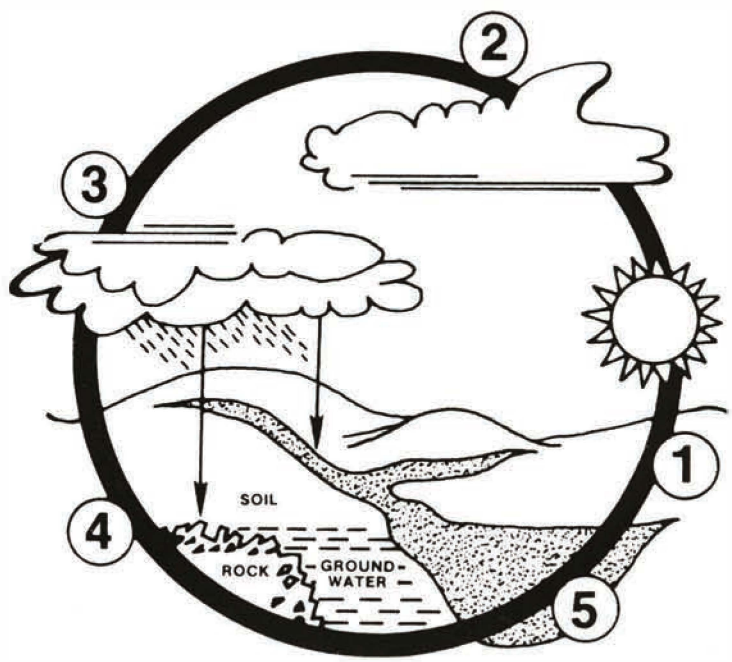
- 4,300 gallons of water to process enough bread and roast beef to make sandwiches for a family of four.
- 10,000 gallons of water to make one automobile.

All of this discussion about how much and what for — where does this water originate and how do our supplies get replenished so inconspicuously? All we need to do is look at the sky to get the answer. If it is raining, the job is being done, if it is not, you can bet that nature's forces are at work. They will see that the job gets done, and sooner than some of us might appreciate if we're at a picnic or playing a round of golf.

Figure III-1

HYDROLOGIC CYCLE

1. Water at earth's surface is heated by sunlight and evaporates. The water vapor becomes part of the air we breathe.
2. As warm air rises and cools, the water vapor forms small particles of liquid or ice such as clouds.
3. The particles in the clouds grow until they fall to earth as rain or snow.
4. Some rain or melted snow soaks into earth and dissolves some of the minerals.
5. Some rain and snow falls into streams, lakes and oceans. Eventually, the water again is heated and the cycle repeats.



Each day, in fact, rain is falling, and at the same time somewhere else, rain is "ascending." You might have surmised by now that water travels in circles. Enough water evaporates into the atmosphere and returns to the earth as rain to submerge all of New England under nearly 8,000 feet of water every two weeks.

This replenishing process is called the hydrologic cycle — what goes up must come down. Simply stated, the earth, the sun and the atmosphere could be thought of as a huge still. The sun, acting as a heater warms the water on the earth's surface. This "warm" water evaporates and ascends into the atmosphere where, at higher altitude the water is cooled and condenses to form clouds. These clouds eventually lead to rain (or snow, sleet, etc.).

This deluge of precipitation would appear to be more than enough to meet the needs of man. However, since the earth's surface is mostly water, some 75% falls right back where it came from. The remainder is expended in so many ways that less than 10% is available for surface run-off to sustain rivers, lakes and wells.

IV. Water Chemistry

Water chemistry really begins with a simple formula—H_20. Water is 11% hydrogen and 89% oxygen. The discussion now ceases to be simple and elementary since it is really the chemistry of water's impurities that concern us.

During the hydrologic cycle water goes from pure to impure and then back to pure again. The water that evaporates into water vapor and ascends into the atmosphere is the purest of naturally occurring water. It retains this purity until the condensation and precipitation cycles begin.

The minute water condenses and begins to form a cloud, it picks up impurities of many kinds. Starting with dissolved gases, water becomes increasingly "dirtier" until it either evaporates or is treated to remove impurities.

Water picks up dissolved gases in the atmosphere and becomes acidic and very aggressive. Once on the earth this "acidic" water wants to dissolve any and virtually all minerals it contacts. Thus, it becomes hard, brackish and contaminated to many varying degrees.

Since the degree of contamination is directly related to the problem it creates, a discussion measuring the impurities is certainly in order. There are many standards used to define water purity or degrees of impurity.

A. Water Analysis Terms

The degree of mineral contamination of water can be measured either by chemical analysis or in some cases by measuring the water's ability to conduct (or resist) an electric current.

When determined by chemical analysis, impurities are usually expressed in one or more of three very important terms, mg/1 (milligrams per liter), ppm (parts per million) and GPG (grains per gallon). All are used arbitrarily by laboratories that analyze water.

The key to interpretation of a lab report lies in ones ability to convert one expression to another and to understand what each means. The term parts per million means precisely that, one part per every million parts, and is basically equal to a mg/1. A grain per gallon is another story. Its origin comes from ancient Rome and at best is a semi-logical system of measurement. To relate it to something familiar, an aspirin tablet usually weighs 5 grains. If you dissolved an aspirin in one gallon of pure water, you would have a 5 grain per gallon solution. Conversion of the terms is greatly simplified by the use of Figure IV-2 on page 6.

Figure IV-2

Conversion Factors

GPG	x	17.1	=	ppm
GPG	x	17.1	=	mg/l
ppm	÷	17.1	=	GPG
mg/l	÷	17.1	=	GPG

Examples:

30 GPG x 17.1 = 513 ppm
513 mg/l ÷ 17.1 = 30 GPG

B. Hardness In Water

There is no doubt that water hardness is the most common of all water problems. Its presence costs industries millions of dollars annually in equipment and plumbing maintenance and replacement. Hardness, then, was the mother of invention to the water softener industry.

Referring again to our understanding of the hydrologic cycle let's have a look at how hardness enters our water supplies. As water in the atmosphere condenses it dissolves carbon dioxide from the air and forms a weak acid called carbonic acid:

1) $H_20 + C_20 \rightarrow H_2C0_3$

This acid water falls to the earth as rain and trickles through the top soil to bed rock, often limestone. Limestone is calcium and magnesium carbonate. The acid water dissolves the lime and neutralizes the acid. At the same time, the water becomes hard:

2) $H_2C0_3 + CaC0_3 \rightarrow (HC0_3)$
3) $H_2C0_3 + MgCO_3 \rightarrow Mg\ (C0_3)_2$

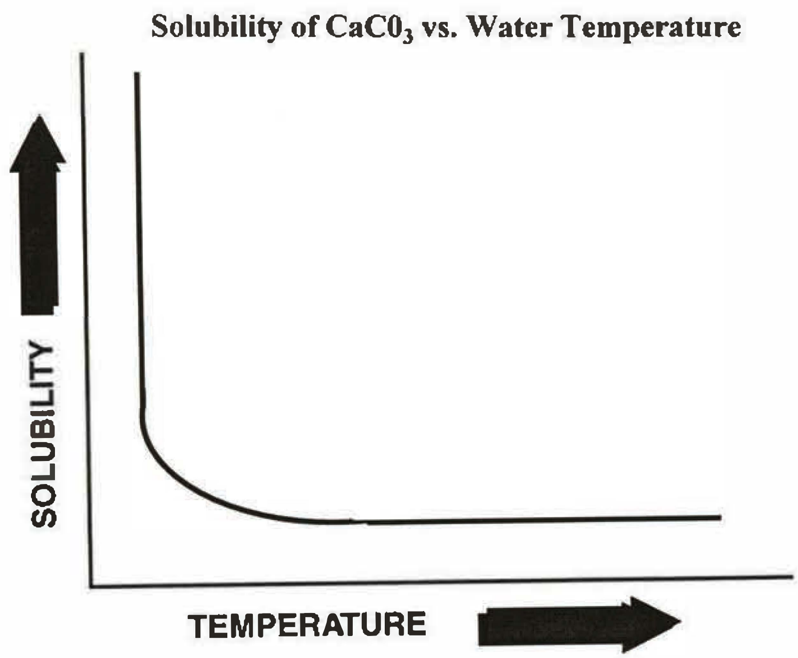
C. Hardness Scale Formation

There are many problems caused by the hardness minerals in water, but the most common is hardness scale. To understand the formation of hardness scale we need only to reverse the formula we used to demonstrate the water "hardening" phenomena:

$Ca\ (HC0_3)_2$ (heat) $\rightarrow H_20 + CO_2 \uparrow$ (gas) + $CaC0_3 \downarrow$ (scale)

The solubility of hardness in water is temperature dependent. The reaction, as indicated above in the formula, is that the CO_2 is driven out of the solution by the heating process and the result is a $CaC0_3$ precipitation or scale formation. The higher the operating temperature, the more scale forming tendency there is. This is illustrated by Figure IV-3.

Figure IV-3



D. Water Softening

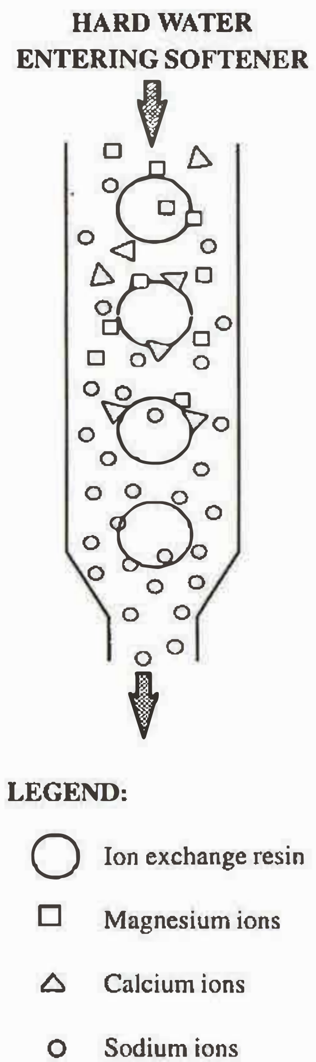
A water softener functions on the ion exchange principle in the removal of hardness minerals and certain other contaminants from raw water. The equipment contains a bed of softening material known as resin, through which the raw, untreated water flows. As the water passes through the resin the hardness minerals attach themselves as illustrated in Figure IV-4. This ion exchange process, as chemists call it, occurs literally billions of times during the softening process. Eventually so much hardness collects on the resin that the unit can no longer soften water. At this point it is considered "exhausted." Water passing through a unit in this "exhausted" condition would remain hard. Regeneration or recharging is now necessary. To recharge the resin, it must be rinsed with a rich brine solution. This washes out the hardness and replaces it with sodium and once again the renewed resin is ready to remove hardness from water. At this point the hardness minerals and the excess brine solution are rinsed down the drain.

During the recharging cycle the unit is also backwashed. This reversing of the normal flow of water serves to remove any turbidity and sediment which may have accumulated during the softening process due to the filtering action of the ion exchange material. Backwashing also loosens and fluffs the bed resin bed.

Water softener capacity is in terms of the grains of hardness it will remove with each recharging. The harder the water, the more frequent the recharging necessary. A water softener with a rated capacity of 50,000 grains will remove hardness from 10,000 gallons of five grain hard water, or it will remove hardness from 1,000 gallons of a 50 grain water before recharging is necessary.

Figure IV-4

The Ion Exchange Column



E. Saturation or Stability Index

Hardness scale formation in water heating systems is not only a result of the water heating process, but is directly related to the pH and the alkalinity of the water supply. Some very educated people have studied the scaling tendencies of water and have developed formulas to predict the same.

In 1936, Professor Langelier published his Saturation Index that measures the positive or negative driving force of water. The positive effect means the water has scaling tendencies. The negative effect means the water has corrosive tendencies. During the 1940's, J.W. Ryznar evidently became frustrated with the Langelier Index of Saturation because few water supplies have a "zero" or balanced state of equilibrium. Ryznar then developed a Stability Index that gave a more expanded range to predict the stability of a water supply and its potential for scale forming tendencies.

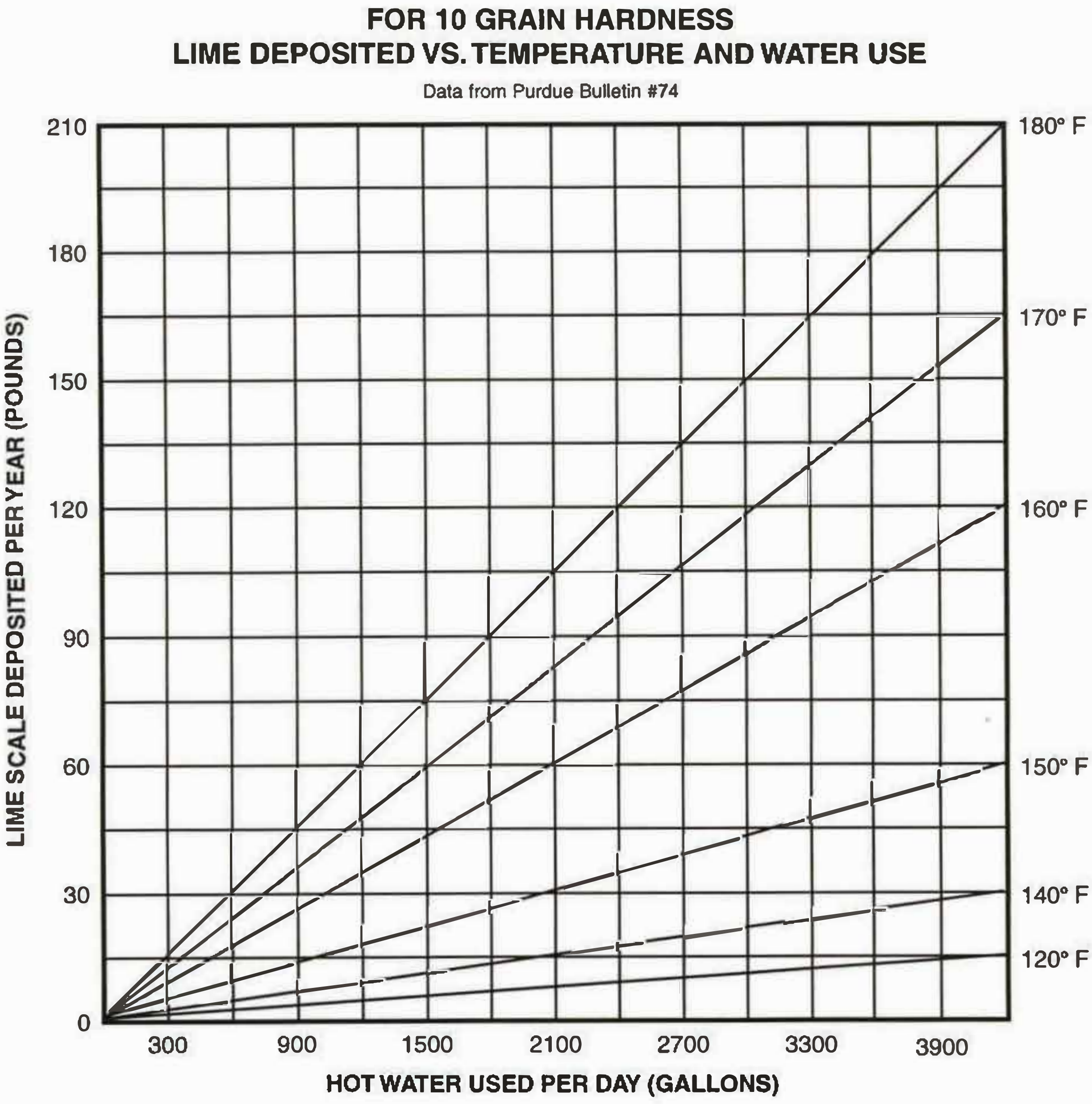
These indexes and resulting formulas and charts are much too extensive to be discussed in detail here, but can be found in many reference books, such as the Betz Handbook of Industrial Water Conditioning. What it basically boils down to is that water containing hardness consisting primarily of $CaC0_3$, having a pH of 7.2 and above, will have scale forming tendencies.

V. Scale Effects in Water Heating

A. Scale Accumulation Rate

If a hard water supply is processed by a water heater for a period of time, a scale or limestone deposit will form on the heater elements or walls of the heater. The scale is deposited at a rate which is dependent on the water hardness and to what degree the water is heated. The rate of scale accumulation for a 10 grain hard water supply can be found in Figure V-4, which is from a Purdue University study.

Figure V-4



To use this chart for determining the amount of scale deposited for different water hardness conditions, Figure V-5 provides multiplication factors for various hardness levels.

Figure V-5

Scale Deposit Multiplication Factors

Water Hardness	Mult. Scale Deposited Per Year from Fig.V-4 By:
5 GPG	0.5
10 GPG	1.0
15 GPG	1.5
20 GPG	2.0
25 GPG	2.5
30 GPG	3.0
40 GPG	4.0

Examples:

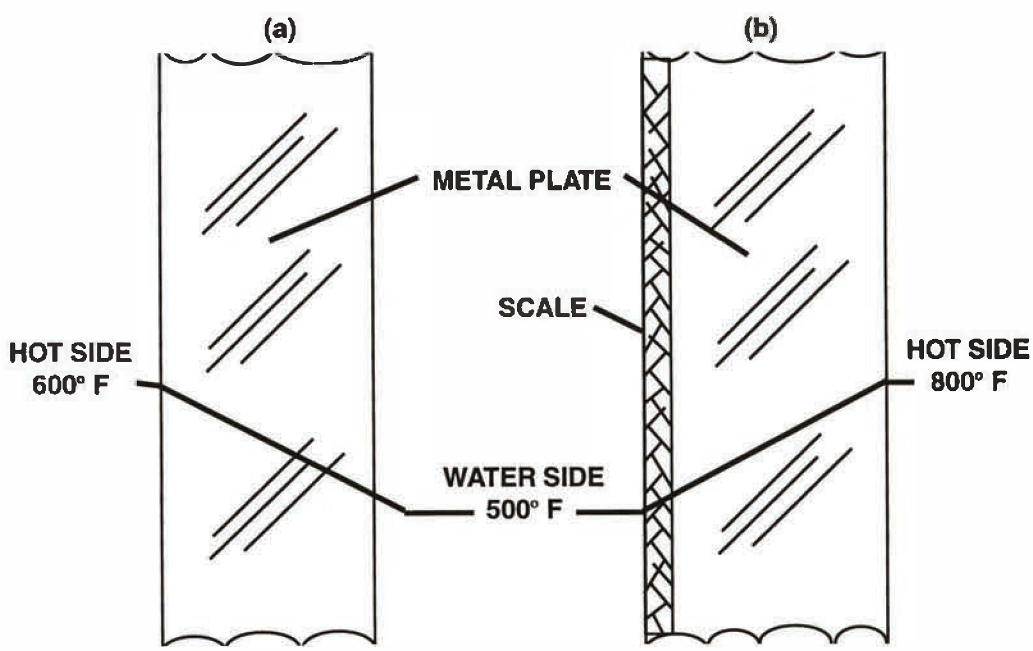
1. You have a hard water supply containing 10 grains of hardness. It is heated to 170°F and you use 1500 gallons per day. The result would be a scale or limestone deposit of 60 lbs. per year.
2. You have a 25 GPG hard water supply. It is heated to 150°F and you use 2100 gallons per day. The result would be a scale deposit of 32 lbs. x 2.5 or 80 lbs. per year.

B. Insulating Effects of Scale

As the scale deposits from the use of hard water are allowed to accumulate, the efficiency of the water heating process declines. The hardness scale, as it comes out of solution, will attach itself to the hot or heated surface and act as an insulating barrier. The result is a reduction in heat transfer as illustrated in Figure V-6 (a) and (b). The studies that have been conducted have indicated that a scale deposit of only 1/8" can result in a 30% reduction in heat transfer.

Figure V-6

Source: Betz Handbook of Industrial Water Conditioning



C. Hardness Scale Problems

We talked earlier of some of the visible hardness scale that you may have seen, such as the precipitated lime scale that settles to the bottom of the tea kettle. This same type of scale plugs hot water pipes, water heating tanks, water heating elements (see Figure V-7), water circulating pumps, dishwasher screens and rinse nozzles, low water cut-offs for boilers (see Figure V-8), and the list goes on.

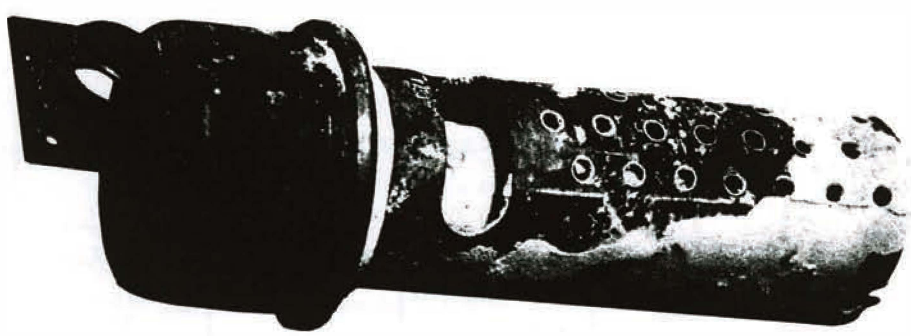
These hardness scale problems result in decreased efficiency of booster heaters for dishwashers and increased maintenance costs to repair, replace or clean plumbing, fixtures and boilers. The scale deposits can lead to another problem, overheating. The overheating of metal surfaces insulated with hardness scale will cause an added heat fatigue factor resulting in the failure of heater elements.

Figure V-7

Hardness Scale Fouled Electric Heater Element

Figure V-8

Hardness Scale Fouled Low Water Cut-Off



VI. The Cost of Heating Water

A. Comparative Fuel Costs

The following chart in Figure VI-9 is rather extensive and rapidly becoming outdated as the cost of fuel escalates. This data will be necessary to determine the approximate total fuel or energy cost to heat water. The data in this chart assumes that the heater involved is new and relatively efficient in fuel usage.

Figure VI-9

A. O. SMITH FUEL CONVERSION RATES

1. Determine fuel used in column Athru F.
2. Find closest fuel cost per billing unit.
3. Then follow the line to the right and read figure in the G column. The G column is the cost to heat 1000 gal. of water when raising the temperature 100° F. Example: Natural gas cost of $2.50 per 1000 cubic feet converts to a $3.30 cost to heat 1000 gal.

A. Natrual Gas $/1000 cu. ft.	B. Propane Gas $/gallon	C. Butane Gas $/gallon	D. Fuel Oil $/gallon	E. Coal in firebox $/ton	F. Electric c/K.W.H.	G. Approx. cost per 1000 gallons hot water at 100° F rise.
1.50	.131	.146	.200	32.74	.772	1.68
1.60	.139	.156	.213	34.92	.823	2.11
1.70	.148	.166	.227	37.10	.875	2.25
1.80	.157	.176	.240	39.28	.926	2.38
1.90	.165	.186	.253	41.47	.977	2.51
2.00	.174	.195	.267	43.65	1.029	2.64
2.10	.183	.205	.280	45.83	1.080	2.78
2.20	.192	.215	.293	48.01	1.132	2.91
2.30	.200	.225	.307	50.20	1.183	3.04
2.40	.209	.234	.320	52.38	1.235	3.17
2.50	.218	.244	.333	54.56	1.286	3.30
2.60	.226	.254	.347	56.75	1.338	3.44
2.70	.235	.264	.360	58.93	1.389	3.57
2.80	.244	.273	.373	61.11	1.441	3.70
2.90	.253	.283	.387	63.29	1.492	3.83
3.00	.261	.293	.400	65.48	1.543	3.97
3.10	.270	.303	.413	67.66	1.595	4.10
3.20	.279	.313	.427	69.84	1.646	4.23
3.30	.287	.322	.440	72.02	1.698	4.36
3.40	.296	.332	.453	74.21	1.749	4.49
3.50	.305	.342	.466	76.39	1.800	4.63
3.60	.314	.352	.480	78.57	1.852	4.76
3.70	.322	.361	.493	80.75	1.904	4.89
3.80	.331	.371	.507	82.94	1.955	5.02
3.90	.340	.381	.520	85.12	2.005	5.16
4.00	.348	.391	.533	87.30	2.058	5.29
4.10	.357	.401	.547	89.48	2.109	5.42
4.20	.366	.410	.560	91.67	2.161	5.55
4.30	.375	.420	.573	93.85	2.212	5.68
4.40	.383	.430	.587	96.03	2.264	5.82
4.50	.392	.440	.600	98.21	2.315	5.95
4.60	.401	.449	.613	100.40	2.367	6.08
4.70	.409	.459	.627	102.58	2.148	6.21
4.80	.418	.469	.640	104.76	2.470	6.35
4.90	.427	.479	.653	106.94	2.521	6.48
5.00	.436	.488	.667	109.13	2.572	6.61
5.25	.457	.513	.700	114.58	2.701	6.94
5.50	.479	.537	.733	120.04	2.830	7.27
5.75	.501	.562	.767	125.50	2.958	7.60
6.00	.523	.586	.800	130.95	3.087	7.93
6.25	.545	.611	.833	136.41	3.216	8.26
6.50	.566	.635	.867	141.86	3.344	8.59
6.75	.588	.659	.900	147.32	3.473	8.92
7.00	.610	.684	.933	152.78	3.601	9.25
7.25	.632	.708	.967	158.23	3.730	9.59
7.50	.653	.733	1.000	163.69	3.859	9.92
7.75	.675	.757	1.033	169.15	3.987	10.25
8.00	.697	.782	1.067	174.60	4.116	10.58
8.50	.741	.830	1.133	185.51	4.373	11.24
9.00	.784	.879	1.200	196.43	4.610	11.90
9.50	.828	.928	1.267	207.34	4.688	12.56
10.00	.871	.977	1.333	218.25	5.145	13.22
11.00	.958	1.075	1.467	240.07	5.670	14.55

B. Softened Water Energy Saving Study

With the advent of the Energy Tax Act in 1978, which provides for a tax incentive to encourage energy conservation, the Water Quality Research Council sponsored a study. Conducted by the New Mexico State University, this study determined specific data on energy savings that could be achieved by using a water softener in conjunction with the water heating process. It was the belief of the Water Quality Research Council that softening water, for the water heating process, reduces energy consumption by preventing the build-up of scale and sediment in water heaters.

The study's purpose was to measure and quantify differences, if any, in energy consumption of water heaters installed and operated on hard and softened water supplies. The objectives were to determine if softening water saves energy in gas and electric water heaters, and to determine how accumulated scale and sediment in the heater effects energy consumption.

The tests were performed at the New Mexico State University laboratory on sixteen heaters: four new heaters and twelve heaters removed from actual applications. The used water heaters were selected to obtain a broad range of in-service time, from five to fifteen years, and amounts of scale deposits.

The efficiencies of eight gas water heaters, four operated on softened water and four operated on hard water, were determined over a fourteen day test period. The gas fired heaters operated and tested on hard water consumed 29.6% more BTU's of energy than those heaters operated and tested on softened water.

In a similar manner, the eight electric water heaters were tested over a fourteen day test period. The electric heaters operated and tested on hard water consumed 21.7% more BTU's of energy than those heaters operated and tested on softened water.

The results and data from this research study have been published by the Water Quality Association.

VII. Energy Savings Examples

The following is a random assortment of examples of the energy saving in terms of today's dollars and actual energy consumption. You may find your situation close to one of the examples, or at least close enough, to equate the potential saving that you could realize.

A. Motel

Application: 100 unit motel

Hot water use: 6,000 gallons per day

Fuel and cost: electric at $.05/KWH or 5.0 c/KWH

Temperature rise: 120°F (hot) - 45°F (supply) = 75°F rise

Fuel use rate (from Fig. VI-9): $12.56 to heat 1000 gal. with 100°F temperature rise

Calculations:

75°F÷100°F =.75 x $12.56 per 1000 gal. = $9.64 per 1000 gal.

$9.42 per 1000 gal. x 6000 gal. per day = $56.52 per day

$56.52 x 21.7% = $12.26 per day (savings for electric heaters)

$12.26 per day x 365 days = $4475 per year in savings

The $4475 per year operating cost reduction converts to a deduction in usage of over 91,000 KW/year of electrical power.

B. Hotel

Application: 250 room hotel

Hot water use: 15,000 gallons per day

Fuel and cost: fuel oil at $1.20 / gallon

Temperature rise: 140°F (hot) - 55°F (supply) = 85° rise

Fuel use rate (from Fig. VI-9): $11.90 to heat 1000 gal. with 100°F temperature rise

Calculations:

85°F÷100°F = .85 x $11.90 per 1000 gal. = $10.12 per 1000 gal.

$10.12 per 1000 gal. x 15,000 gal per day = $151.80/day

$151.80 x 29.6% = $44.93 per day (assuming a similar percent savings to that of a gas heater)

$44.93 per day x 365 days = $16,399/year (savings)

The $16,399 per year operating cost reduction results in a fuel oil use savings of over 13,500 gallons (320 barrels).

C. Restaurant

Application: restaurant serving 800 meals per day

Hot water use: 5600 gallons per day

Fuel and cost: natural gas at $3.25/1000 ft^3

Temperature rise: 180°F (hot) - 50°F (supply) = 130°F rise

Fuel use rate: $4.36 to heat 1000 gal. with 100°F temperature rise

Calculations:

130°F÷100°F = 1.30 x $4.36 per 1000 gal. = $5.67 per 1000 gal.

$5.67 per 1000 gal. x 5600 gal per day = $31.75 per day

$31.75 per day x 29.6% = $9.40 per day (savings)

$9.40 per day x 365 days = $3431 per year (savings)

The $3,431 per year savings is a significant reduction in operating cost and leads to a 1,030,000 ft^3 reduction in natural gas consumption per year.

D. Laundry

Application: Laundry using 150 pound washers at 50 loads per day

Hot water use: 18,750 gallons per day

Fuel and cost: natural gas at $3.50/1000 ft^3

Temperature rise: 160°F (hot) - 60°F (supply) = 130°F rise

Fuel use rate: $4.63 to heat 1000 gal. with 100°F temperature rise

Calculations:

60°F÷100°F = .60 x $4.36 per 1000 gal. = $2.78 per 1000 gal.

$2.78 per 1000 gal. x 18,750 gal. per day = $52.13 per day

$52.13 per day x 29.6% = $15.43 per day (savings)

$15.43 per day x 365 days = $5,632 per year (savings)

E. Hospital

Application: 60 bed hospital

Hot water use: 10,000 gallons per day

Fuel and cost: natural gas at \$3.25/1000 ft^3

Temperature rise: 140°F (hot) - 40°F (supply) = 100°F rise

Fuel use rate: \$4.36 to heat 1000 gal. with 100°F temperature rise (from A.O. Smith conversion chart)

Calculations:

40°F÷100°F = .40 x \$4.36 per 1000 gal. = \$1.74 per 1000 gal.

\$1.74 per 1000 gal. x 10,000 gal. per day = \$17.40 per day

\$17.40 per day x 29.6% = \$5.15 per day (savings)

\$5.15 per day x 365 days = \$1,880 per year (savings)

The \$1,880 per year is a signifacant savings, but just as important, it converts to a recuction in usage of over 1.5 million ft^3 per year of natural gas.

F. Nursing Home

Application: 120 bed home

Hot water use: 6,000 gallons per day

Fuel and cost: electric at \$.05/KWH or 5.0 c/KWH

Temperature rise: 120°F (hot) - 60°F (supply) = 60°F rise

Fuel use rate: \$12.56 to heat 1000 gal. with 100°F temperature rise

Calculations:

60°F÷100°F = .60 x \$12.56 per 1000 gal. = \$7.54 per 1000 gal.

\$7.54 per 1000 gal. x 6,000 gal. per day = \$45.24 per day

\$45.24 per day x 21.7% = \$9.82 per day (savings)

\$9.82 per day x 365 days = \$3,584 per year (savings)

The \$3,584 per year savings is again a significant reduction in operating cost.

G. School

Application: high school with 1500 students

Hot water use: 22,500 gallons per day

Fuel and cost: natural gas at \$3.00/1000 ft^3

Temperature rise: 140°F (hot) - 50°F (supply) = 90°F rise

Fuel use rate: \$3.97 to heat 1000 gal. with 100°F temperature rise

Calculations:

90°F÷100°F = .90 x \$3.97 per 1000 gal. = \$3.57 per 1000 gal.

\$3.57 per 1000 gal. x 22,500 gal. per day = \$80.33 per day (savings)

\$80.33 per day x 365 days = \$29,320 per year (savings)

The \$29,320 per year savings results in over 9.7 million ft^3 of natural gas consumption.

H. Private Home

Application: single family dwelling with 4 people

Hot water use: 120 gallon/day

Fuel and cost: electric at $.05/KWH or 5.0 c/KWH

Temperature rise: 140°F (hot) - 55°F (supply) = 85°F rise

Fuel use rate: $12.56 to heat 1000 gal. with 100°F temperature rise

Calculations:

85°F÷100°F = .90 x $12.56 per 1000 gal. = $10.68 per 1000 gal.

$10.68 per 1000 x 120 gal. per day = $1.28 per day

$1.28 per day x 21.7% = $.28 per day (savings)

$.28 per day x 365 days = $102 per year (savings)

The $102 per year savings may seem relatively small when compared to hospitals, schools, etc. but the family could make better use of the money than spending it on excess fuel consumption.

VIII. Glossary of Terms

ACID — A substance which releases hydrogen ions when dissolved in water. Most acids will dissolve the common metals, and will react with a base to form a neutral salt and water.

ALKALINITY — The quantitative capacity of a water or water solution to neutralize an acid. It is usually measured by titration with a standard acid solution of sulfuric acid, and expressed in terms of its calcium carbonate equivalent.

AQUIFER — A layer below the surface of the earth which is capable of yielding a significant volume of water.

BACKWASH — The process in which beds of filter or ion exchange media are subjected to flow opposite of the service flow direction which loosens the bed to flush suspended matter, collected during the service run, to waste.

BED — The ion exchange or filter media in a tank or other operational vessel.

BRINE — A strong solution of salt(s), such as the sodium chloride brine used in the regeneration of ion exchange water softeners, but also applied to the mixed sodium, calcium and magnesium chloride waste solution from regeneration.

CALCIUM — One of the principle elements making up the earth's crust, the compounds of which when dissolved make the water hard. The presence of calcium in water is a factor contributing to the formation of scale and insoluble soap curds which are a means of clearly identifying hard water.

CAPACITY — An expression of the quantity of an undesirable material which can be removed by a water conditioner between servicing of the media i.e., cleaning, by regeneration or replacement. For ion exchange water softeners, the capacity is expressed in grains of hardness removal between successive regenerations and is related to the pound of salt used in regeneration. For filters, the capacity may be expressed in the length of time or total gallons delivered between servicing.

CARBONATE — The CO_3 ion.

CARBONATE ALKALINITY — Alkalinity due to the presence of the carbonate ion.

CARBONATE HARDNESS — Hardness due to the presence of calcium and magnesium bicarbonates and carbonates in water; the smaller of the total hardness and the total alkalinity.

CARBON DIOXIDE — A gas present in the atmosphere and formed by the decay of organic matter; the gas in carbonated beverages; in water it forms carbonic acid.

CORROSION — The destructive disintegration of a metal by electrochemical means.

CYCLE — A series of events or steps which ultimately lead back to the starting point, such as the exhaustion-regeneration cycle of an ion exchange system.

DISSOLVED SOLIDS — The weight of matter in true solution in a stated volume of water; includes both inorganic and organic matter; usually determined by weighing the residue after evaporation of the water at 105° or 180°C.

EFFICIENCY — The ratio of output per unit input; the effectiveness of performance of a system; in an ion exchange system, often expressed as the amount of regenerate required to produce a unit of capacity, such as the pounds of salt per kilograin of hardness removal.

EXHAUSTION — The state of ion exchange material in which it is no longer capable of effective function due to the depletion of the initial supply of exchangeable ions; the exhaustion point may be defined in terms of a limiting concentration of matter in the effluent, or in the case of demineralization, in terms of electrical conductivity.

FLOW RATE — The quantity of water or regenerant which passes a given point in a specified unit of time, often expressed in gallons per minute.

GRAIN — (gr.) A unit of weight equal to 1/7000th of a pound, or 0.0648 grams.

GRAIN PER GALLON — (GPG) A common basis for reporting water analyses in the United States and Canada; one grain per U.S. gallon equals 17.12 milligrams per liter (mg/1) or parts per million (ppm). One grain per British (Imperial) gallon equals 14.3 milligrams per liter or parts per million.

GRAM — (g) The basis unit of weight (mass) of the metric system, originally intended to be the weight of one cubic centimeter of water at 4°C.

HARDNESS — A characteristic of natural water due to the presence of dissolved calcium and magnesium; water hardness is responsible for most scale formation in pipes and water heaters, and forms insoluble "curd" when it reacts with soaps. Hardness is usually expressed in grains per gallon, parts per million, or milligrams per liter, all as calcium carbonate equivalent.

HARD WATER — Water with a total hardness of one grain per gallon or more, as calcium carbonate equivalent.

HYDROGEN ION CONCENTRATION — The concentration of hydrogen ions in moles per liter of solution; often expressed as pH. (See pH.)

ION — An atom, or group of atoms which function as a unit, and has a positive or negative electrical charge, due to the gain or loss of one or more electrons. (See Ionization.)

ION EXCHANGE — A reversible process in which ions are released from an insoluble permanent material in exchange for other ions in a surrounding solution; the direction of the exchange depends upon the affinities of the ion exchanger for the ions present, and the concentrations of the ions in the solution. (See Base Exchange.)

ION EXCHANGER — A permanent, insoluble material which contains ions that will exchange reversibly with other ions in a surrounding solution. Both cation and anion exchangers are used in water conditioning.

IONIZATION — The process in which atoms gain or lose electrons and thus become ions with positive or negative charges; sometimes used as synonymous with dissociation, the separation of molecules into charged ions in solution.

IRON — An element often found dissolved in ground water (in the form of ferrous iron) in concentrations usually ranging from zero to 10 ppm (mg/1). It is objectionable in water supplies because of the staining caused after oxidation and precipitation (as ferric hydroxide), because of tastes, and because of unsightly colors produced when iron reacts with tannins in beverages such as coffee and tea.

LANGELIER'S INDEX — A calculated number used to predict whether or not a water will precipitate, be in equilibrium with, or dissolved calcium carbonate. It is sometimes erroneously assumed that any water which tends to dissolve calcium carbonate is automatically corrosive.

LIME — The common name for calcium oxide (CaO); hydrated lime is calcium hydroxide $Ca(OH)_2$

LIME SCALE — Hard water scale containing a high percentage of calcium carbonate.

LIMESTONE — A sedimentary rock, largely calcium carbonate, and usually also containing significant amounts of magnesium carbonate.

LITER — The basic metric unit of volume; 3,785 liters equals 1 U.S. gallon; 1 liter of water weighs 1000 grams.

MAGNESIUM — One of the elements making up the earth's crust, the compounds of which when dissolved in water make the water hard. The presence of magnesium in water is a factor contributing to the formation of scale and insoluble soap curds.

MILLIGRAM PER LITER (mg/1) — A unit concentration of matter used in reporting the results of water and wastewater analyses. In dilute water solutions, it is practically equal to the part per million, but varies from the ppm in concentrated solutions such as brine. As most analyses are performed on measured volumes of water, the mg/1 is a more accurate expression of the concentration, and is the preferred unit of measure.

MINERAL — A term applied to inorganic substances, such as rocks and similar matter found in the earth strata, as opposed to organic substances such as plant and animal matter. Minerals normally have definite chemical composition and crystal structure. The term is also applied to matter derived from minerals, such as the inorganic ions found in water. The term has been incorrectly applied to ion exchangers, even though most of the modern materials are organic ion exchange resins.

NEUTRALIZATION — In general, the addition of either an acid or a base to a solution as required to produce a neutral solution. The use of alkaline or basic materials to neutralize the acidity of some water is a common practice in water conditioning.

NONCARBONATE HARDNESS — Water hardness due to the presence of compounds such as calcium and magnesium chlorides, sulfates or nitrates; the excess of total hardness over total alkalinity.

PARTS PER MILLION (ppm) — A common basis for reporting the results of water and wastewater analyses, indicating the number of parts by weight of a dissolved or suspended constituent, per million parts by weight of water or other solvent. In dilute water solutions, one part per million is practically equal to one milligram per liter, which is the preferred unit.

PERMANENT HARDNESS — Water hardness due to the presence of the chlorides and sulfates of calcium and magnesium, which will not be precipitated by boiling. This term is largely replaced by "noncarbonate hardness."

pH — The reciprocal of the logarithm of the hydrogen ion concentration. The pH scale is from zero to 13, and 7.0 is the neutral point, indicating the presence of equal concentrations of free hydrogen and hydroxide ions, pH values below 7.0 indicate increasing acidity, and pH values above 7.0 indicate increasing base concentrations.

PRECIPITATE — To cause a dissolved substance to form a solid particle which can be removed by settling or filtering, such as in the removal of dissolved iron by oxidation, precipitation, and filtration. The term is also used to refer to the solid formed, and to the condensation of water in the atmosphere to form rain or snow.

RATED CAPACITY — The basis for calculating the period of time, or number of gallons delivered by a water softener or filter, between regenerations or servicing, as determined under specific test conditions.

RATED SOFTENER CAPACITY — A water softener capacity rating based on grains of hardness removed while procuring soft water between successive regenerations, and related to the pounds of salt required for each regeneration, as determined under standard test conditions.

RAW WATER — Untreated water, or any water before it reaches a specific water treatment device or process.

RED WATER — Water which has a reddish or brownish appearance due to the presence of precipitated iron and/or iron bacteria.

REGENERATION — In general, includes the backwash, brine, and fresh water rinse steps, necessary to prepare a water softener exchange bed for service after exhaustion. Specifically, the term may be applied to the "brine" step in which the sodium chloride solution is passed through the exchanger bed. The term may also be used for similar operations relating to demineralizers and certain filters.

RESIN — Synthetic organic ion exchange material, such as the high capacity cation exchange resin widely used in water softeners.

SALT — The common name for the specific chemical compound sodium chloride, used in the regeneration of ion exchange water softeners. In chemistry, the term is applied to a class of chemical compounds which can be formed by the neutralization of an acid with a base.

SODIUM — An ion found in natural water supplies, and introduced to water in the ion exchange water softening process. Sodium compounds are highly soluble, and do not react with soaps or detergents.

SODIUM CHLORIDE — The chemical name for common salt, widely used in the regeneration of ion exchange water softeners.

SOFT WATER — Any water which contains less than 1.0 gpg (17.1 mg/l) of hardness minerals, expressed as calcium carbonate.

SOFTENED WATER — Any water that is treated to reduce hardness minerals to 1.0 gpg (17.1 mg/l) or less, expressed as calcium carbonate.

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