Benefits from Fitting a Domestic Ion-exchange Water Softener to a Hard Water Supply

The following lists the primary benefits of fitting an ion-exchange water softener to a hard water supply and also gives examples of the documented evidence which is available to substantiate those benefits.

1. *Eliminates limescale formation and deposition in all water using appliances which are supplied with the softened water, including central heating systems, hot water supplies, dishwashers, washing machines, kettles, water heaters, shower-heads, hot and cold taps.*

Evidence:

Established science: The occurrence of limescale deposition from hard water supplies is well documented in the literature and text books – as is its treatment which dates back over 100 years. It forms spontaneously in, or on, the hottest parts of water heating appliances or where the water pressure drops suddenly such as the outlet of taps or shower heads. The primary cause is decomposition of the soluble, temporary hardness (principally calcium bicarbonate) to insoluble limescale (principally calcium carbonate). An ion exchange water softener replaces the calcium (magnesium and other multivalent cations) with sodium for which the salts are highly soluble. The source of the limescale is therefore reduced virtually to zero.

Battelle study[i] - examined the effects of hard and softened water on 20 gas and 10 electric water heaters, 6 dishwashers, 6 washing machines, 10 low-flow taps and 10 low-flow shower heads using a protocol designed to simulate 15 years of normal domestic operation. All the appliances on hard water, scaled up heavily; all of those on softened water remained clean and without blockage. The shower heads, for example, blocked completely after the equivalent of 16 months operation on hard water, while those on softened water were still clear and functional at the end of the simulated 15 years.

New Mexico State University[ii] study investigated the effect of scale build up in gas and electric water heater and found up to 40 pounds of scale deposits in gas and electric storage heaters.

Ministry of Health Report[iii]on Water Softening – reviewed the evidence and problems associated with hard water supplies, including formation of scale in instantaneous and storage heaters, and kettles. In considering methods for addressing hard water problems it describes (ion exchange) water softeners as "the only one (method) which can operate satisfactorily with the sort of attention the householder can be expected to give".

2. *Reduces water heating appliance maintenance and servicing*

Evidence:

Battelle study[i] – all of the appliances supplied with hard water scaled up heavily during the trial and needed extensive cleaning, whereas those on softened water remained clean. The report provides quantitative and photographic evidence. The instantaneous gas water-heaters on hard water, blocked completely 9 times during the simulated 15 years operation and had to be cleaned each time.

Ministry of Health Report on Water Softening[iii] – refers to pipe blockages caused by scale, and methods, frequency and cost for its removal from heaters

3. *Reduce energy consumption, fuel costs and carbon emissions over the life time of the appliance*

Evidence:

Established science: From published literature, limescale has a thermal conductivity 400 times lower than copper and 100 times lower than steel; it is therefore a very effective insulator and, when built up on

boiler tubes, increases the time necessary to heat the water to the set temperature, and, consequently, the amount of fuel used and heat wasted in the flue gas.

Battelle study[i] – monitored the thermal efficiency of 10 instantaneous gas heaters and 20 gas/electric storage heaters, half with softened water and half with hard water supply over a simulated 15 year domestic operational period. All of the heaters on softened water maintained their "as-new" efficiency. The gas instantaneous water heaters dropped in thermal efficiency by 8 % over a simulated 1.6 years – but fouled to the point where flow could not be maintained. They were therefore descaled regularly throughout the testing. However the original efficiency was not restored after descaling. Softener payback time due to energy and descaling costs was forecast to be 1 year. Gas storage heaters dropped in efficiency from 70% down to 56% over a predicted 10 years.

New Mexico State University[ii] study tested 12 used gas and electric water heaters from homes in an area supplied with the same hard water, half of which were fitted with a water softener. The study found that the energy usage by the gas water heaters was 23.8% lower where a water softener was installed and 17.8% for the electric water heaters on a softened water supply.

UKWTA study[iv] - A partially scaled domestic water heater was sourced from premises in the Great Yarmouth area. Efficiency was measured by the test house before and after descaling using procedures as near as possible to specification EN26 : 1999. The heat exchanger was de-scaled and approximately 9 grams of hard water scale were removed which resulted in an average reduction of 5.6% in gas boiler efficiency.

Ministry of Health Report[iii] on Water Softening – identified that 0.5 mm of hard scale increases fuel costs by 9.4%. Similar evidence is cited in more recent studies: 0.8mm scale increases fuel costs by 10%[v]

The Domestic Heating Compliance Guide[vi], provides guidance on compliance with the Building Regulations, Part L, (Conservation of fuel and Power) amended in 2006, contains the requirement:

> "where the mains water hardness exceeds 200 parts per million, provisions should be made to treat the feed water to water heaters and the hot water circuit of combination boilers to reduce the rate of accumulation of limescale and consequent reduction in energy efficiency".

This inclusion followed industry representation to the CLG in recognition of the major impact from limescale on reduced energy efficiency of domestic heating appliances.

4. *Remove existing scale*

Evidence:

Established science – although calcium carbonate has a very low solubility in water, it is slightly soluble to a level of 20 mg/l at 20˚C[vii]. Water softeners typically reduce the hardness to below 5 mg/l so there is a positive but small driving force towards dissolution of existing scale when a water softener is fitted and hardness reduced to "zero" (5 mg/l or less). Field experience has confirmed that existing scale is removed but over several months.

Many customers that have a water softener fitted report that scale is removed from a kettle within 6 weeks of starting to boil softened water. They also report that shower heads self clean after a couple of months and remain clean. Plumbers report that when working in a house with a water softener there is no evidence of limescale anywhere in the household plumbing system.

5. *Reduce soap, shampoo and detergent consumption*

Evidence:

Established science – when soap or detergent is added to hard water, it must react with the hardness ions present and precipitate them as scum before it can perform its function of adhering to dirt particles. The harder the water, the more soap or detergent it is using to precipitate the hardness scum.

Scientific Services Study[viii] – evaluated the effect of water hardness, detergent dose and temperature on stain removal by washing machines and cleaning efficacy of dish washers. The study found that softening the hard water supply had a much greater effect on improved washing efficacy than increased detergent for both washing machines and dishwashers. In fact, the stain removal efficacy in washing machines was better with softened water at the lowest temperature and lowest detergent dosage than hard water at the maximum temperature and maximum detergent dose and consequently softening the water supply saves detergent and energy – and still improves washing efficacy.

Detergent manufacturers recommended dose levels are identified on their packets. The dose is usually specified for hard, medium and soft water supplies. The dosage range varies by manufacturer but, from a review of the products displaced on supermarket shelves, the difference between hard and soft is up to 62%.

Ministry of Health Report on Water Softening[iii] – specifically addresses soap and detergent consumption and explains that the original definition of "hard water" emanates from its difficulty in obtaining a lather and the degree of hardness of a water source was, at one time, measured by the quantity of soap needed to obtain a lather.

6. *Improves laundry stain removal*

Evidence:

Scientific Services Study[vi]: stain removal efficacy (dL value) in washing machines was found to be better for softened water when set at the lowest temperature and detergent dosage, than for hard water with the machine set at highest temperature and highest dose.

7. *Less environmental impact from reduced detergent use*

Evidence: Soaps and detergents contain chemicals that pose a threat to the environment: phosphates, for example, are used as builders in detergents and are progressively being banned. Excessive use of soaps and detergents increases the load on sewage treatment plants and inevitably increases the level of chemicals discharged to the environment.

8. *Improves laundry life*

Evidence

Established science: detergent scum is known to deposit within the fibres of clothes and laundry during the washing cycle and this increases abrasion between the fibres during use increasing material wear.

YMCA Laundry Study[ix] - the life of a wide range of hotel laundry (bed linen, towels, table cloths, etc) was measured over a five year period with hard water and compared to a five period with softened water. All forms of laundry showed an increase in life with softened water ranging from 10% for dish towels to 39% for pillow slips.

Ministry of Health Report on Water Softening[iii] – refers to evidence that curd (soap scum) is deposited on fabrics and that their useful life is reduced – as is their texture ("feel").

9. *Eliminates scum around baths and sinks and, consequently, reduces cleaning effort and frequency of sanitary-ware, as well as cleaning materials and labour costs*

Evidence:

Established science - as mentioned in 5 above, soap scum is precipitated from hard water as calcium stearate before it can provide its cleansing function. The scum is deposited around baths and sinks and is perhaps the most evident symptom to the householder of their hard water supply. The scum layer is difficult to remove and requires proprietary cleaning agents and effort to restore the sanitary ware to its unblemished finish.

Motel study[x] - a study was conducted on 6 motels in the Chicago area, to evaluate the effect of installing a water softener on the costs of maid service and cleaning materials. All 6 motels showed reduced maid service cost ranging from 5.5 % to 27.6% of the costs when hard water was supplied. Similarly cleaning supplies were reduced in all six cases by 18% to 82%.

Ministry of Health Report on Water Softening[iii] – states "It is also a fact that the labour of washing clothes and other articles is much reduced when the water is soft".

10. Kinder to the skin and softer hair

Evidence:

Customer reports are frequently received within the industry that customers have made unsolicited remarks concerning softness of hair and improvement in skin condition. Similar reports have been noted from the medical profession. Ecological epidemiological studies in Japan, Spain and the UK have indicated incidence of eczema to be related to the hardness of the water supply. The cause is hypothesised to be due to the impact of residual soap scum on the hair or skin after washing and within clothes and bedding after laundry. A recent randomised controlled trial in the UK using softened water failed to show a significant benefit although a major proportion of the participants post-trial opinion was that there is benefit.

Ministry of Health Report on Water Softening[iii] – also makes reference to the possibility "that curd (soap scum) has a harmful effect on the skin".

Stearate impact reports[xi] – soaps form insoluble salts in hard water, such as water containing magnesium, calcium, or iron. The insoluble salts form bathtub rings, leave films that reduce hair lustre, and gray/roughen textiles after repeated washings.

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[i] Battelle Memorial Institute, Columbus, OH, *Study on Benefits of Removing Hardness (calcium & magnesium ions) from a water supply*, 2009

[ii] New Mexico State University *Water Softeners as Energy Saving Investments* 1981

[iii] Ministry of Health, *Water Softening, Report of the Sub-committee of the Central Advisory Water Committee*, 1949

[iv] UKWTA *Study by Advantica* 2005

[v] 1. *Heat Transfer Implications of Scaling and Fouling in Cooling Water Systems* – RK Deshpande & DJ Banerjee of Aquapharm Chemical Co. Pvt. Ltd. Pune-411.026 published in Corrosion and Maintenance Journal July-Sept. 1984

2. Federal Technology Alert – Non-Chemical Technologies for Scale & Hardness Control published by US Department of Energy http://www.space-age.com/magwater/fta/index.html Jan 1998

3. Effect of Scale Deposits in Boilers – Results of studies made by the University of Illinois and the US Bureau of Standards published in National Institute of Standards and Technology, Handbook 115, Supplement 1

[vi] *Domestic Heating Compliance Guide*, OPDM, 2006

[vii] Kay and Laby, *Physical and Chemical Constants*, p112

[viii] Scientific Services Study, *Evaluation of the Relative Effects of Hardness, Detergent Dose and Temperature on Stain Removal Efficacy of Laundry Machines*, 2011

[ix] YMCA Laundry Study, *How Softened Water Lengthens Linen Supply Life*, LH Hein, Chicago

[x] *Motel Cost Savings*, WQRF 1967

[xi] http://chemistry.about.com/od/howthingsworkfaqs/a/softwaterrinse.htm