



Study Findings and Executive Summaries

Consumer Benefits Study:

- **Scale Prevention**
- **Scale Removal**
- **Energy Savings**

An Independent Study

Consumer Benefits Study



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The Independent Consumer Benefits Study of NuvoH2O was conducted from 2011- 2012 in conjunction with, but not endorsed by, the Battelle Memorial Institute and funded by NuvoH2O.



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Introduction

The NuvoH2O patented design and proprietary formulation was developed from almost thirty years of commercial experience. First designed for the food services industries, these products have helped solve complex water problems for some of the nation's largest businesses.

NuvoH2O's residential product is a point-of-entry, cartridge-based water softening system containing a citric acid media, which lowers the water's alkalinity and chelates the hardness causing ions (See Figure 1). This prevents and removes scale formation in appliances and fixtures installed in the home. The cartridge inside the NuvoH2O System is expended throughout the use cycle, typically, 6 months of normal household usage.



Figure 1. NuvoH2O Water Softening Systems and Cartridges

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An estimated 85% of the United States face hard water issues. Two primary concerns are the decreased life of any appliance subjected to scale build-up and increased energy consumption to heat water for household use.

First, hard water build-up clogs and corrodes pipes, fixtures and appliances shortening their lifespan by as much as 25-30%. NuvoH2O prevents scale, increasing the life of the appliance and decreasing the potential repair costs associated with scale. NuvoH2O can also remove scale in many existing applications returning the appliances an improved state of efficiency.

Second, heating water is the second largest energy expense in a typical household according to the U.S. Department of Energy (DOE); it can be directly translated that a scaled heating element can cause a higher energy bill than an un-scaled element. Every day, countless homes waste untold millions due to the inefficient heating of water caused by hard water buildup. NuvoH2O prevents the scale from inside the water heater decreasing the energy required to heat the water.

NuvoH2O tasked Battelle with confirming and quantifying the benefits of the NuvoH2O System. A primary component of the study was the longevity of appliances (instantaneous water heaters) and fixtures (showerheads) and the resulting energy savings for a typical U.S. household from use of the NuvoH2O System (See Figure 2).



Figure 2. Battelle Lab

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Study Findings

Scale Prevention. The results of the Battelle study are conclusive - the NuvoH2O System prevents the formation of scale. The visual assessment of the heating elements after teardown analysis clearly shows that the NuvoH2O systems prevented scale. The visual observation is supported by the detailed breakdown quantifying the exact scale amounts.

On average, untreated heaters exhibited more than 50x the scale mass than NuvoH2O treated heaters with some untreated heaters exhibiting as much as 90x to 140x more scale formation. The average measure of scale (.87 g NuvoH2O vs. 45.6 g untreated) indicates that the NuvoH2O system effectively prevented over 98% of the scale formation over the simulated 2.2-year test period.

In addition, the NuvoH2O-treated showerheads had less surface scaling than the untreated showerheads with the worst performing showerheads having more than 80% of their nozzles were clogged.

Scale Removal. The NuvoH2O systems are effective at improving energy efficiency and removing existing scale. When installed into existing homes, not only will the NuvoH2O system prevent the scale build-up but can also remove scale and improve appliance efficiency in many applications.

Energy Savings. The more time required to achieve a steady operational state suggests that (1) additional energy is used to bring the water temperature to a desired level and (2) water is typically run longer resulting in increased water waste.

The NuvoH2O-treated water heaters exhibited over a 25% shorter time to achieve a steady state of operation when compared to untreated water heaters. This decrease is achieved because the NuvoH2O-treated elements were able to directly transfer the heat from the copper elements to the water whereas scale on the untreated heating elements acted as a barrier to the heat transfer.

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Executive Summary

The NuvoH2O Efficacy and Consumer Benefits Study tested tankless water heaters supplied with NuvoH2O softened water and untreated hard water under controlled laboratory conditions designed to accelerate the waterside scaling and then quantify the scale growth and the performance efficiencies.

The independent study specifically focused on the effectiveness of the NuvoH2O systems in (1) preventing scale and protecting the appliance from the corrosive and destructive power of scale, (2) preventing scale and producing an energy savings for the consumer, and (3) removing scale and returning appliances to a more efficient state of operation.

The study protocol was Battelle-developed and approved by NuvoH2O. For this study, Battelle tested 15 Bosche RP17PT electric tankless water heaters and was performed using treated municipal water with approximately 15 grains per gallon hardness and a pH value of about 7.8 – 8.0.

The first phase simulated approximately 2.2 years of water heater use in approximately 4.5 months of testing. Five (5) NuvoH2O-treated instantaneous electric water heaters (IEWHs) and ten (10) untreated IEWHs were set up for continuous testing. Battelle performed teardown analysis on five (5) NuvoH2O-treated heaters and five (5) selected untreated heaters at end of the first phase to assess scaling in the water heaters.

The treated and untreated water also flowed through corresponding Delta RP42578 showerheads that provide full spray at the identified test flow rates/pressure to further analyze scale growth.

For the second phase of testing, the remaining five (5) untreated water heaters were transitioned to installation with NuvoH2O Systems. The intention of Phase II was to document NuvoH2O System's ability to remove existing scale and improve appliance efficiency. The heaters selected for the second phase of study exhibited various degrees of scaling which served as the baseline heater condition.

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Phase I Results

The objective of the first phase was to prove that NuvoH2O water softeners can prevent scale, and to determine the longevity of the appliances and fixtures and resulting energy savings from use of the NuvoH2O Systems. The accelerated life test protocol was developed to mimic household usage of the instantaneous water heaters and the downstream showerheads and then compare the performances of units fed with NuvoH2O System treated water and those fed directly with calcium-laden city water supply.

Phase I testing led to the following key observations:

1. Visual assessments showed NuvoH2O Systems prevented scale formation in instantaneous electric water heaters.
2. On average, untreated heaters exhibited more than 50x the scale of NuvoH2O-treated water heaters after 2.2 years simulated use.
3. Longer time to reach steady-state temperature for untreated vs. NuvoH2O-treated water heaters.

Visual Assessment. A visual inspection of the water heaters and showerheads was performed at end of the Phase I as part of the teardown analysis. No scaling was observed on all but one of the heating elements of the NuvoH2O -treated instantaneous electric water heaters which only had minor visible scaling. On the other hand, all but one of the untreated water heaters showed very significant scaling (See Figures 3 and 4).



Figure 3. Untreated Element (Left) and Treated Elements (Right)

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Figure 4. Untreated Canister (Left) and Treated Canister (Right)

Analytical Assessment. To quantify the visual assessment of the scale in the test heaters, the scale from the heating elements and canister for each respective heater was dissolved using 5% w/w Sulfamic acid (H_3NSO_3) solution. Calcium and magnesium concentrations for each sample were determined via atomic absorption spectroscopy (AA) and used to report mass of the scale deposited as $CaCO_3$.

The average NuvoH2O-treated water heater had an average of less than one gram of scale (.868) with the typical result being less than .25 grams of scale. The average non-treated water heater had an average of 45.6 grams of scale, but based on visual assessment of all of the water heaters the typical result suggests a range of 20 – 120 grams of scale (53-gram average) resulting in the NuvoH2O system preventing over 99% of scale formation (See Figure 5).

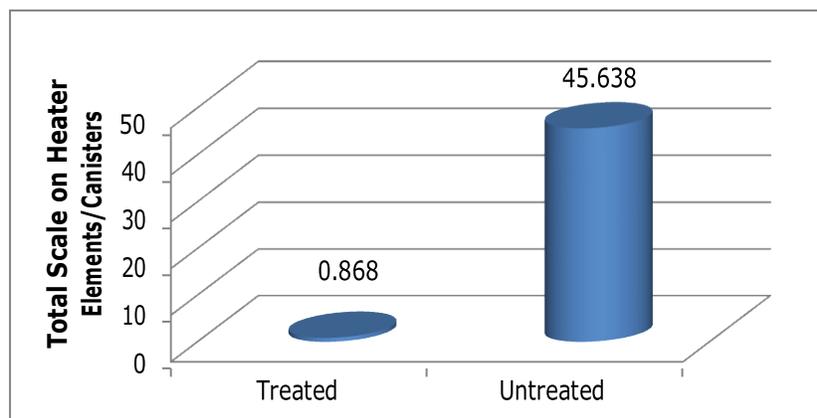


Figure 5. Scale dissolution results (Average for five treated and five untreated heaters)

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Water Heater Efficiency: Steady-state Temperature. A key metric used to track water heater performance is time to steady state operational temperature. The time to steady state operational temperature is the amount of time it takes for the heater to consistently deliver the user-set temperature once the heater is active.

This metric is expressed in seconds per degree Fahrenheit (sec/oF). This represents the time taken by the water heater to heat the water by a one degree and is directly proportional to the cost of energy. The NuvoH2O-treated systems responded in an average of 8.34 (sec/oF) versus 10.6 (sec/oF) for non-treated heaters – over 27% less time on average to reach the steady state performance.

The scale on the untreated heating elements acted as a barrier to the heat transfer, whereas the Nuvo-treated elements were able to directly transfer the heat from the copper elements to the water.

As water heating is the second largest energy expense in a typical household according to the U.S. Department of Energy (DOE), it can be directly translated that a scaled heating element can cause a higher energy bill than an un-scaled element. For example, when a user is waiting for the tap water to heat to the desired temperature, the user will let the water run longer which in turn increases water as well as electricity consumption (See Figure 6).

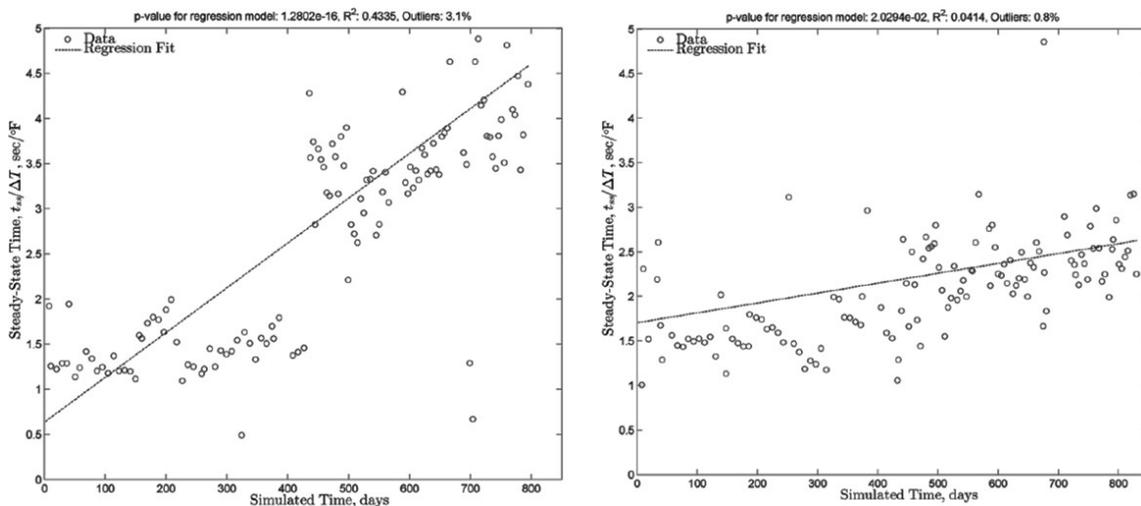


Figure 6. Regression Model Plots Time to steady state temperature for an untreated heater (Left) and NuvoH2O-treated heater (Right).

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Phase II Results

The objective of Phase II was to determine the ability of the NuvoH2O Systems to restore performance, efficiency, and aesthetics to scaled water heaters and showerheads. Untreated water heaters from the first phase were installed downstream of NuvoH2O Systems to determine the efficacy of the NuvoH2O systems to remove scale. The protocol from Phase I was continued through the Phase II testing which ran for duration of approximately 10 weeks or one simulated year.

Phase II testing indicated that the NuvoH2O system can effectively remove existing scale and improve energy efficiency.

Visual Assessment. Unlike Phase I, a visual assessment of scale removal was not conclusive. While previous Battelle studies have demonstrated scale formation in accelerated life studies, no previous accelerated use studies have been performed on the NuvoH2O formulation. Previous testing by NuvoH2O indicated that with fixed dosing, treatment time was the most critical element in the removal of scale from appliances and fixtures. Phase II testing replaced treatment time with increased water flow that simulated higher use. It was not universally anticipated that visual confirmation of scale removal would appear in a shortened test cycle.

Analytical Assessment. Phase II testing used no scale dissolution for analytic assessment because the scale needed to remain intact on the water heaters from Phase I. This left the second phase without a reference point for quantification.

Water Heater Efficiency: Steady-State Temperature. A measured decrease in steady state temperature is an indicator of an improved efficiency. Just as an increasing time to steady state temperature would indicate scale accumulation, a decreasing rate in the time to steady state temperature would indicate either a decrease in scale or scale density. After installation of the NuvoH2O system, the majority of the water heaters in Phase II experienced a decline in the steady state temperature rate to near the initial measurements (See Figure 7).

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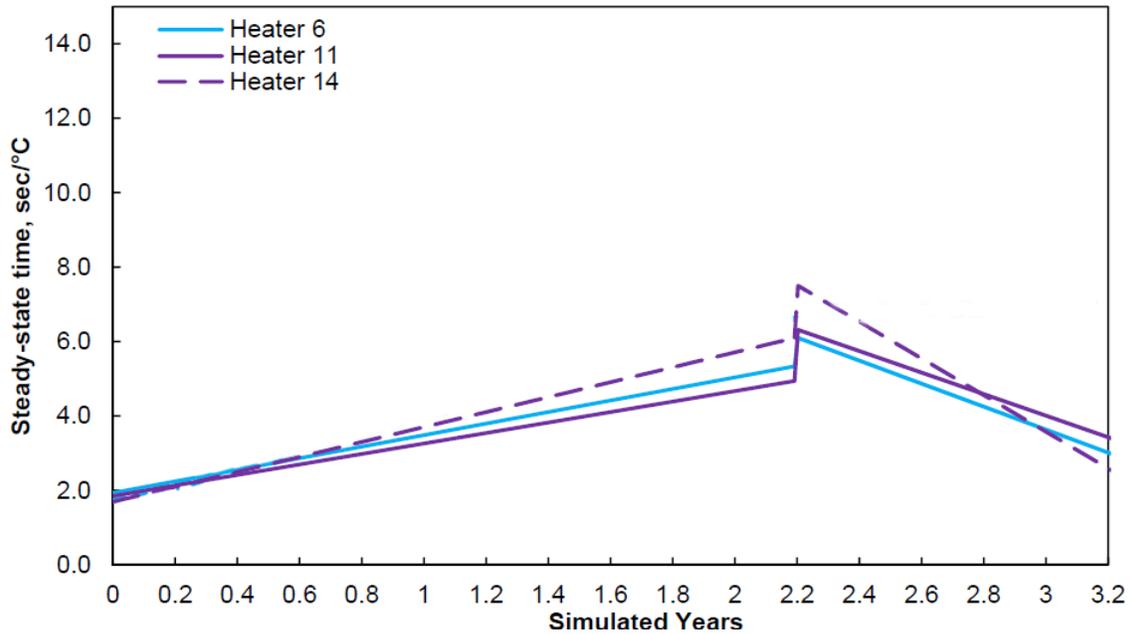


Figure 7. Phase II heaters with a decrease of time to steady state.

The study found that the NuvoH2O system can remove scale. However, the removal process cannot fix corrosion caused by scale and there will be cases where the scale formation has progressed to a point where the NuvoH2O system will not reverse or restore the appliance to pre-scale condition. A previous Battelle study indicated the point of failure for gas tankless water heaters to be approximately 1.6 years equivalent field service whereas Phase II of the NuvoH2O Consumer Benefit Study started with electric tankless water heaters that had 2.2 years of equivalent field service. Certainly, this study approached, if not surpassed in some cases, the point at which the de-scaling benefits of the NuvoH2O System may no longer be effective.

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Conclusion

The use of the NuvoH2O System will (1) prevent scale and protect the appliance from the corrosive and destructive power of scale; (2) prevent scale and produce energy and potentially a water savings for the consumer, and (3) remove existing scale and in most cases return appliances to a more efficient state of operation.



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