BON AQUA

PERFORMANCE TESTS

Utah Department of Health Laboratory

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by

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Introduction

The Utah Department of Health has been asked by the Utah Attorney General's Office on behalf of the Utah Trade Commission to experimentally investigate the water treatment claims of the Bon Aqua magnetic water treatment device. Attempts by the inventor to explain the mode of operation of his device using currently accepted physical chemistry theory have failed. Company officials explained that they were not sure how the device worked, but that it did perform to the benefit of the average consumer.

This study attempts to experimentally examine the only two company authorized claims for the device:

1. The average consumer will notice a savings in detergent and soap consumption (the water behaves as if it were softened, according to company officials). Conventional chemical tests will not detect this difference in Hardness, however, the company maintains there will be a noticeable difference in the behavior of the water.

2. Hard water scale deposits on fixtures and within pipes will be reduced and finally rinsed away because of a "charge effect" as the result of magnetic treatment.

Preliminary Discussion

Previous company data have had serious flaws since they have failed to account for several variables involved in trying to describe the device's beneficial effects. One company advisor claimed that the compressive strength of concrete was increased when the concrete was prepared with magnetically treated water. Unfortunately, examination of this data revealed a failure to account for the random uncertainty involved in measuring pressures to the nearest psi near 5000 psi.

Another fault of previous studies has been the failure to control normal variations in water quality when using a large urban water system as a water source for experiments. Investigation of several endorsements claiming salt savings on water softener operation has, upon investigation, been tentatively attributed to an actual change in the chemical quality of the supplied water. This occurs when the city water department uses a source of different chemical quality. This belief was verified at the Utah State Health Laboratory as the first Bon Aqua test was conducted over a ten-working day period in November of 1978. Here, this study revealed the fact that the influent quality to the testing area had changed from 64 mg/l Calcium (a principle component of water Hardness) to 112 mg/l; and Alkalinity had changed from 161 mg/l to 230 mgl. This change correlated with the known chemistry of various water supply sources used by the water system (See appendix). Obviously an attempt to discern the effects of magnetic treatment must account for the influence water quality changes.

A final serious error of previous studies related to this product was a failure to conduct simultaneous parallel tests of treated and untreated water. A fairly typical summary of previous work would be to, (1) perform a chemical analysis of the "before" water, (2) apply the device, (3) conduct lengthly detailed studies of water chemistry of the treated water, and finally (4) point to the small differences found in the treated and untreated water during the course of the experiments. Given the water quality variation at one location discussed above and the normal precision of the chemical tests, it was felt that previous data lacked sufficient credibility.

A review of published scientific literature indicate others have conducted performance tests critical of magnetic treatment (1-8). A strictly experimental approach was adopted here, despite the earlier criticisms of the merits of magnetic water treatment.

Installation of Devices

Mr. Hugh Bradley, a local salesman for the company, agreed to install two units for study. The units were installed in Room 343 of the Utah State Health Laboratory in Salt Lake City on October 9, 1979. Two units were installed based on the company recommendation of one unit for each 150 mg/l of Hardness. This location has had a history of water problems related to scale forming deposits. This provided an ideal problem area to study some of the water treatment claims visually as well as chemically. The devices were installed according to company instructions by Mr. Bradley, with all the recommended grounding and radio interference protection installed (slides of the installation are available) on a 1 1/4 inch galvanized iron line. A tap was located before the two units as well as another tap, approximately 6 feet downstream.

Those present for the tests conducted on October 23, 1979 were: Hugh Bradley and his assistant Linda, Representing Techniclean (who sell the Bon Aqua Product); Larry Scanlan of the Utah Department of Health's Bureau of Public Water Supplies; Harry Judd, Laboratory Technician and Terry Winward, Quality Assurance Chemist for the Utah State Health Laborato

Discussion of Experiments

The tests to be performed were designed to demonstrate the validity of the two claims mentioned in the introduction section of this report. The soap test was suggested by Bon Aqua representatives, who said that response to Joy detergent by magnetically treated water was particularly good. Within general guidelines suggested by Bon Aqua, the soap tests were developed by the author. In this report, the author equates the words soap and detergent, although chemically, there is a difference (see the Conclusions section of this report). The scale tests were also developed by the Autho using examples of experimental work taken from the modern literature (9-1 Both Phase I (soap tests) and Phase II (scale test) data would be subjected to statistical analysis. Statistical analyses were needed to clar the results of the tests and to discriminate whether there were any significant differences between treated and untreated water. The overall

objective of both tests was to answer the basic question: Does the treated water exhibit the beneficial effects advertised, or rather, is it the same as the untreated (control) water?

Soap Tests

Flow at the treated and untreated taps adjusted to approximately 950 ml/min (about 1/4 gallon per minute) soap samples were collected simultaneously by Larry Scanlan (collecting untreated water) and Harry Judd (collecting treated water) in 1000 ml breakers. One hundred ml pipettes were then used by Mr. Scanlan to transfer a portion of these simultaneously collected samples to 300 BOD bottles marked Treated and Untreated. Delivery of the 100 ml pipettes used was assumed to be accurate to at least the nearest 0.3 ml (+0.3% relative error). Successive samples were collected between 11:15 a.m. and 11:50 a.m. Portions of these samples were analyzed for water Hardness at the beginning, middle, and end of the sampling period. Results ranged from 189 mg/l as $CaCO_3$ to 191 mg/l. Water temperature during sampling remained constant at 17°C.

samples of treated and untreated water transferred to 300 ml bottles using 100 ml pipettes.

Using a previously calibrated microliter pipette (mean delivery for 40 replicates was 48.3 microliters with a standard deviation of 1.3 microliters), 50 microliters of full strength Joy brand detergent was delivered to each Treated and Untreated sample. At the suggestion of Terry Winward, paper collars were fitted over each bottle and the samples were randomly mixed by Mr. Winward as the author turned his back to the samples. Each sample was given three vigorous shakes and the maximum suds height at the side of the bottle was measured and recorded to the nearest millimeter. Each collected sample pair was similarly treated, carefully shaken, and measured. The results of the "Soap" tests are presented in the discussion section of this report.

Scale Tests

The scale test proposed was the familiar marble test (9-11), commonly used by the water treatment industry to assess the scale forming or corrosive properties of a given water. An explanation of the significance of this test is perhaps worthwhile before describing the details.

A principle component of scale associated with water of drinking quality is Calcium Carbonate ($CaCO_3$). According to accepted chemical theory (12), a water with a given Dissolved Solids content, PH, Temperature, and Alkalinity can only dissolve a certain amount of Calcium. If excess Calcium is present, equilibrium shifts to precipitate the excess Calcium Carbonate, thereby lowering the Calcium and Alkalinity content of a water.

By closely monitoring the dissolved Calcium and Alkalinity for a particular water, a water can be classified as either "Scale Forming", "Stable" or "Corrosive". Water at the Utah Department of Health's laboratory is predicted by this theory to be "Scale Forming". This prediction is indeed verified by the actual observation of large amounts of scale covering many water fixtures in the laboratory.

If the water quality changes as a result of any treatment, a sensitive method of detecting this change is provided by the method used. When the water becomes more corrosive, additional Calcium will be dissolved. When the water becomes more scale forming, Calcium will be removed as a Calcium Carbonate precipitate. When a stable water is analyzed, dissolved Calcium will remain the same.

The following basic steps were taken for the Scale Tests:

1. Simultaneous samples were collected by Larry Scanlan (untreated water) and Harry Judd (treated water) on 1000 ml beakers. The water temperature remained at 17°C throughout sample collection.

2. Sample pairs collected were split two ways, one sample filling an untreated 300 ml BOD bottle, the other similarly filling a 300 ml BOD bottle which contained approximately 0.3 to 0.4 g $CaCO_3$ powder of reagent grade quality. Both samples were then capped to prevent the exchange of any gas which could affect the sample's PH. The bottles were then frequently mixed by inverting over the next several hours. In this manner, thirty samples of each water were collected.

3. The following day, untreated and $CaCO_3$ treated samples were filtered through fresh 0.45 micron filters and collected in new clean containers. Dissolved Calcium is by definition, that which passes this filter, suspended or precipitated Calcium being trapped on the filter.

4. This same day, all samples were measured for Calcium and random samples were measured for PH, Alkalinity, and Hardness by accepted electrometric and colorimetric methods (13, 14, 15). Were a longer time period available, each of the 120 samples could have been checked for PH, Alkalinity and Hardness.

5. The results of these tests are presented in the Discussion and Appendix sections of this report.

Discussion

Several interesting observations were made in the course of these tests which were noteworthy. Regarding the soap tests, it was observed that for the same detergent concentration, the millimeters of suds height could be varied from 1 millimeter (gentle swirl) to 28 millimeters (shaking the samples very hard). This fact was not known to the author before the experiments were undertaken. If it were known, a dual-mechanic shaker of some kind would have been suggested in order to minimize the variation observed.

At the request of Hugh Bradley, the samples reported here were shaken with what could be called "medium" intensity. Despite absolute attempts by the author to shake the samples uniformly, the data suggests a definite

trend for both treated and untreated water. An analysis of variance (see A-NOVA calculations in appendix) indicates a definite trend as the test proceeded. The lower mean suds height near the end of the tests indicate the author was tiring during the tests.

Another effect which was observed, but not recorded, was the fact that the author's left hand produced consistently lower suds heights despite attempts at uniformity (recall that samples were fitted with paper collars and randomly mixed by Terry Winward before the author handled them). These effects could be further studied using statistical methods, but this is an area for future study. Because these samples were randomly mixed by Terry Winward, an equal effect on the Treated and Untreated sample results was assumed.

The fact that the detergent used responded similarly to softened water (10 mg/l) and the Untreated hard water (190 mg/l) indicates that this test could not produce the desired results. Ideally, magnetically treated water should show more or the same amount of suds as softened water. A nine to forty percent or more increase in suds height over the untreated water was expected if Bon Aqua's claims were accurate. On the contrary, magnetically treated water and the softened water behaved the same towards the detergent as the hard water. This finding is consistant with the fact that modern synthetic detergents are unaffected by water Hardness.

Scale in water pipe and on fixtures is affected by the Temperature, Alkalinity, PH, and Calcium levels for any water. This study attempted to find some change in the Calcium level of the treated water. If more Calcium would appear in the magnetically treated water than the control, then scale could have been dissolved at the part per million level from the pipes or fixtures cleaned. If less Calcium appeared in the treated water, Calcium could have precipitated in the water pipe or would have been removed as a precipitate during the filtration steps. This precipitated Calcium would indicate that the water was still scale forming with respect to fixtures and water pipe. Therefore, it was felt that this method provided a sensitive technique to detect any small changes in the scale chemical ($CaCO_3$) present. The results indicate both treated and untreated water were oversaturated with respect to Calcium Carbonate and thus, some calcium had precipitated over a 24 hour period indicating both waters were still "scale forming".

Conclusions

As a result of reviewing the data produced, the following conclusions can be drawn:

1. ~~On the basis of the suds tests, no beneficial effect was observed. The statistics generated by the suds test indicated a fairly wide variation in results as well as a grouping error bias. Part of the observed variation was due to the inability to manually shake the two samples identically.~~

2. A direct correlation exists between suds height and intensity of shaking, although this was not investigated in detail in this series of tests, it was nevertheless observed by all present. The grouping error bias mentioned in No. 1 above, appeared to be the unintentional tiring of the person shaking the sample.

3. The scale tests indicate that statistically the likelihood of magnetic water treatment being at least 5% better to the consumer than no treatment at all is less than one chance in a hundred.

4. On the contrary, magnetically treated water appears to have a detrimental effect, i.e. more scale is formed under magnetic treatment conditions tested. The statistics indicate that there is a probability of 30 chances out of 31 that magnetized water is not worse. The explanation for this result is not known.

Final Conlusions

Experimental data developed indicates that neither of the company's claims have been substantiated. The experimental work indicates that a person paying for the unit is not at all likely to obtain the beneficial results noted in the introduction section of this report.

Confidence levels associated with the soap test still exhibit wide variation. Because of this wide variation, hundreds of measurements would be needed to be sure of any differences between treated and untreated water. The validity of this comparison is doubtful however, given the fact that softened water behaves about the same as hard untreated water. This is consistent with chemical theory which indicates synthetic detergent's sudsing ability is independent of water Hardness. Ordinary bar soap is affected by Hardness however. Thus, it appears that the company has suggested an inappropriate chemical for the Phase I test to verify their claims. A valid future test would be to measure the height and duration of suds produced from measured quantities of bar soap added to treated and untreated water. Also, measured amounts of grease could be used to evaluate suds duration in future work.

The scale tests showed a much smaller standard deviation and coefficient of variation, indicating that an adequate conclusion could be drawn using the fairly small number (30 each) of samples. The results of these tests show no detectable benefit to the consumer.