

Summary Report

Evaluation of the Effects of Water Hardness on Performance of Washing Machines and Dishwashers

Carried out by Scientific Services Inc. NY, USA

On behalf of the Water Quality Association

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Scientific Services Inc.ⁱ carried out testing on behalf of the WQAⁱⁱ, to compare the effects of hard and softened water on washing machine and dishwasher performance. For both washing machine and dishwasher efficacy, the effect of using softened water showed substantial savings in detergent use and, in the case of washing machines, the performance was better even at the low temperature setting thereby demonstrating energy savings also.

Washing Machine Performance

The effectiveness of stain removal from cotton swatches was measured using 5 different (non-phosphate) laundry detergents and a statistical matrix of water hardness levels of 0, 256 and 513 ppm (as CaCO₃), detergent dose of 50, 75 and 100% of the manufacturer's recommended dose and wash temperature of 60, 80 and 100 °F. Nine different stainsⁱⁱⁱ were used and the stain removal effectiveness was measured using deltaL^{iv} reflectance measurements.

From statistical analysis of the results, equations were developed and the results plotted to show the relationship of water hardness, wash temperature and detergent dose on deltaL, stain removal. Within the ranges tested, the graphs were linear. All of the results were highly significant at the 95% confidence level.

Reduction of water hardness was significantly more effective on stain removal than either increase in temperature or detergent dose. In fact, even with the lowest (50%) detergent dose, together with the lowest wash temperature (60 °F), the washing yielded better results with softened water compared to washing with hard water at 100 °F and 100% detergent dose. Based on averaging the results from the 5 detergents and 9 stains, the improvement factor for detergent dose, temperature and water softness was 1.2, 1.26 and 5.8 respectively. This demonstrated savings in energy efficiency as well as detergent usage.

Tests were initially conducted with a top loading washing machine and then repeated using a side-loader. The conclusions were similar although the numerical differences were most dramatic with the top-loader.

A few tests were conducted with lower than 50% detergent usage but results were no longer linear and "performance became more drastic as the level approached zero".

Dishwasher Performance

Tests were carried out to measure the effectiveness of using softened water^v compared to hard, in a dishwasher in removing difficult soils^{vi} as well as spot and film reduction, using 3 different brands of non-phosphate dishwasher. The procedure used for the test is defined in ASTM D3556^{vii} and employed trained panel evaluators. The dishwashers were loaded for each run with plates, cutlery, glasses and saucers. Tests were conducted using a statistical matrix of water hardness levels of 0, 256 and 513 ppm and a detergent dose of 30, 60 and 80 grammes. From statistical analysis of the results, linear equations were developed and the results plotted to show the relationship of water hardness and detergent dose soil, spot and film removal.

The results showed that water softening is much more effective than increased detergent dose for spot and film reduction. In fact, hardness reduction was up to 6 times more effective than detergent dose for spot reduction and twice as effective for film reduction. Savings of up to 70% in detergent use were predicted by softening from 513 ppm hardness.

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ⁱⁱ <http://www.wqa.org/pdf/pressreleases/detergents.study.pdf>

ⁱⁱⁱ Blood, coffee, dust-sebum soil, grass, chocolate, pudding, chocolate ice-cream, red wine, BBQ sauce, ground-in-clay soil.

^{iv} http://www.hunterlab.com/appnotes/an08_96a.pdf

^v Unlike Europe, dishwashers in the US do not typically have built in water softeners.

^{vi} Oatmilk, dry milk, grease. Egg yolk, pizza sauce, spinach, brownie mix, fish (bread crumbs and olive oil)

^{vii} ASTM D3556 - 85(2009) Standard Test Method for Deposition on Glassware During Mechanical Dishwashing