# High Performance Clothes Washer In-Situ Demonstration in a Multi-Housing Multi-User Environment

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## ABSTRACT

The objective of the study was to measure, analyze and report on the efficiency of 4 high performance residential-style clothes washer brands compared to a conventional (baseline) clothes washer brand in multi-housing facilities at the Fort Hood Texas military base. The demonstration study also included a parallel study to ascertain the maintenance of these same clothes washer brands. This was the first independent in-situ evaluation of several brands of high performance clothes in a multi-housing environment in the U.S. This paper will focus on the energy savings for determining the cost-effectiveness of the machines for this multi-housing application.

The demonstration involved 6 conventional 6-year old washers manufactured by Roper (the baseline washers), and 6 new high performance washers from each of 4 manufacturers – Whirlpool, Inc., Maytag, Inc., Staber Industries, and Alliance Industries, Inc. (Speed Queen). Each of the 30 total individual washers in the study was metered in real-time for hot water use and temperature, cold water use and temperature, machine energy use, and the number of cycles completed. Data were collected from a central data logger and retrieved on a weekly basis over a phone line through the central polling computer over an 18 month period representing an average of over 350 uses (cycles) per machine.

The average machine electricity use of the baseline machines was 0.26 kWh/cycle and the machine energy use of 4 high performance brands averaged 0.20 kWh/cycle for a 23% reduction in machine energy use. The total average water use for the baseline machines was 35.4 gallons/cycle and the average for the 4 high performance brands was 18.8 gallons/cycle for a 47% reduction in water use. The baseline conventional machines used an average of 9.0 gallons hot water/cycle (5,610 Btu/cycle) whereas the 4 high performance brands used an average of 3.4 gallons hot water/cycle (2,120 Btu/cycle) for a 62% reduction in hot water use.

The average use of the washers in this study was 6.4 cycles/machine /day. Based on that average and extrapolated for an entire year (365 days), the total average water savings of the high performance machines compared to the baseline conventional machines is 38,780 gallons/year/machine. The machine energy savings is 140 kWh/year/machine and the hot water energy savings (at the clothes washer) for Fort Hood is $8.1 \times 10^6$ Btu/year/machine.

## WASHERS AND DEMONSTRATON SITE DESCRIPTION

Fort Hood Army installation located near Killeen, Texas, was a site for a demonstration of high-performance commercial family-sized clothes washers. This demonstration was conducted by the Pacific Northwest National Laboratory for the U.S. Army Forces Command.

The objective of the study was to measure, analyze, and report on the efficiency of the high-performance clothes washers relative to the conventional (baseline) V-axis clothes washers in use at the installation. While the information reported here is believed to be accurate, it is not from a controlled experiment. All findings presented here are “average” consumption and use findings specific to the Fort Hood barracks setting and thus represent an accurate long-term “average” use profile of clothes washers at Fort Hood. The characteristics of the clothes washers evaluated in this study are shown in Table 1.

Table 1. Fort Hood clothes washer characteristics.

| Clothes Washer Brand/Manufacturer (Model #) | Age of Equipment at Start of Study | Tub Volume1 & Machine Weight | Axis of Rotation of Tub | Clothes Loading Location | Number of Access Doors for Loading |
|---|---|---|---|---|---|
| Roper/Whirlpool Corp. (AL6245VWO) **Baseline Clothes Washer** | 6 years | 2.50 cu.ft. ~170 lbs. | Vertical | Top | 1 |
| Maytag/Maytag Corp. (MAH14PNAWW) | New | 2.86 cu.ft. 181 lbs. | Horizontal | Front | 1 |
| Speed Queen/Alliance Laundry Systems (SWF561) | New | 2.80cu.ft. 240 lbs. | Horizontal | Front | 1 |
| Staber/Staber Industries, Inc. (2300) | New | 1.93 cu.ft. 220 lbs. | Horizontal | Top | 2 |
| Whirlpool/Whirlpool Corp. (LSW9245) | New | 3.0 cu. ft. ~175 lbs. | Vertical | Top | 1 |

[1]Volume determined according to US DOE test procedure: Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-Automatic Clothes Washers," Code of Federal Regulations, Title 10, Part 430, Subpart B, Appendix J.
In comparing clothes washers it is important to note their tub volumes; smaller tub volume may result in more clothes washing cycles (thus more energy and water use) to wash a given volume of laundry.

Figures 1 through 5 below show the 5 brands of clothes washers (baseline + 4 high performance washers) evaluated in this study.

Figure 1. Roper Model #AL6245VWO baseline V-axis clothes washers.

Figure 2. Maytag Model #MAH14PNAWW H-axis clothes washers

Figure 3. Speed Queen Model #SWF561 H-axis clothes washers.

Figure 4. Staber Model #2300 H-axis clothes washers.

Figure 5. Whirlpool Model #LSW9245 V-axis clothes washers.

The demonstration involved three nearly identical barracks buildings of the same style, size, and occupancy levels (~140 troops/barracks). The barracks also housed soldiers from the same military assignment/training and thus had similar laundry use requirements. Each of the three barracks buildings has one central laundry room containing six clothes washers and six clothes dryers. Each of the three barracks buildings laundry rooms received identical end-use metering equipment. In each laundry room one central data logger was installed to record and store the relevant per-cycle energy and water data for each machine. A description of each monitored parameter is included below. The baseline V-axis and new high performance clothes washer monitoring strategy was identical. Figure 1 details the metering arrangement common to each clothes washer.

## METERED PARAMETERS

*Clothes Washer Water Temperature:* Water temperature, both hot and cold was monitored using resistance temperature detectors (RTDs). These are 1,000 ohm platinum RTDs (model S1764Pf) and were made by Minco Products, Inc. of Minneapolis, MN. The RTDs provided the temperature data to the central data logger where it was stored in a time-series format.

*Clothes Washer Water Use:* Water use was monitored by installed water flow meters on the hot and cold supply line to the machines. These water meters are conventional water utility nutating disk meters (model RCOL 25) made by Badger Meter, Inc. of Milwaukee, WI. To provide the appropriate output, the meters were modified with a reed switch, which opens and closes in proportion to the volume of water passing through. The output of these meters, conditioned to be a pulse output, provided per-cycle water use data to the central data logger where it was stored in a time-series format.

*Clothes Washer Energy Use:* Electrical Energy use was monitored by installed current transformers (CTs) on the power connections to the washers. The CTs provided per-cycle electricity use data to the central data logger where it was stored in a time-series format.

*Clothes Washer Utilization:* The total numbers of cycles per machine were captured by the CTs connected on the power line to the washer. The CTs provided the run-time data to the central data logger where it was stored in a time-series format.

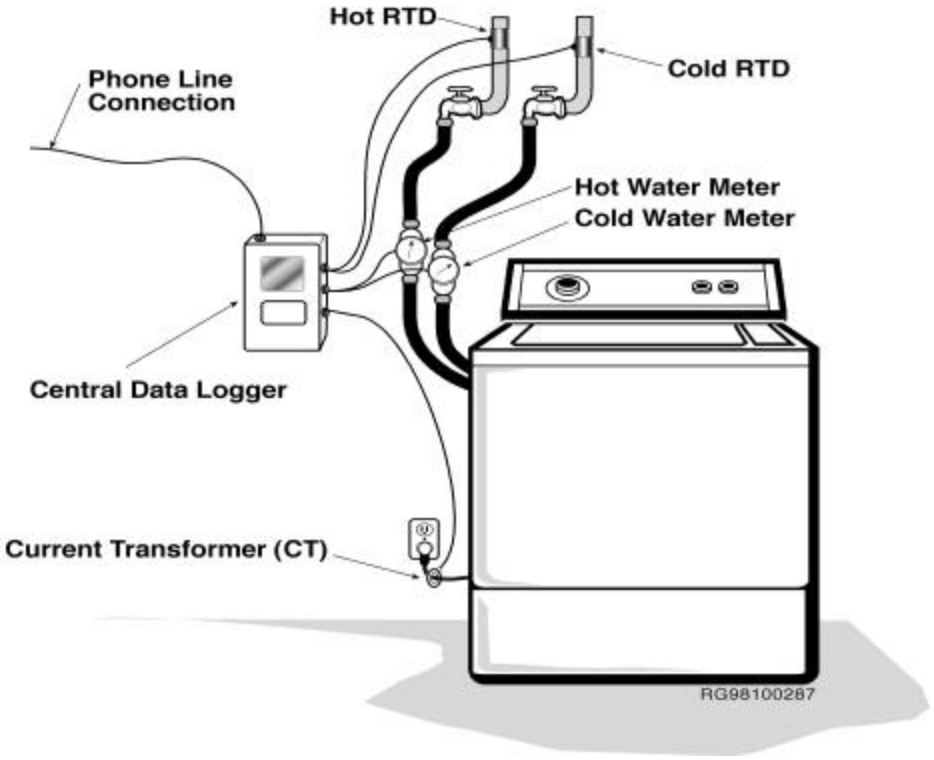


**Figure 1**. Clothes washer metering equipment and connections.

## METERING DURATION AND CYCLES

The metering of the six baseline conventional (Roper) clothes washers in one laundry room took place over a 2-month time period in late 1997 and included 1,050 wash cycles. The baseline clothes washers were then replaced by six high-performance clothes washers from a single manufacturer and these were likewise metered. High- performance clothes washers were also located in the other two identical-sized laundry rooms and were metered. Each metered laundry room was equipped with six high- performance clothes washers from the same manufacturer. Metering of the high- performance clothes washers took place over a 17-month time period from February 1998 through July 1999. During this metering period, the use of the high-performance washers ranged from 1,918 to 5,078 cycles/manufacturer, with an average of 3,026 cycles/manufacturer.[1]

## PERFORMANCE AND OPERATIONS RESULTS

Figure 6 presents the average motor and controls electricity (machine electricity) use in kWh/cycle. The four high-performance brands showed a reduction in machine electricity use over the baseline machine electricity use of 0.26 kWh/cycle. The average high-performance machine electricity use was 0.20 kWh/cycle. This resulted in an average electricity use reduction is 0.06 kWh/cycle (or 23%) for the four high-performance brands.

Figure 6. Average motor and controls electricity use (average kWh/cycle).

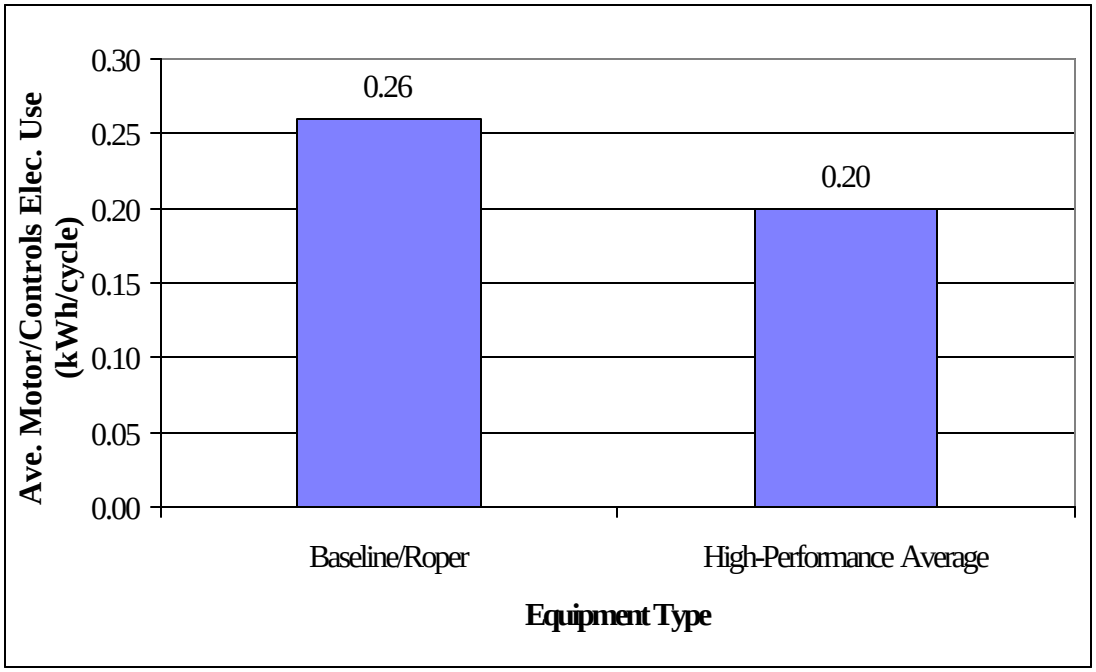


Figure 7 presents the average gallons/cycle with both the hot water and cold water components of the average total water use shown. The four high-performance brands showed a significant reduction in total average water use over the baseline machine water use of 35.4 gallons/cycle. The average high-performance total water use was 18.8 gallons/cycle, resulting in water savings of 16.6 gallons/cycle. These savings represent a 47% reduction in total water use.

The baseline conventional machines used an average of 9.0 gallons hot water/cycle whereas the average high-performance hot water use was 3.4 gallons/cycle. The average reduction in hot water use by the four high- performance brands was 5.6 gallons/cycle, or 62% of the baseline machine.

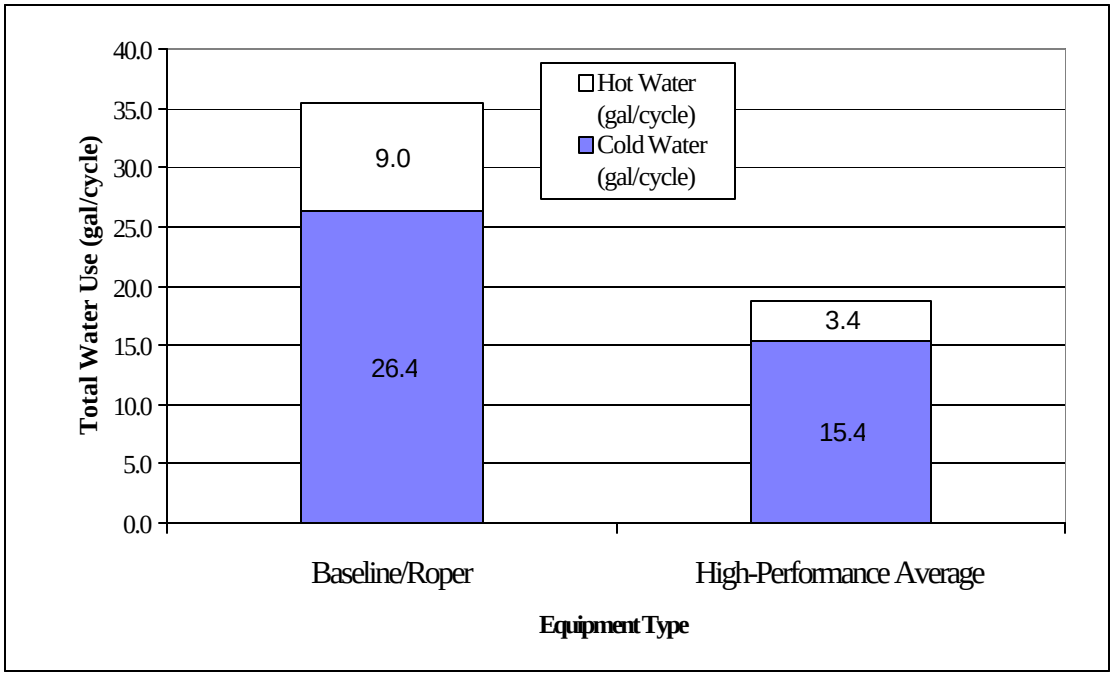


Figure 7. Average total water use (average gallons/cycle).

The average cycles/day for each machine in the study varied considerably ranging on average from 3.2 to 10.9 cycles/day for all 30 machines (6 conventional baseline machines + 24 high-performance machines) that were monitored. For the baseline (Roper) conventional machines, the average over the time period of monitoring for all six machines was 4.2 cycles/day. For the high-performance machines, the average was 7.0 cycles/day over the time period of the monitoring for all 24 machines.

In most cases, the variance in individual machine use was related to troop activity (i.e., variable occupancy levels due to field exercises). Other variables included the physical location of the machine relative to the laundry room door. The machines closest to the door received the greater use, which was expected. On average, the first two clothes washers nearest the door were used 55% more often than the two clothes washers farthest away from the door.[2]

It should be noted that in comparing between the high-performance clothes washers studied, consideration should be given to the clothes washer tub volume. Clothes washers of different tub volumes will be have an impact on the amount of clothes washed per cycle and therefore on the amount of annual energy and water use and savings; the relevance of this point is that three of the four washers studied here have significantly larger tub volumes than the fourth. In fact, while showing relatively similar energy and water use, the three larger machines theoretically would be capable of washing a load about 30-40% larger (based on their relative tub volumes) and thus have a higher efficiency per unit of laundry washed. This point is relevant in situations where full loads are commonly washed.

## ECONOMIC RESULTS

Based on Figures 6 and 7, the four high-performance brands saved an average of 5.6 gallons of hot water, 11.0 gallons of cold water, and 16.6 gallons of total water for each cycle of use compared to the

average for the baseline conventional V-axis washers. Thus the savings by the four high-performance brands was 62% of hot water, 42% of cold water, and 47% of total water.

The baseline conventional clothes washers used an average of 5,610 Btu/cycle of hot water energy (at the clothes washer), and the average of the four high-performance brands used 2,120 Btu/cycle/machine in hot water energy. This is an average hot water energy savings of 3,490 Btu/cycle/machine and does not take into account hot water conversion inefficiencies. Given the average use of all five manufacturers' machines (baseline + high-performance) at Fort Hood over the time period of the study of 6.4 cycles/day/machine and extrapolated for an entire year (365 days), the total water savings of the high-performance machines compared to the baseline conventional machines at Fort Hood is 38,780 gallons/year/machine. The machine energy savings is 140 kWh/year/machine, and the hot water energy savings at the clothes washer is 8.1 million Btu/year/machine.

Based on Fort Hood utility rates,[3] the total water cost savings is $39/year/machine, the total machine electrical cost savings is $4/year/machine, and the hot water energy cost savings is $43/year/machine for the high-performance machines. This results in a *total cost savings of $86/year/machine* for the average of the four high- performance brands compared to the conventional baseline clothes washers.

Data are presented in Figures 8 and 9 showing expected lifetime water and energy cost savings of the high-performance clothes washers compared to conventional (baseline) V-axis clothes washers. The values used to develop the curves in Figures 8 and 9 are given in Table 2 below.

Figure 8 presents the present value of lifetime combined energy and water savings for the average of the four manufacturer's high-performance clothes washers (compared to the conventional baseline clothes washer) as a function of water/sewer price ($/1,000 gallons) electricity with a 100% conversion efficiency.

Table 2. Values used for clothes washer economic analysis.

| Economic Analysis Metric | Value | Source/Notes |
|---|---|---|
| Baseline motor/controls electricity (kWh/cycle) | 0.26 | Average of the baseline (conventional) machines metered values |
| Baseline machines water consumption: hot/cold/total (gal/cycle) | 9.0/26.4/35.4 | Average of the baseline (conventional) machines metered values |
| High-performance machines motor/controls electricity Consumption (kWh/cycle) | 0.20 | Average of the 4 high-performance brands metered values |
| High-performance machines water consumption: hot/cold/total (gal/cycle) | 3.35/15.35/18.7 | Average of the 4 high-performance brands metered values |
| Clothes washer use (cycles/day/machine) | 6.4 | Average value of all machines metered in the study |
| Clothes washer life (years) | 5 | Typical commercial (OPL) washer life or lease term |
| Discount Rate (%) | 3.1 | Federal government discount rate for 1999 |

Figure 9 presents the value of lifetime combined energy and water savings for the average of the four manufacturer's high performance clothes washers (compared to the conventional/baseline clothes washers) as a function of water/sewer price ($/1,000 gallons) and natural gas price (cents/therm), assuming water is heated using natural gas with a 75% conversion efficiency. In Figure 9, the savings for the machine (motor and control) electrical energy is fixed at 6 cents/kWh and included in the analysis; in Figure 8, this savings is calculated based on the selected electricity rate.

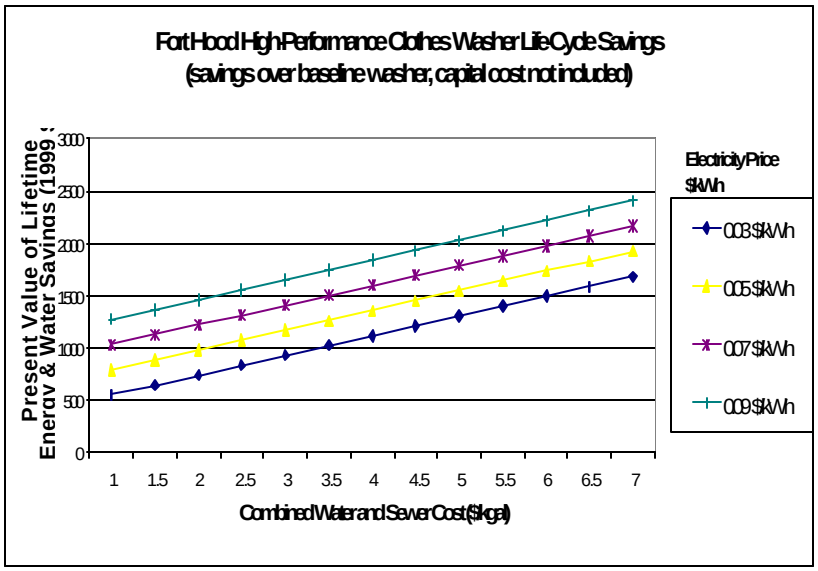


Figure 8. Average high-performance clothes washer lifetime savings – electric water heating.

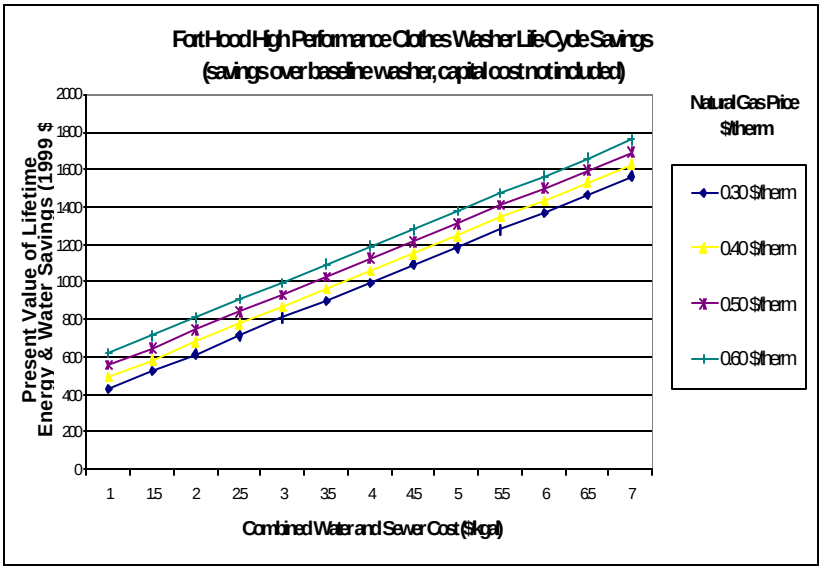


Figure 9. Average high-performance clothes washer lifetime energy savings – natural gas water heating.

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[1] The relatively short duration of metering the baseline clothes washers compared to duration of the metering of the high-performance clothes washers was due to the site scheduling the replacement of all their V-axis washers with new high-performance washers during the time of the baseline metering.
[2] In discussions with commercial clothes washer route operators, this same phenomenon necessitates these operators to rotate equipment so that equipment is used uniformly thus extending its life.
[3] Assuming 60% efficient hot water generation and distribution system, a 32 cents/therm natural gas cost; 3.2 cents/kWh electricity cost and $1.00/1000 gallons water/wastewater cost for Fort Hood.