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Coming Changes in the U.S. Clothes Washer Market

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Historically, the U.S. market for clothes washers has consisted of top-loading, vertical-axis washers with an agitator. In recent years, two large U.S. manufacturers started building and selling horizontal-axis or tumble washers in the U.S. This change was prompted by anticipation of new energy efficiency standards for clothes washers. The change in U.S. Department of Energy minimum energy efficiency standard levels for clothes washers will take place in two stages, in years 2004 and in 2007. Technologies that will be used to meet these new standards include horizontal-axis washers, vertical-axis washers with a spray rinse, washers using lower wash temperatures, better temperature controls, adaptive load controls, and higher spin speeds. The introduction of more efficient clothes washers to the U.S. market may lead to greater similarities to European designs but will be tempered by preferences for features desired by the U.S. consumer. Typically clothes washers in the United States are larger and most consumers have matching clothes dryers.

The test procedure for clothes washers will also change in 2004. The new test procedure will consider not only the energy to wash the clothes but also the amount of water remaining in the clothes after a spin dry cycle and therefore the energy needed to dry the clothes after they are removed from the washer. The new U.S. test procedure will not include a cleaning performance requirement or measurement.

BACKGROUND

Historically, the United States has used vertical-axis washers, often referred to as top-loading washers. These use approximately 76 liters (20 gallons) of water to wash the clothes and 76 liters (20 gallons) to rinse the clothes. On average, 14% of laundry is washed with hot water, 49% with warm water, and 37% with cold water. Warm water is used for rinsing the clothes 27% of the time with the rest being rinsed in cold water. In the United States, washers are supplied with hot water from an external water heater. Both hot (typically 49EC to 71E C)(120 EF to 160 EF) and cold water is plumbed to the washer. Warm water temperature is achieved by mixing water from the hot and cold water lines. Unlike most European washers, U.S. manufactured washers do not have an internal heater and need only 120 volts. Both gas and electricity are important fuels for doing laundry in North America. Electric water heaters are used in 45% of U.S. households while the remaining 55% use natural gas fired water heaters. For clothes dryers, 75% are electric and 25% are gas.

Based on survey results, the average household in the U.S. washes 392 cycles per year. An average size load in the U.S. washer is 3.4 kg (7.5 lbs) for a typical basket capacity of 82-85 liters (2.90 to 3.0 ft^3). The average clothes washer is disposed of after 14 years.

For the typical vertical-axis, standard size washer, the energy used is mainly to heat the water (88%), the other 12% of the energy is electrical input to the motor. Since washers and dryers are often sold together as a set and because 84% of washer loads are dried in a clothes dryer, it is useful to look at the entire energy use for doing laundry. The energy use for doing laundry with a typical vertical-axis clothes washer is as follows: hot water, 49% (1.587 kWh), washer motor, 7% (0.209 kWh), and clothes dryer 44%(1.43 kWh).

In the 1950s and 1960s horizontal-axis washers were marketed in the U.S. but had a reputation for having maintenance problems. Until the last few years, the only horizontal axis washers available were European imports. Horizontal axis washers are now being re-introduced to the residential market by U.S. manufacturers and are currently at about 10% of the market. This change in the clothes washer market has most likely been driven by anticipated changes in the U.S. Department of Energy (DOE) minimum efficiency standard. The current standard has been effective since May 1994. A new standard will become effective in two stages in the years 2004 and 2007. There are currently both vertical and horizontal axis washers that can meet the new proposed standards.

TEST PROCEDURE

Introduction

A new U.S. (DOE) test procedure (referred to as Appendix J1) will become effective at the same time as a new energy efficiency standard (the new standard will become effective on January 1, 2004).[1] Changes in the test procedure will give credit for adaptive control systems, automatic fill control and lower remaining moisture content (RMC) in the wash load after the wash cycle.[2] Because the new test procedure gives credit for these features, it will encourage manufacturers to use these design strategies in future clothes washer designs. There is no cleaning performance testing required for minimum efficiency standards nor for efficiency labels.

Definitions

The current metric for efficiency is the Energy Factor (EF). In January of 2004, when the new efficiency level first becomes effective, the efficiency metric will be Modified Efficiency Factor (MEF). There is no simple conversion factor to convert from the current test procedure to the future test procedure. In addition to energy use, the test procedure provides for a standard way to measure water consumption, although a maximum level water consumption factor (WCF) is not specified. Some basic definitions of efficiency, water consumption and water content of test cloth are provided below.

$$EF = \frac{(\text{volume capacity of basket})}{(\text{energy to heat water} + \text{motor energy})}$$

$$MEF = \frac{(\text{volume capacity of basket})}{(\text{energy to heat water} + \text{motor energy} + \text{dryer energy})}$$

$$WCF = \frac{(\text{gallons per cycle})}{(\text{volume capacity of basket})}$$

$$RMC = \frac{(\text{wet cloth weight} - \text{dry cloth weight})}{(\text{dry cloth weight})}$$

Proposed Test Procedure Effective in 2004 (Appendix J1)

In the current test procedure (Appendix J), the following measures are optional: total (both hot and cold) water consumption, remaining moisture content (RMC) in a test load after the final spin cycle, and a modified energy factor (MEF).[2] The MEF includes the energy needed to dry clothes in a dryer after a final washer spin cycle.*

The new test procedure will make some of the voluntary measurements in the current "Appendix J" test procedure mandatory. Major changes in the test procedure preclude converting EF to MEF by using a correction factor. Among the changes in test procedure will be (1) new temperature use factors (TUFs)(Temperature use factors are used to prorate energy consumption among cold, warm and hot wash, as well as to factor in a warm rinse if offered.); (2) the assumption of a hot to cold temperature differential of 42EC (75EF) instead of 50EC (90EF) and (3) the addition of provisions to account for adaptive control systems. The clothes washer test loads specified will depend on the clothes washer container volume. RMC will be accounted for and MEF will replace the current EF. The above changes will result in a more accurate prediction of actual energy use needed to do laundry.

Test Cloth Issue Resolved

During the recently completed clothes washer standard setting process, a discrepancy in RMC results was discovered when results for the same washer differed depending on who did the testing. This difference in the RMC results for the same washer was due to different manufacturers using the specified test cloth from different batches and different test cloth providers. This suggested that the test cloth was not specified in enough detail. The issue was resolved by additionally specifying the performance of the test cloth after being spun in a standard extractor at various RPMs. The test cloth is then adjusted to the results of a reference cloth for which a spin speed versus RMC curve had been constructed. These adjustments to the Appendix J1 test procedure are explained in detail in the Technical Support Document (TSD) supporting the Final Rule.[1 3]

Waivers

If a washer has features such that the test procedure does not adequately represent the energy usage of it, the manufacturer is allowed to apply for a waiver such that an appropriate test procedure can be used to establish realistic energy use for that washer.

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* Although Appendix J contains a calculation for an optional MEF, it is not equivalent to the J1 MEF because of changes in the test procedure parameters.

Standby Energy

Presently there is no provision to measure off-cycle energy use. Therefore, the energy consumption of transformers used to power computer chips or electronic controls are currently not a consideration in determining the energy use of a washer.

Networked Appliances

Manufacturers are beginning to offer appliances that can be networked or that can communicate with other appliances in a household. Appliance test procedures do not account for how appliances networked together might impact the energy use of an appliance.

U.S. MINIMUM EFFICIENCY STANDARDS

Minimum Standard Levels and Product Classes

The current minimum energy efficiency standard for residential clothes washers became effective in May 1994. This standard is summarized in Table 1 below.

Table 1. Current Efficiency Requirements

Product Class	Requirement (cubic feet / kWh)
Top-loading compact (less than 45 liters capacity) (1.6 ft^3)	EF = 0.9
Top-loading standard (45 liters or greater capacity)	EF = 1.18
Top-loading, semi-automatic	#
Front-loading	#
Suds-Saving	#

must have an unheated rinse option

Negotiations between the manufacturers and efficiency standard advocates resulted in recommendations to the U.S. DOE. The recently adopted standard will become effective in two stages: an MEF of 1.04 in year 2004 and an MEF of 1.26 in 2007 (for standard capacity washers). These MEFs represent a reduction in energy use of 22% and 35% from the current minimum required efficiency level. There is no requirement for cleaning performance testing in either labeling nor in the mandatory minimum efficiency standard. The future minimum efficiency standards are summarized in Table 2 below.

Table 2. Efficiency Requirements

Product Class	Efficiency Requirement (cubic feet / kWh)	
	2004	2007
Top-loading compact (less than 45 liters; 1.6 cu. ft.)	MEF = 0.65	MEF = 0.65
Top-loading standard (45 liters or greater capacity)	MEF = 1.04	MEF = 1.26
Top-loading, semi-automatic	must have an unheated rinse option	
Front-loading	MEF = 1.04	MEF = 1.26
Suds-Saving	must have an unheated rinse option	

For two of the product classes only an unheated rinse is required. Standard levels were not set for these two product classes because of the very limited sales for these categories. However, compact washers do have a minimum standard level even though they account for less than 2% of the market share.

IMPACT OF FUTURE STANDARDS ON PRICE AND SHIPMENTS

U.S. manufacturers will need to redesign some of their washer models in order to meet the new energy efficiency requirements. For this reason, manufacturers have indicated that the average clothes washer price is expected to increase, resulting in a possible decrease in washer sales.

Consumers have indicated that price is the primary factor affecting clothes washer sales.[3] A typical price for a top-loading vertical-axis washer in the U.S. is $421 (1997 data and dollars). Manufacturers estimated that to achieve the efficiency levels required by 2004, the average retail price would increase by $53. To meet the 2007 standard level, the price increase is expected to be $240 (based on converting to a horizontal-axis washer design). Figure 1 below shows the forecasted shipments after the two stage minimum efficiency standard is implemented and compares this to a scenario assuming no change from the current minimum efficiency standard. Although average prices were used for the shipment drop analysis, manufacturers submitted a wide range of estimated increases in manufacturing costs. In addition to manufacturer-based estimates of increases in washer price, the DOE reversed engineered several vertical-axis washers meeting the 2007 standard. Based on an increase in manufacturing cost and multiplying by a markup factor, the DOE estimated an increase in retail price of $150.

VOLUNTARY PROGRAMS

Several voluntary programs are underway to influence U.S. consumers to buy more efficient clothes washers. In some cases, the motivation is to reduce the water consumption as well as the energy consumption of washers.

Energy Star®

In order to encourage the sale of efficient washers, the U.S. DOE authorizes the use of an Energy Star label if a washer has an efficiency rating of at least EF = 2.5. Under a new test procedure, in order to qualify for an Energy Star label a clothes washer will need an MEF of 1.26 in 2001 and MEF of 1.42 in 2004. A list of Energy Star washers are provided on the web site: *http://www.energystar.gov/products/index.html.*

Voluntary Industry Water Use Program

Members of AHAM (American Home Appliance Manufacturers) have agreed to publicly disclose water factors for each model that meets Energy Star® levels, starting sometime in calendar year 2001. In calendar year 2002 and each year thereafter, industry-wide shipment-weighted average water factors for units shipped in the previous year will be reported. Starting in 2007, AHAM members agree to report water factor for all models.

Accelerated Replacement

The appliance industry is promoting accelerated or early replacement of older appliances, stating that consumers will benefit by replacing their less efficient appliances with more efficient appliances.

LABELS

Federal Trade Commission

The U.S. Federal Trade Commission (FTC) administers the Efficiency Label program. Prior to March 2000, the FTC treated "front-loading" and "top-loading" as separate categories with their respective scales showing the relative efficiency of the washer relative to other washers in the same product class. In September 2000, "front" and "top-loading" washers were mixed into the same product class, allowing consumers to more easily compare the efficiency of "front-loading" to "top-loading" machines. The only product categories are now "compact" and "standard" washers.

CONSUMER ISSUES AND MARKET TRENDS

Focus Groups and Conjoint Analysis

As part of the new efficiency standard making process, focus groups were held to determine which attributes were most important to consumers.[3] Once a complete attribute list was derived, respondents were asked to rank the top ten attributes that they would look for when purchasing a new clothes washer. Table 3 below shows the top 12 attributes mentioned as well as the percentage of respondents who listed that attribute in their list of the ten attributes most important to them..

Table 3. Most Important Washer Attributes

Feature	Percent out of all 90 Participants
Price	83
Capacity	81
Energy & Water Costs	72
Load Size Options	68
Durability	60
Water Temperature Options	60
Door Placement	42
Quiet Operation	40
Wash Time	38
Warranty	37
Multiple Wash Cycle Options	33
Horizontal/Vertical Axis	28
Wash Time	38

Trends

The general trend is toward larger sizes or capacities for clothes washers. See historical data below.[4]

Table 4. Tub or Basket Volume

Year	Average Volume	
	cubic feet	liters
1985	2.5	71
1990	2.6	74
1995	2.7	77

Differences in Washers as Compared to European Designs

Detergent:

Detergents designed for vertical-axis washers produce more suds than those for horizontal axis washers. If an equivalent amount of detergent formulated for vertical-axis washers is used in a horizontal-axis washer, over-sudsing can occur. Two manufacturers in the U.S. are now producing detergent made specifically for horizontal-axis washers; however, these are currently more expensive per dose than the average detergent designed for vertical-axis washers. Some consumers with horizontal-axis washers continue to use vertical-axis detergents but reduce the amount of detergent used.

Pre-soak:

The typical washer in the U.S. has a cycle selection called pre-soak. This allows consumers to let clothes sit in water before the actual washing cycle begins.

Sold Together:

Clothes washers and clothes dryers are typically sold together as a matched pair. They are usually similar in appearance. About 88% of households with a clothes washer also have a clothes dryer. Of these, approximately 80% are electric with the rest being gas.

Time to do a wash:

The average vertical-axis washer take less time to run through a wash cycle than a European-style horizontal-axis washer. However, the time required to dry the clothes is usually longer than the time to wash it. This is a problem when more than one load of wash is being done at a time. The dryer is then the determining factor on how long it takes to do the wash.

Consumer issues:

European washers are smaller than U.S. washers and have smaller door openings.

NEW TECHNOLOGIES AND DESIGNS

Expected New Design Features for the U.S. Market

Adaptive control systems:

An adaptive control feature adjusts washer operation or washing conditions based on characteristics of the clothes load placed in the clothes container, without requiring user intervention or actions. The automatic adjustments may, for example, include automatic selection, modification, or control of any of the following: wash water temperature, agitation or tumble cycle time, number of rinse cycles, and spin speed. The characteristics of the clothes load which could trigger such adjustments, could, for example, be the presence of either soil or soap, suds. (Accounted for in J1 but not in Appendix J)

Adaptive water fill control system:

An adaptive water fill control system is capable of automatically adjusting the water fill level based on the size or weight of the load placed in the clothes container, without allowing or requiring user intervention and/or actions.

Thermostatically controlled water valves:

These controls have the ability to sense water temperature and adjust the hot and cold supply water.

Spray rinse:

A rinse cycle that is sprayed onto the clothes load for a definite period of time without maintaining any specific water level in the clothes container.

Horizontal-axis washers:

This style of washer is now being marketed by three of the five major clothes washer manufacturers in the U.S. The U.S. washers are larger than those sold in Europe to meet the preferences of the U.S. market. One manufacturer has tilted the wash drum in order to facilitate adding and removing the laundry load.

Time delay:

This feature allows a consumer to pre-set the actual start time of the wash.

More choice in cycle selection:

This will allow users to set the cycle combinations of time, agitation and spin for specific clothes and in some cases allow the user to customize (program) their own cycles.

Wash plate and spray rinse:

One U.S. manufacturer has introduced a vertical-axis washer without an agitator. In place of an agitator, it has a disk at the bottom of a top-loading washer that rotates and bounces clothes up and down

while water and detergent are sprayed on top of the laundry. This looks like a conventional top-loading washer of a vertical-axis design but without a large agitator in the middle of the basket. This allows for easier loading of large bulky items. A design of this type is said to have efficiency levels high enough to meet the 2007 DOE minimum efficiency requirement.

Direct drive washers:

These washers have variable speed motors that are controlled electronically. One manufacturer combined this design option with others to meet the 2007 DOE required efficiency level of 1.26 MEF with a vertical-axis design.

Standby Power:

Unlike the trends discussed above, which will be used to meet the more stringent efficiency standards, washers with computer chips and electronic controls will increase standby power consumption, although it may also allow for features that save energy. Should standby power be measured in future test procedures, technologies are available to reduce standby power to a minimum amount.

Networked Appliances:

Clothes washers will have the ability to communicate with other appliances or be controlled from a remote location. An application may be to limit the total electricity load for a house during peak usage periods. At present there are no special provisions in the test procedure to address this design feature.

FUTURE TRENDS

Driving Forces

Future trends outside of those necessary to meet clothes washer standard will have an impact on appliance and clothes washer design.

Deregulation and time-of-use pricing or peak load based tariffs:

Unlike commercial and industrial electricity tariffs, residential rates can vary from month to month or by seasons but do not vary with the time of day. There is speculation that a residential time-of-use rate may become more common in the future. The purpose would be to reduce the peak loads for utilities in order to avoid the possibility of insufficient electricity supply. Should time-of-use rates become more common, consumers will want to mitigate high peak prices by incorporating several energy-use strategies. In addition to selecting more efficient appliances, consumers may look for time-delay features on washers that allow washing to occur during off-peak hours. Some of these efforts to reduce peak load may come at the expense of overall energy use. For example, if water is heated during off-peak hours, there is an associated standby loss from the storage water heater.

Another future possibility is load-dependent electricity pricing. Smart washers that are linked to other household appliances could control the operation of all household appliances such that a set total household energy use is not surpassed during peak periods.

Importance of water savings:

In some areas of the U.S. and around the world, the scarcity of water is as critical an issue as the need to conserve energy. It is conceivable that water use will be regulated at the state or local levels through building codes or state appliance standards. Water prices are expected to increase over time as populations increase.

Intelligent home control "smart machines":

Future homes will be electronically interconnected allowing appliances to communicate with each other. This can allow household electric usage to be controlled as a system. Prototypes of these "smart" houses have already been built. Washers are currently available that allow the user to program customized wash cycles. Incorporating computer chips into washers will allow their operation to be easily changed by downloading different control programs from the Internet. This will have implications for the test procedure.

Standby power use:

Although computerizing appliances can increase their efficiency, this can also have the affect of increasing their standby losses. This topic is currently being addressed and solutions to minimize standby losses are being studied.

New detergents:

Advances in detergent formulations may decrease hot water use by allowing more cold water washes.

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