

Purdue University

Technical Assistance Program

**COMPARISON OF CONSUMPTION
BETWEEN THE DISHMASTER®
FAUCET AND AUTOMATIC
DISHWASHING MACHINES**

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PROBLEM STATEMENT

The purpose of this project is to compare water usage between the Dishmaster® faucets (Fig. 1) and automatic dishwashing machines. The comparison will be performed by washing the same amount of dishes as the standard load for dishwashers. Amount of water spent by the Dishmaster® is measured by a flow meter. This value will be compared with claimed consumption of different automatic dishwasher manufacturers.



Figure 1. Dishmaster® M2000 faucet.

SUMMARY

Experimental comparison of water consumption was not performed. However, results of search on performance of dishwashing machines are presented. Also, some recommendations on how to perform the experiment are given.

As noted in the body of the text, manufacturers of dishwashing machines perform measurements by themselves and also by a third party. Therefore, preliminary comparison tests can be performed by the manufacturer and in the case that a positive result is feasible a third party can be hired to perform independent analysis.

A person with average dishwashing skills, has to consume less than 3 to 5 gallons of water per one load of dishes (specified in the text), in order to be claimed that the Dishmaster® faucet consumes less water than the average dishwashing machine.

CONSUMPTION OF COMMERCIAL AUTOMATIC DISHWASHERS

Comparison of Consumption between Dishwashers and Hand-Washing

The common opinion is that automatic dishwashers consume less energy than hand washing. This is illustrated in Figure 2, taken from the Government's official website.

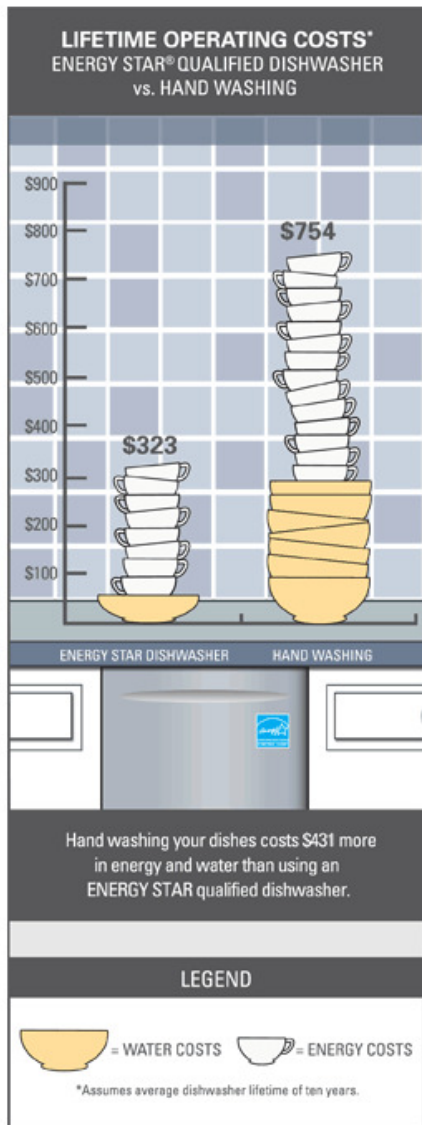


Figure 2. Comparison between energy and water consumption of average Energy Star qualified dishwasher and hand-washing.

Source:

http://www.energystar.gov/index.cfm?c=dishwash.pr_handwash_dishwash

Comparing the efficiency of automatic dishwashers and hand washing of dishes is difficult because hand-washing techniques vary drastically by the individual performing such washing. A 2004 peer-reviewed study concluded that the best automatic dishwashers available at the time, when fully loaded use less electricity, water, and detergent than the average European hand-washer. The most efficient hand-washers in that study, however, were far more energy efficient

than the dishwashers. The most efficient hand-washers apply detergent onto the sponge, and pile up dishes. Then they rinse them with water from the faucet.

It is important to note that rinsing dishes (a usual practice by many) can use up to 20 gallons of water before the dishes are even loaded in a dishwasher. It is claimed by dishwashing manufacturers that this is an unnecessary step, since Energy Star qualified dishwashers and today's detergents are designed to do the cleaning without rinsing. Instead of pre-rinsing, only scrubbing is recommended. Dishwasher's rinse feature uses a fraction of the water needed compared to hand rinsing of dishes.

Energy saving is particularly effective in dishwashers that are capable of heating water internally, like cold fill European models, which do not lose heat during transport to the faucet as the quantity of water to be loaded is usually very little, in average 4-5 liters for each section of the wash.

Comparison studies do not address costs associated with the manufacture and disposal of dishwashers, the cost of possible accelerated wear of dishes from the chemical harshness of dishwasher detergent. On the other hand, studies do not include the value of labor saved when dishes are washed in the machine.

Dishwashers may have more negative impact on environment than hand-washing. Efficiency of dishwashers is largely based on powerful chemistry of detergents used in them. Most dishwasher detergent contains complex phosphates, as they have several properties that aid in effective cleaning. However, the same chemicals have been removed from laundry detergents in many countries as a result of environmental concerns.[http://en.wikipedia.org/wiki/Dishwasher - cite note-15](http://en.wikipedia.org/wiki/Dishwasher_-_cite_note-15) In addition, rinse aids (that make pre-rinsing unnecessary) contain nonylphenol and nonylphenol ethoxylates. These have been banned in the European Union by EU Directive 76/769/EEC.

Performance Metrics for Dishwashers

The newest Energy Star criteria for dishwashers were introduced on August 11, 2009. By the criteria a dishwasher must have a maximum energy and water use of:

- Standard models: 324 kWh/year and 5.8 gallons per cycle.
- Compact models: 234 kWh/year and 4.0 gallons per cycle.

Table 1 shows the energy and water consumption of a few manufacturers and their models. If there is only one model listed for the manufacturer, it has about the lowest consumption found for that brand. If more models are listed, they include the best one, while the others can give insight in the range of consumption the manufacturer offers for its dishwashers.

Figure 3 shows current and future requirements for dishwasher energy and water consumption. As can be seen, Federal Standard currently uses Energy Factor (EF) as the criterion. However, starting this January, EF will be discontinued, and the same units will be used as in Energy Star criteria.

Table 1. Energy and water consumption of some of dishwasher manufacturers and their models.

Brand	Model	Size	kWh/Year	Gallons/Cycle	Energy Factor (EF)	Federal Standard (EF)
AEG-Electrolux	F45078I-M	Standard	320	4.12	0.67	0.46
AEG-Electrolux	F65478VI-S	Standard	316	4.35	0.68	0.46
Ariston	L63*	Standard	270	5	0.80	0.46
Bosch	SHE42L1#UC	Standard	315	2.89	0.68	0.46
Bosch	SHE68E05UC	Standard	180	1.57	1.23	0.46
Bosch	SHE98M05UC	Standard	190	2.05	1.13	0.46
Frigidaire	DGHD2433	Standard	283	3.68	0.79	0.46
Gaggeneau	DF260760	Standard	180	1.57	1.23	0.46
GE	GDWT1**R	Standard	322	5.1	0.68	0.46
GE Profile	PDWT51*P10	Standard	322	5.5	0.72	0.46
General Electric	GHDA69*P	Standard	302	5.2	0.74	0.46
Ikea	IUD9750V	Standard	313	4	0.70	0.46
Kenmore	1310*K***	Standard	301	4.19	0.72	0.46
Kenmore	1332	Compact	174	2.7	1.30	0.62
Kuppersbusch	IGVS6607UL	Standard	234	2.21	0.92	0.46
LG	LDF993#**	Standard	285	3.4	0.76	0.46
LG Electronics	LDF692#**	Standard	285	3.4	0.76	0.46
Maytag	MDB8959AW**	Standard	291	4.15	0.75	0.46
Samsung	DMR78***	Standard	289	5.2	0.76	0.46
Siemens	SL65A703UC	Standard	290	2.58	0.74	0.46
Whirlpool	DP1040XTX**	Standard	296	3.96	0.73	0.46
Whirlpool	DU018DWT*	Standard	313	5.15	0.72	0.46

It is important to know the definition of the dishwasher size, as what the EF is.

Energy Factor

Energy Factor (EF) is the previous dishwasher energy performance metric. EF is expressed in cycles per kWh and is the reciprocal of the sum of the machine electrical energy per cycle, M, plus the water heating energy consumption per cycle, W:

$$EF = \frac{1}{M + W}$$

This equation may vary based on dishwasher features such as water heating boosters or truncated cycles. The greater the EF, the more efficient the dishwasher is. EF does not give a very clear estimation of real consumption, especially since it gives the average cycles per kWh. So the average annual consumption year is based on number of cycles per year. Recently, this number has been lowered from 264 cycles per year to 215 cycles per year. Moreover, EF includes weighted electricity and water consumption, and weighting factors are vague. The new criteria, used by Energy Star now, include also standby energy in the annual consumption.

STANDARD SIZED MODELS			
Criteria/Product Type	Current Criteria Levels	January 1, 2010	July 1, 2011
ENERGY STAR	<= 324 kWh/year <= 5.8 gallons/cycle		<= 307 kWh/year <= 5.0 gallons/cycle
Federal Standard	EF >= 0.46	<= 355 kWh/year <= 6.5 gallons/cycle	

COMPACT SIZED MODELS			
Criteria/Product Type	Current Criteria Levels	January 1, 2010	July 1, 2011
ENERGY STAR	<= 234 kWh/year <= 4.0 gallons/cycle		<= 222 kWh/year <= 3.5 gallons/cycle
Federal Standard	EF >= 0.62	<= 260 kWh/year <= 4.5 gallons/cycle	

The current ENERGY STAR criteria for dishwashers became effective August 11, 2009.

Figure 3. Energy Star and Federal Standard requirements (current and future) for standard size dishwashers.
Source: http://www.energystar.gov/index.cfm?c=dishwash.pr_crit_dishwashers

Dishwasher Capacity

There is no specific definition for the number of pieces of dishware that goes into a standard sized dishwasher. The international standard for the capacity of a dishwasher is expressed as standard place settings (dishes or plates of irregular sizes may not fit properly in a dishwasher's cleaning compartment). Dishwashers that are installed into standard kitchen cabinets have a standard width and depth of 60 cm (Europe) or 24 inches (US), and most dishwashers must be installed into a hole a minimum of 86 cm (Europe) or 34 inches (US) tall. Portable dishwashers exist in 45 and 60 cm (Europe) 18 and 24 inches (US) widths, with casters and attached countertops. Dishwashers may come in standard or tall tub designs; standard tub dishwashers have a service kickplate beneath the dishwasher door that allows for simpler maintenance and installation, but tall tub dishwashers have approximately 20% more capacity and better sound dampening from having a continuous front door.

The clearest definition is that given by Energy Star (Figure 4).

It also can be estimated what goes into one load of a standard sized dishwasher by looking at manuals for some of them. Figure 5 illustrates loads for two standard sized models.

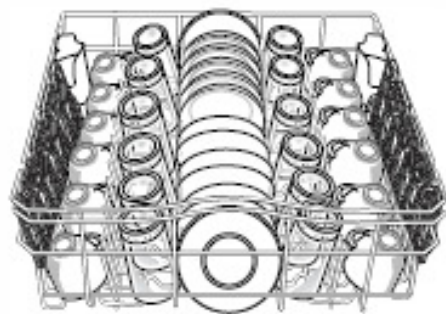
Equipment	Capacity
Standard Sized Models	>= 8 place settings + six serving pieces
Compact Sized Models	< 8 place settings + six serving pieces

Figure 4. Energy Star definition of the standard and compact sized dishwasher.

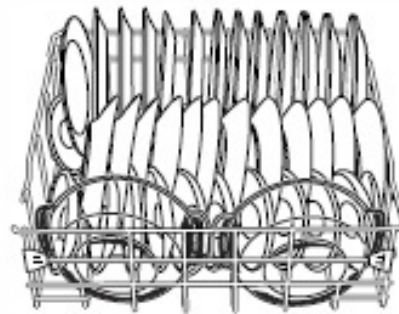
Proper loading = cleaner dishes

Careful placement, plus an enzyme detergent and a rinse aid, can make the difference between glistening dishes and grungy ones. But skip pre-rinsing. It wastes time, energy, and as much as 6,500 gallons of water per year.

- 1** Keep large items at the sides and back, so that they don't block water and detergent from reaching other dishes.
- 2** Load dirtier side of dishes toward the center for more exposure to the spray.
- 3** Use the top rack for plastic and delicate items that are dishwasher safe.
- 4** Rest glasses on prongs to prevent breakage.
- 5** Put silverware handles down, but knife handles up. If your dishwasher has an open basket, mix spoons, forks, and knives to prevent them from sticking together.
- 6** Place items with baked-on food facedown and toward the sprayer in the bottom rack.



Upper rack



Lower rack

Figure 5. Illustration of the load that is placed in the standard-sized dishwasher.

Test Procedure for Dishwashers

A test for water consumption is defined by NSF/ANSI 3-2007 Standard, Commercial Warewashing Equipment. It can be purchased for \$155.00 on the following website:

http://www.techstreet.com/cgi-bin/detail?product_id=1374545

It should be noted that all machines must be certified to NSF/ANSI 3 by a third party laboratory capable of testing to the above referenced test procedure.

Other test standards found relate to energy consumption:

- Idle Energy Rate for Hot Water and Chemical Sanitizing Undercounter and Stationary Rack Single Tank Door-Type Dishwashers: ASTM Standard F1696, Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, Door-Type Commercial Dishwashing Machines; and
- Idle Energy Rate for Hot Water and Chemical Sanitizing Single and Multiple Tank Rack Conveyor Dishwashers: ASTM Standard F1920, Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines.

Dishwasher manufacturers must self-test their equipment according to the new DOE test procedure defined in 10 CFR 430, Subpart B, Appendix C

In order to qualify for Energy Star, manufacturers are required to perform tests and self-certify those product models that meet the Energy Star guidelines. The test results must be reported to EPA using the Commercial Dishwasher QPI Form. In measuring water consumption and idle energy rate, partner agrees to use the test standards mentioned above.

EXPERIMENT

In order to state that DISHMASTER® faucet uses less water than a dishwasher it is recommended to:

- Attach a flow meter to the inlet hose of the faucet;
- Wash the same amount of dishes as it would be washed in a dishwasher; and
- Compare measured water consumption of water with the consumption stated for the dishwasher model.

There are a few ambiguities in quantification:

- There is no precise quantity that defines how much dishware goes into one dishwasher load. The amount can be guessed from Figure 5;
- Consumption of different dishwasher models varies, as can be seen in Table 1. So, one should choose which value to use for comparison. It is obviously hard to beat consumption of 1.57 gallons/cycle. The optimal value to compare with should be around 3 to 5 gallons per one load of dishes; and

- The difference shown in the comparison is valid only if it is statistically significant. This means that appropriate number of subjects has to wash the same amount of dishes, and appropriate statistical analysis should be performed.

There are two ways to measure water consumption.

- 1) One method is to attach a flow meter to inlet pipes and measure the flow. One flow meter would be for hot and the other for cold water (Fig. 6). One flow meter can be used with using just cold water (hot water valve closed).

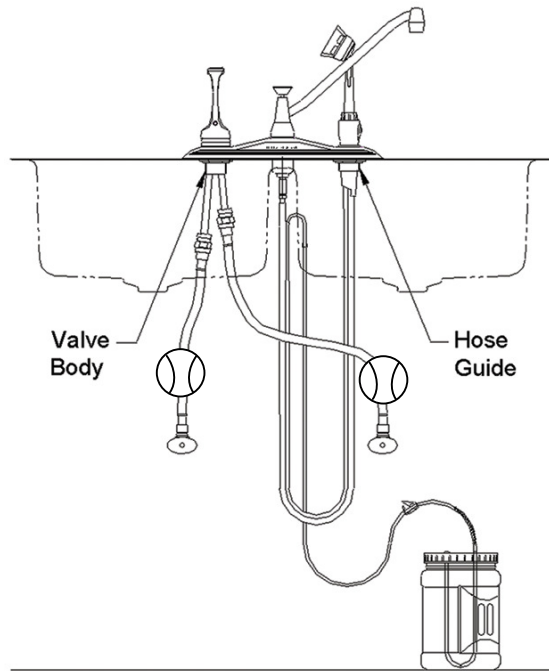


Figure 6. Installation of flow meters.

- 2) The other method is to measure the weight of water before and after washing. This can be done as depicted in Figure 7. Water pressure in a household is 30 to 80 psi. Ideally, it should be between 50 and 60 psi. To achieve pressure of 60 psi, water column has to be 166 inches (13.84 ft) high. So, for ideal water pressure (50 to 60 psi), water level should be 138.3 to 166 inches (11.53 to 13.84 ft) above the point with that pressure (Figure 7).). It is quite a wide range, so the whole experiment can be performed with height difference between the water free surface and the washing zone in that range. The consumption is determined by measuring amount of water (weight or volume) before and after washing. The only disadvantage of this method is that warm water should be mixed in the vessel

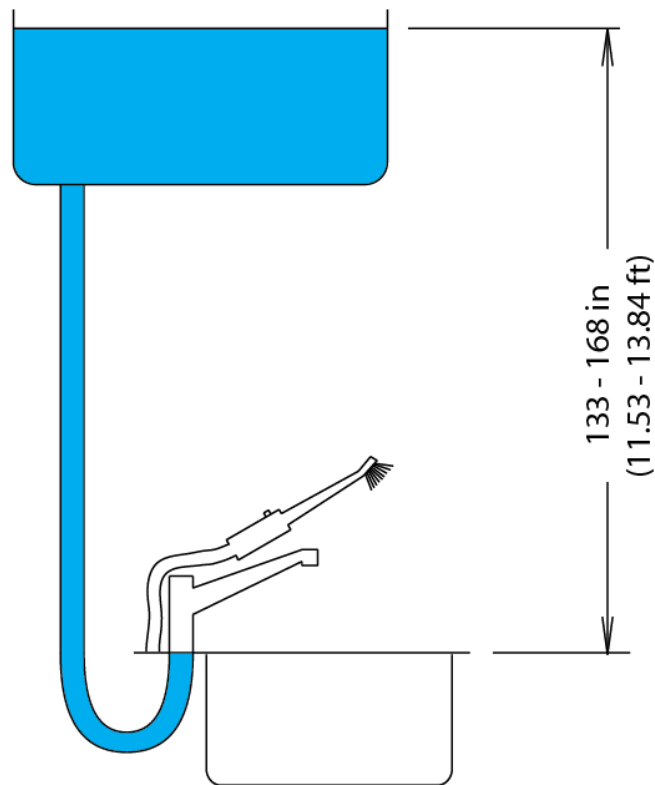


Figure 7. Alternative method to measure water consumption.

The experiment was not performed in this project due to some obstacles. The department has flow meters that measure small flow rates, so the method of direct measurement of water consumption (Fig. 6) could not be used. Performance of an alternative method (Fig. 7) was impaired mainly by problems to find a location for experiment.

CONCLUSIONS AND RECOMMENDATIONS

Since experiments were not performed, it remains up to the customer to perform comparison testing. The task would be to spend less than 3 to 5 gallons of water per one load. This load could be approximately 6 complete serving sets (12 big plates, 6 small plates, 6 coffee cups with plates, 6 glasses, together with accompanying silverware), and additional space for at least 8 pieces of serving dishes, including bowls. The size of the load varies, as can be seen in Fig. 5. According to Fig.5, one load can contain 24 big plates, 25 small plates, 12 coffee cups and 12 glasses.

In order for this comparison to be competent, the result must be statistically significant. This means that a large enough number of participants with different dishwashing skills has to be included and appropriate statistical analysis performed.

By consulting several persons, and according to personal experience and estimations, it seems unlikely that washing dishes out of a dishwashing machine can lead to smaller water consumption. Limiting factors with the Dishmaster® is that water has to run all the time. Even detergent has to be applied with running water. As our survey shows, only persons who could spend less water are those with very economic ways of washing: they apply detergent on the sponge, and stack washed dishes in the compartment with a small amount of water in it to dilute remaining detergent so a very small amount of fresh water is needed for final rinsing. Some do not even stack soaped dishes in the water, but just rinse it quickly at the end. It should be noted that these measurements were done with the purpose to compete with dishwashing machines, so those persons did their best to spend less water as much as possible.

Dishwashing machines have other negative aspects that have not been considered. One of them is that they use heavy detergents in order to consume less water. On the other hand the detergent used by the Dishmaster® is quite diluted (1 table spoons in 16 ounces of water) and is biodegradable, with no phosphates, enzymes, or citrus additives. Also, end-of-life of dishwashers is not considered, i.e. problems with their disposing, recycling, permanent waste. One should perform more detailed analysis to determine does savings in energy and water overweight negative ecological aspects. It is possible that dishwashing machines might leave a greater “ecological footprint” than other methods of dishwashing.