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Test procedures, measurements and standards for domestic washing machines

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1 Measurement standards and test procedures

A standard definition for energy consumption and a test procedure to measure it are necessary to ensure market transparency and to apply effective policies. Electricity consumption by washing machines is measured in accordance with four main test standards in different world regions.

A standard definition for the specific energy consumption per unit is necessary to compare the energy and water consumption of washing machines. Furthermore, a test procedure is needed to measure this specific energy and water consumption. The definition and the test procedure together form a **test standard**. Such a standard makes it possible to introduce Minimum Performance Standards and labels. Based on the measured specific energy or water consumption, the efficiency of washing machines is defined as the degree of electricity or water consumption per wash cycle, per year or per kg of laundry, or vice versa. In addition, the functional performance is defined in comparison to a reference appliance. This relationship between an individual appliance and the reference appliance can also be expressed for energy efficiency using an energy efficiency index (e.g. in the recent European Standard). The standard energy consumption of the reference appliance is also often expressed as a function of the washing capacity (kg) or the volume (litres, cubic feet).

2 Different test standards

There are four main test standards that have been adopted for washing machines almost worldwide. The IEC / EN and ANSI / AHAM standards are the most important reference standards. The EU and many other countries with mostly horizontal-axis washing machines have based their test standards on IEC, often with more or less significant modifications. The harmonized AS / NZS standard in Australia/New Zealand and the Japanese JIS C standard also refer to early revisions of IEC 60456, but differ considerably from the original document nowadays, especially considering the vertical-axis washing technology dominating these markets. In North America and parts of South America with predominantly vertical-axis machines, test standards are based on the AHAM reference test standard. **Table 1** gives an overview of their main characteristics and differences.

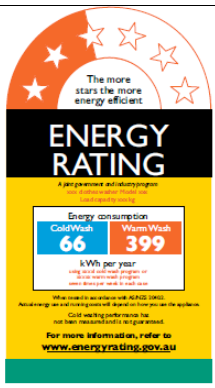
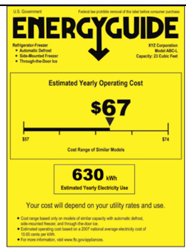
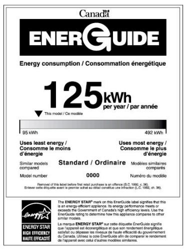
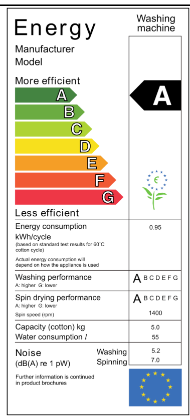
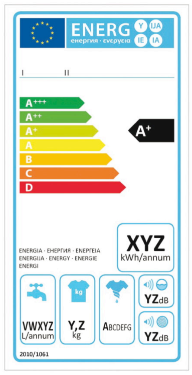
Table 1: General testing conditions under the main standards and examples of labels based on the standards

Testing Parameters	AS/NZS (2040.1, based on IEC 60456:1994 but differs significant-ly)	ANSI/AHAM (HLW-1-2007)	IEC / EN (60456)	JIS C (9606, focus on vertical axis washing machines (impeller or agitator)
Selection of coun-tries applying the test standards	Australia, Indone-sia, New Zealand	USA, Canada (reference standard), Mexico, Chile	EU, China / Hong Kong, South Korea (KS C EC 60456, Identical to IEC 60456:2003), adapted stand-ard for horizontal axis machines), India (uses a variant) Brazil and many others. Refer-ence Test Standard for Turkey, Vietnam, The Philippines, South Africa, Singapore, Ar-gentina, Iran, Russia (APEC/CLASP 2011	Japan, South Korea (KS C 9608), Thai-land, Taiwan, China / Hong Kong (vertical axis ma-chines)
Load capacity	Manufacturer-rated capacity in kg (mixture of materials defined in the standard).	Standard type household clothes washers: Tub/Drum capacity of 1.6 ft^3 (45 L / 13 gallons) of water or more.	Manufacturer-rated capacity in kg	
Wash temperature	Nominally 40°C (technical re-quirement: >35°C), “Cold wash”:	Variable (de-pending on washer unit type, water	60°C Cotton Cycle (without pre-wash) in accordance with	Use of “cold water” at 20°C (meas-ured at 65%

	20°C.	and temperature control), Typical tests: (adjusted) average of a combination of temperatures.	the manufacturer's instructions. At least 5 complete cycles.	air humidity)
Energy consumption	Energy Consumption (Full programme cycle declared by manufacturer as "warm wash" including energy embodied in external hot water if not self-heated (Unit: kWh/load). Annual energy consumption incl. Power consumed in "Off mode" and "end of cycle" mode. Identical for the declared "cold wash" programme.	(Adjusted) sum of electrical energy consumption, the hot water energy consumption and the energy required for removal of the remaining moisture in the wash load, Typically averaged across a number of cycle types.	Total Energy = Tested Energy + Cold Water Correction + Hot Water Correction, Average of 5 cycles	Test procedure does not specify energy consumption measurements
Energy efficiency	Model energy consumption divided by the declared load capacity.	Modified Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle (ft^3/kWh/cycle)	Total Energy of model divided by rated load (kWh/cycle/kg).	
Water consumption	Complete cycle of warm or cold wash, Label: Annual water consumption	WF: quotient: total weighted per-cycle water consumption / capacity clothes	Complete volume of water used during energy consumption test (litres). Average of 5 cycles	

		washer. Total weighted per-cycle water consumption: variable depending on washer unit type, water and temperature control typically averaged across a number of cycle types.		
Wash quality rating (cleaning performance)	Soil removal value (%), not measured in cold test.	No wash performance test	Soiled test strips, Ratio of average reflectance measured (compared with reference unit). At least 5 cycles from series.	Test procedure is intended to measure wash performance in terms of reflectance ratios and spin extraction performance or the remaining moisture of the laundry after the wash cycle.
Rinse efficiency / quality	PBIS method (chemical marker), not measured under cold test.		Based on alkalinity of detergent in base load following normal cycle. Value of 2-5 cycles (1st cycle after normalising not to be used)	
Spin efficiency	Water extraction index, (bone dry mass as 0% moisture content), not measured in the	Typically: (Weight of Test Load After Cycle - Weight of	Moisture remaining in base load after spinning relative to the conditioned	Spin extraction and washing performance requirements

	cold test.	Bone Dry Test Load)/Weight of Bone Dry Test Load x 100, with slight modifications depending on unit type and wash temperatures. Maximum Load Capacity is required. (Bone-dry condition defined in the standard).	mass of the same load. (Mass of Base Load after Spin - Mass of conditioned base load)/Mass of conditioned base load. Average of at least 5 cycles. Based on normalised mass as 0% which is about 7% moisture based on bone dry mass.	
Cold intake (wash) temperature	20°C (± 2K)	If electrical energy consumption and water energy consumption are not affected by the inlet water temperature: cold water supply shall be maintained at 15.6 °C±2.8 °C, else temperature of the cold water supply at the water inlets shall not exceed 15.6 °C.	Cold Water: 15°C +/-2°C	
Hot water intake	60°C (± 2K)	If electrical energy consumption and water energy consumption are not affected by the	Hot Water (for use in units without heating elements): 60°C +/-2°C (or as directed by manufacturer)	

		inlet water temperature: hot water supply shall be main-tained at 57.2°C±2.8°C, else tempera-ture of the hot water supply at the water inlets shall not exceed 57.2°C.		
Wash cycle time	Program time in minutes (defined differently)			
Exemplary Energy Labels based on the different test stand-ards	 	  	  	

Source: IEA-4E 2011A, Fridley et al. 2010

Generally, European, African and most Asian countries including China, Russia as well as many newly industrialising countries, such as Thailand, tend to align their national test standards for appliances with those of ISO, with mostly minor modifications. The national test standards for Japan, Korea, India, Chinese Taipei, Australia and New Zealand, the Philippines and Sri Lanka are also often aligned with ISO / IEC but some significant differences exist for certain products. In the Americas, the United States uses its own test procedures, which are occasionally aligned to ISO / IEC tests. Canada and Mexico are essentially aligned with the United States regarding test standards. Most South American countries, including Brazil, use ISO / IEC test procedures but some (e.g. Venezuela) use variations of US test procedures (OECD 2006A).

3 Why different test standards?

Efficiency standards and labels are based on energy and water consumption values obtained from test standards. Because of differences within and between countries (e.g. due to traditional washing habits or customary garments) and the varying washing machine technologies, specifically adapted regional test standards are used. Consequently, it can be very hard or even impossible to compare the energy and water consumption values obtained from different test standards. In North America, for example, clothes are washed in warm or hot water, which is provided to the washing machines by distinct external appliances. By contrast, most washing machines in Europe use ambient-temperature water from the tap and heat it up using integrated electric heating rods. In Japan people tend to wash their clothes in cold water or residual water from a bath (OECD 2006A).

Furthermore, user- and situation specific factors, such as chosen washing temperature, size of the wash load and the respective washing water level account for differences between test conditions and reality. Hence, the energy consumption assigned through testing is only a rough indicator of the actual energy consumption of a particular unit. For that reason, test standards should adopt test conditions, which reflect the existing in-field conditions to a reasonable extent, as well as procedures, which account for the effects of user behaviour on energy and water consumption (OECD 2006A).

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