



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



	20°C.	and tempera-	the manufactur-	air humidity)
	20 C.	ture control),	er's instructions.	all Hullialty)
		•		
		Typical tests:	At least 5 com-	
		(adjusted)	plete cycles.	
		average of a		
		combination		
		of tempera-		
		tures.		
Energy consumption	Energy Consump-	(Adjusted)	Total Energy =	Test proce-
	tion (Full pro-	sum of elec-	Tested Energy +	dure does not
	, , ,			
	gramme cycle	trical energy	Cold Water Cor-	specify ener-
	declared by	consumption,	rection + Hot	gy consump-
	manufacturer as	the hot water	Water Correc-	tion meas-
	"warm wash" in-	energy con-	tion,	urements
	cluding energy	sumption and	Average of 5	
	embodied in ex-	the energy	cycles	
			Cycles	
	ternal hot water if	required for		
	not self-heated	removal of		
	(Unit: kWh/load).	the remaining		
	Annual energy	moisture in		
	consumption incl.	the wash		
	Power consumed			
		load,		
	in "Off mode" and			
	"end of cycle"	Typically		
	mode.	averaged		
	Identical for the	across a		
	declared "cold	number of		
		cycle types.		
	'	Cycle types.		
	gramme.	AA DC I	T	
Energy efficiency	Model energy	Modified	Total Energy of	
	9,		= -	
	consumption di-	Energy Factor	model divided	
	9,		= -	
	consumption di-	Energy Factor	model divided	
	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quo- tient: capacity	model divided by rated load	
	consumption di- vided by the de-	Energy Factor (MEF), quo- tient: capacity clothes con-	model divided by rated load	
	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quo- tient: capacity clothes con- tainer divided	model divided by rated load	
	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quo- tient: capacity clothes con- tainer divided by the total	model divided by rated load	
	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quo- tient: capacity clothes con- tainer divided	model divided by rated load	
	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quo- tient: capacity clothes con- tainer divided by the total	model divided by rated load	
	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quo- tient: capacity clothes con- tainer divided by the total energy con-	model divided by rated load	
	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per	model divided by rated load	
Water consumption	consumption di- vided by the de- clared load capac-	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle	model divided by rated load	
Water consumption	consumption divided by the declared load capacity.	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle (ft³/kWh/cycle) WF: quotient:	model divided by rated load (kWh/cycle/kg). Complete vol-	
Water consumption	consumption divided by the declared load capacity. Complete cycle of warm or cold	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle (ft³/kWh/cycle) WF: quotient: total	model divided by rated load (kWh/cycle/kg). Complete volume of water	
Water consumption	consumption divided by the declared load capacity. Complete cycle of warm or cold wash, Label: An-	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle (ft³/kWh/cycle) WF: quotient: total weighted per-	model divided by rated load (kWh/cycle/kg). Complete volume of water used during	
Water consumption	consumption divided by the declared load capacity. Complete cycle of warm or cold	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle (ft³/kWh/cycle) WF: quotient: total weighted per- cycle water	model divided by rated load (kWh/cycle/kg). Complete volume of water	
Water consumption	consumption divided by the declared load capacity. Complete cycle of warm or cold wash, Label: An-	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle (ft³/kWh/cycle) WF: quotient: total weighted per-	model divided by rated load (kWh/cycle/kg). Complete volume of water used during	
Water consumption	consumption divided by the declared load capacity. Complete cycle of warm or cold wash, Label: Annual water con-	Energy Factor (MEF), quotient: capacity clothes container divided by the total energy consumption per cycle (ft³/kWh/cycle) WF: quotient: total weighted per- cycle water	model divided by rated load (kWh/cycle/kg). Complete volume of water used during energy con-	



			T	1
		washer.		
		Total		
		weighted per-		
		cycle water		
		consumption:		
		variable de-		
		pending on		
		washer unit		
		type, water		
		·		
		and tempera-		
		ture control		
		typically av-		
		eraged		
		across a		
		number of		
		cycle types.		
Wash quality rating	Soil removal value	No wash	Soiled test strips,	Test proce-
(cleaning perfor-	(%), not measured	performance	Ratio of average	dure is in-
mance)	in cold test.	test	reflectance	tended to
,			measured (com-	measure
			pared with refer-	wash perfor-
			1 '	
			ence unit). At	mance in
			least 5 cycles	terms of re-
			from series.	flectance
				ratios and
				spin extrac-
				tion perfor-
				mance or the
				remaining
				moisture of
				the laundry
				after the wash
				cycle.
Rinse efficiency /	PBIS method		Based on alkalin-	cycle.
quality	(chemical marker),		ity of detergent	
	not measured		in base load	
	under cold test.		following normal	
			cycle. Value of	
			2-5 cycles (1st	
			cycle after nor-	
			malising not to	
			be used)	
Spin efficiency	Water extraction	Typically:	Moisture remain-	Spin extrac-
· •	index, (bone dry	(Weight of	ing in base load	tion and
	mass as 0% mois-	Test Load	after spinning	washing per-
	ture content), not	After Cycle -	relative to the	formance
	measured in the	Weight of	conditioned	requirements



Test Load X (Mass of Base Load after Spin - Mass of Conditional Sight modifications despending on unit type and wash temperature. Cold Intake (wash) temperature 20°C (1.2K) Cold Intake (wash) temperature Cold water supply shall be maintained at 15.6 "C±2.8 "C, else temperature cold water supply shall be maintained at 15.6 "C±2.8 "C, else temperature cold water supply shall be maintained at 15.6 "C±2.8 "C, else temperature cold water supply at the water inlets shall not exceed 15.6 "C. Hot water intake 60°C (±2K) File electrical energy consumption are not affered by the interest of the cold water supply at the water inlets shall not exceed 15.6 "C. Hot water intake For C (±2K) File electrical energy consumption and water energy consumption are not affered at 15.6 "C. Else temperature cold water supply at the water inlets shall not exceed 15.6 "C. For C (±2K) File electrical energy consumption and water energy consumption and energy consumption are not affered by the maintained at 5.6 "C. Flot water intake energy consumption are not affered by the maintained at 6.0"C. Flot water intake energy consumption are not affered by the maintained at 6.0"C. Flot water intake energy consumption are not affered by the maintained at 6.0"C.		cold test.	Bone Dry	mass of the	
Load)Weight of Bone Dry Test Load x 100, with 100 with 100 base 10ad after Spin - 100, with 100 with 100 base 10ad)Mass of conditioned 10adyMass o		cold test.	-		
of Bone Dry Test Load x 100, with slight modifications de- pending on unit type and wash temper- atures. Maxi- mum Load Capacity is required. Based on nor- malised mass as Capacity is required. Cold intake (wash) temperature 20°C (± 2K) If electrical energy consumption are not af- fected by the inlet water temperature: Cold water supply shall be main- tained at 15.6 °C:12.8 °C, else tempera- ture of the cold water supply at the water inlets shall not ex- ceed 15.6 °C. Hot water intake 60°C (+ 2K) If electrical energy con- sumption and water energy consumption are not af- fected by the inlet water temperature: cold water supply shall be main- tained at 15.6 °C:12.8 °C, else tempera- ture of the cold water supply at the water inlets shall not ex- ceed 15.6 °C. Hot Water (for use in units without heating energy con- sumption and water energy elements; 60°C consumption are not af- directed by the directed by the directed by elements; 60°C consumption are not af- directed by directed by elements; 60°C consumption are not af- directed by					
Test Load x 100, with tioned base slight modifications depending on base load, wash temperatures. Maximum Load Capacity is of which is required. (Bone-dry condition bone dry mass.) (Bone-dry ture based on condition bone dry mass.) (Bone-dry ture based on condition bone dry mass.) (Bone-dry ture based on bone dry mass.) (Bone-dry ture based on bone dry mass.) (Bone-dry ture based on condition bone dry mass.) (Bone-dry ture based on conditioned water energy consumption are not affected by the inlet water temperature: cold water supply shall be main-tained at 15.6 "C±2.8 "C, else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply at the water inlets shall not exceed 15.6 "C. else temperature of the cold water supply shall be main-ture				•	
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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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bigEE is an international initiative of research institutes for technical and policy advice and public agencies in the field of energy and climate, co-ordinated by the Wuppertal Institute (Germany). Its aim is to develop the international web-based knowledge platform **bigee.net** for energy efficiency in buildings, building-related technologies, and appliances in the world's main climatic zones.

The bigee.net platform informs users about energy efficiency options and savings potentials, net benefits and how policy can support achieving those savings. Targeted information is paired with recommendations and examples of good practice.

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