Commission communication in the framework of the implementation of Commission Regulation (EU) No 814/2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks and of Commission Delegated Regulation (EU) No 812/2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device

(2014/C 207/03)

1. Publication of titles and references of transitional methods of measurement and calculation [1] for the implementation of Regulation (EU) No 814/2013, and in particular Annexes III, IV and V thereof, and for the implementation of Delegated Regulation (EU) No 812/2013, and in particular Annexes VII, VIII and IX thereof.

2. Parameters *in italics* are determined in Regulation (EU) No 814/2013 and in Delegated Regulation (EU) No 812/2013.

3. References

Measured/calculated parameter	Organisation	Reference	Title
Test procedure for A_{sol}, *IAM* and additional elements of collector efficiency testing of parameters η_0, a_1, a_2, *IAM*	CEN	EN 12975-2:2006	Thermal solar systems and components — Solar collectors — Part 2: Test methods
Sound power level of heat pump water heaters	CEN	EN 12102:2013	Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling — Measurement of airborne noise — Determination of the sound power. The standard EN12102:2013 is applicable with the following modifications: Clause 3.3 of EN12102:2013. Replace the 2nd paragraph by: The 'standard operating conditions' shall be defined as the conditions for the operating points of the unit in accordance with Regulation (EU) No 814/2013, Annex III, Table 4. The definitions given in EN16147 also apply. Clause 5: Replace the 2nd paragraph 'The unit …' by: The unit shall be installed and connected (e.g. shape and dimension of air ducts, water pipes connection, etc.) for the test as recommended by the manufacturer in its installation and operation manual and tested in the rated conditions indicated in Regulation (EU) No 814/2013, Annex III, Table 4. The accessories provided by option (e. g. heating element) shall not be included in the test.

[1] It is intended that these transitional methods will ultimately be replaced by harmonised standard(s). When available, reference(s) to the harmonised standard(s) will be published in the *Official Journal of the European Union* in accordance with Articles 9 and 10 of Directive 2009/125/EC.

Measured/calculated parameter	Organisation	Reference	Title
			The unit is kept at ambient conditions of operation for at least 12 h; The temp. at the top of the tank of the water heater is monitored; The electric consumption of the compressor, the fan (if present), the circulation pump (if present), are monitored (to know the period of defrosting). The product is filled with cold water at 10 °C ± 5 °C. Clause 5: Replace the 4th paragraph 'The noise measurement …' by: The measurement points shall be performed in steady state conditions at the following water temperatures at the top of the tank: 1st point at 25 ± 3 °C, 2nd point at (Tset+25)/2 ± 3 °C, 3rd point at Tset +0/- 6 °C (Tset is water temperature in 'out of the box-mode'). During the measurement of noise: the water temp. at the top of the tank should be included in the tolerance range (e.g. included between 25 °C ± 3 °C for the first measurement); the periods of defrosting are excluded (zero electric consumption of the compressor, the fan or the circulation's pump).
Sound power level of gas-fired instantaneous and storage water heaters	CEN	EN 15036-1:2006	Heating boilers. Test regulations for airborne noise emissions from heat generators. Airborne noise emissions from heat generators
		ISO EN 3741:2010	Acoustics — Determination of Sound Power Levels of Noise Sources Using Sound Pressure — Precision Methods for Reverberation Room
		ISO EN 3745:2012	Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Precision methods for anechoic rooms and hemi-anechoic rooms
Sound power level of electric instantaneous and storage water heaters	Cenelec	Considering that no procedure is available for the time being it is assumed that water heaters without moving parts have a noise of 15 dB	

Measured/calculated parameter	Organisation	Reference	Title
Test gases	CEN	EN 437:2003/A1:2009	Test gases — Test pressures — Appliance categories
Standby power consumption solsb	CLC	EN 62301:2005	Household Electrical Appliances: Measurement of standby power
Test-rig for Q_{elec} of electric storage water heaters	CLC	prEN 50440:2014	Efficiency of domestic electrical storage water heaters and testing methods
Test-rig for Q_{elec} of electric instantaneous water heaters	CLC	EN 50193-1:2013	Closed electrical instantaneous water heaters, Methods for measuring performance.
Test-rig for Q_{fuel} and Q_{elec} of gas-fired instantaneous water heaters	CEN	EN 26:1997/A3:2006, Clause 7.1, except clause 7.1.5.4.	Gas-fired instantaneous water heaters for sanitary uses production, fitted with atmospheric burners
Test-rig for Q_{fuel} and Q_{elec} of gas-fired storage water heaters	CEN	EN 89:1999/A4:2006, Clause 7.1, except clause 7.1.5.4.	Gas-fired storage water heaters for the production of domestic hot water
Test-preparation for Q_{fuel} of gas-fired instantaneous water heaters and gas-fired storage water heaters	CEN	EN 13203-2: 2006, Annex B 'Test rig and measurement devices'	Gas-fired domestic appliances producing hot water — Appliances not exceeding 70 kW heat input and 300 litres water storage capacity — Part 2: Assessment of energy consumption
Test-preparation for Q_{fuel} of heat pump water heaters using fuel	CEN	EN 13203-2: 2006, Annex B 'Test rig and measurement devices'	Gas-fired domestic appliances producing hot water — Appliances not exceeding 70 kW heat input and 300 litres water storage capacity — Part 2: Assessment of energy consumption
Test-rig for heat pump water heaters	CEN	EN 16147:2011	Heat pumps with electrically driven compressors — Testing and requirements for marking for domestic hot water units
Standing loss *S* of storage tanks	CEN	EN 12897: 2006, clause 6.2.7, Annex B and Annex A (for the correct positioning of the heater)	Water Supply – Specification for indirectly heated unvented (closed) storage water heaters.

Measured/calculated parameter	Organisation	Reference	Title
Standing loss *S* and psbsol of storage tanks	CEN	EN 12977-3:2012	Thermal solar systems and components — Custom built systems — Part 3: Performance test methods for solar water heater stores
Standing loss *S* of storage tanks	CEN	EN 15332:2007, Clauses 5.1 and 5.4 (Measurement of standby-loss).	Heating boilers – Energy assessment of hot water storage tanks
Standing loss *S* of storage tanks	CLC	EN 60379: 2004, clauses 9, 10, 11, 12 and 14	Methods for measuring the performance of electric storage water-heaters for household purposes
Emission of nitrogen oxides NO_x for gas-fired storage water heaters	CEN	prEN 89:2012, clause 6.18 Nitrogen oxides	Gas-fired storage water heaters for the production of domestic hot water
Emission of nitrogen oxides NO_x for gas-fired instantaneous water heaters	CEN	prEN 26, clause 6.9.3 Nitrogen oxides emissions	Gas-fired instantaneous water heaters for the production of domestic hot water
Water heating energy efficiency η_{wh} of water heaters and standing loss *S* of storage tanks	European Commission	Point 4 of this Communication	Additional elements for measurements and calculations related to the energy efficiency of water heaters and storage tanks

4. Additional elements for measurements and calculations related to the energy efficiency of water heaters and storage tanks

For the purpose of Delegated Regulation (EU) No 812/2013 and Regulation (EU) No 814/2013 each water heater shall be tested in the 'out of the box-mode'.

The 'out of the box-mode' is the standard operating condition, setting or mode set by the manufacturer at factory level, to be active immediately after the appliance installation, suitable for normal use by the end-user according to the water tapping pattern for which the product has been designed and placed on the market. Any change to a different operating condition, setting or mode, if applicable, shall be the result of an intentional intervention by the end-user, and cannot be automatically modified by the water heater at any time, except for smart control function adapting the water heating process to individual usage conditions with the aim of reducing energy consumption.

In case of combination water heaters, no weighting factors taking into account differences between summer and winter mode shall be considered for the measurement/calculation of Q_{elec} and Q_{fuel}.

In case of conventional water heaters using fuels, in the calculation formula for the Annual Electricity Consumption (AEC) only (see Delegated Regulation (EU) No 812/2013, Annex VIII, point 4.a), the ambient correction Q_{cor} is set equal to zero.

4.1. Definitions

— 'uncertainty of measurement (accuracy)' is the precision with which an instrument or a chain of instruments is capable to represent an actual value as established by a highly-calibrated measurement reference;

— 'permissible deviation (average over test period)' is the maximum difference, negatively or positively, allowed between a measured parameter, averaged over the test period, and a set value;

— 'permissible deviations of individual measured values from average values' is the maximum difference, negatively or positively, allowed between a measured parameter and the average value of that parameter over the test period;

4.2. Energy inputs

(a) Electricity and fossil fuels

Measured parameter	Unit	Value	Permissible deviation (average over test period)	Uncertainty of measurement (accuracy)
Electricity				
Power	W			± 2 %
Energy	kWh			± 2 %
Voltage, test-period > 48 h	V	230/400	± 4 %	± 0,5 %
Voltage, test-period < 48 h	V	230/400	± 4 %	± 0,5 %
Voltage, test-period < 1 h	V	230/400	± 4 %	± 0,5 %
Electric current	A			± 0,5 %
Frequency	Hz	50	± 1 %	
Gas				
Types	—	Test gases EN 437		
Net calorific value (NCV) and Gross calorific value (GCV)	MJ/m^3	Test gases EN 437		± 1 %
Temperature	K	288,15		± 0,5
Pressure	mbar	1 013,25		± 1 %
Density	dm^3/kg			± 0,5 %
Flow rate	m^3/s or l/min			± 1 %
Oil				
Heating gas oil				
Composition, Carbon/Hydrogen/Sulphur	kg/kg	86/13,6/0,2 %		
N-fraction	mg/kg	140	± 70	

Measured parameter	Unit	Value	Permissible deviation (average over test period)	Uncertainty of measurement (accuracy)
Net calorific value (NCV, Hi)	MJ/kg	42,689 (**)		
Gross calorific value (*GCV*, Hs)	MJ/kg	45,55		
Density ρ15 at 15 °C	kg/dm³	0,85		
Kerosene				
composition, Carbon/Hydrogen/ Sulfur	kg/kg	85/14,1/0,4 %		
Net calorific value (NCV, Hi)	MJ/kg	43,3 (**)		
Gross calorific value (*GCV*, Hs)	MJ/kg	46,2		
density ρ15 at 15 °C	kg/dm³	0,79		

Notes:
(**) Default value, if value is not determined calorimetrically. Alternatively, if volumetric mass and sulphur content are known (e.g. by basic analysis) the net heating value (Hi) may be determined with:
$Hi = 52{,}92 - (11{,}93 \times \rho 15) - (0{,}3 - S)$ in MJ/kg

(b) Solar energy for solar collector tests

Measured parameter	Unit	Value	Permissible deviation (average over test period)	Uncertainty of measurement (accuracy)
Test solar irradiance (global G, short wave)	W/m²	> 700 W/m²	± 50 W/m² (test)	± 10 W/m² (indoors)
Diffuse solar irradiance (fraction of total G)	%	< 30 %		
Thermal irradiance variation (indoors)	W/m²			± 10 W/m²
Fluid temperature at collector inlet/outlet	°C/K	range 0– 99 °C	± 0,1 K	± 0,1 K
Fluid temperature difference inlet/ outlet				± 0,05 K
Incidence angle (to normal)	°	< 20°	± 2 % (< 20°)	
Air speed parallel to collector	m/s	3 ± 1 m/s		0,5 m/s
Fluid flow rate (also for simulator)	kg/s	0,02 kg/s per m² collector aperture area	± 10 % between tests	
Pipe heat loss of loop in test	W/K	< 0,2 W/K		

(c) Ambient heat energy

Measured parameter	Unit	Permissible deviation (average over test period)	Permissible deviations (individual tests)	Uncertainty of measurement (accuracy)
Brine or water heat source				
Water/brine inlet temperature	°C	± 0,2	± 0,5	± 0,1
Volume flow	m^3/s or l/min	± 2 %	± 5 %	± 2 %
Static pressure difference	Pa	—	± 10 %	± 5 Pa/5 %
Air heat source				
Outdoor air temperature (dry bulb) T_j	°C	± 0,3	± 1	± 0,2
Vent exhaust air temperature	°C	± 0,3	± 1	± 0,2
Indoor air temperature	°C	± 0,3	± 1	± 0,2
Volume flow	dm^3/s	± 5 %	± 10 %	± 5 %
Static pressure difference	Pa	—	± 10 %	± 5 Pa/5 %

(d) Test conditions and tolerances on outputs

Measured parameter	Unit	Value	Permissible deviation (average over test period)	Permissible deviations (individual tests)	Uncertainty of measurement (accuracy)
Ambient					
Ambient temperature indoors	°C or K	20 °C	± 1 K	± 2 K	± 1 K
Air speed heat pump (at water heater off)	m/s	< 1,5 m/s			
Air speed other	m/s	< 0,5 m/s			
Sanitary water					
Cold water temperature solar	°C or K	10 °C	± 1 K	± 2 K	± 0,2 K
Cold water temperature other	°C or K	10 °C	± 1 K	± 2 K	± 0,2 K
Cold water pressure gas-fired water heaters	bar	2 bar		± 0,1 bar	

Measured parameter	Unit	Value	Permissible deviation (average over test period)	Permissible deviations (individual tests)	Uncertainty of measurement (accuracy)
Cold water pressure other (except electric instantaneous water heaters)	bar	3 bar			± 5 %
Hot water temperature gas-fired water heaters	°C or K				± 0,5 K
Hot water temperature electric instantaneous	°C or K				± 1 K
Water temperature (in-/outlet) other	°C or K				± 0,5 K
Volume flow rate heat pump water heaters	dm^3/s		± 5 %	± 10 %	± 2 %
Volume flow rate Electric Instantaneous Water Heaters	dm^3/s				≥10 l/min: ± 1 % < 10 l/min: ± 0,1 l/min
Volume flow rate other water heaters	dm^3/s				± 1 %

4.3. Test procedure for storage water heaters

The test procedure for storage water heaters to establish the daily electricity consumption Q_{elec} and the daily fuel consumption Q_{fuel} fuel during a 24-hour measurement cycle is the following:

(a) Installation

The product is installed in test environment according to manufacturer's instructions. Designated floor-standing appliances may be placed on the floor, on a stand supplied with the product, or on a platform for easy access. Wall-mounted products are mounted on a panel at least 150 mm from any structural wall with a free space of at least 250 mm above and below the product and at least 700 mm to the sides. Products designated to be built-in are mounted according to manufacturer's instructions. The product is shielded from direct solar radiation, except solar collectors.

(b) Stabilisation

The product is kept at ambient conditions until all parts of the product have reached ambient conditions ± 2 K, at least 24 hours for storage type products.

(c) Filling and heat-up

The product is filled with cold water. Filling stops at the applicable cold water pressure.

The product is energized in 'out of the box-mode' to reach its operating temperature, controlled by the product's own means of control (thermostat).The next stage starts at thermostat cut out.

(d) Stabilisation at zero-load

The product is kept at this condition, without draw-offs during at least 12 hours.

Subject to a control cycle this stage ends — and next stage starts — at the first thermostat cut-out after 12 hours.

During this stage the total fuel consumption in kWh in terms of *GCV*, the total electricity consumption in kWh in terms of final energy and the exact time elapsed in h are recorded.

(e) Water draw-offs

For the declared *load profile*, draw-offs are made in accordance with the specifications of the appropriate 24 h tapping pattern. This stage starts directly after thermostat cut out from stabilisation part with the first tapping at the time-value according to the appropriate tapping load profile (see Regulation (EU) No 814/2013, Annex III point 2 and Delegated Regulation (EU) No 812/2013, Annex VII point (2). From end of last water draw-off until 24:00, no water is tapped.

During the water draw-offs relevant technical parameters (power, temperature, etc.) are established. For dynamic parameters the overall sample rate is 60 s or less. During draw-offs the recommended sample rate is 5 s or less.

The fossil fuel and electricity consumption over the 24-hour measurement cycle, $Q_{testfuel}$ and $Q_{testelec}$, are corrected as specified in point (h).

(f) Re-stabilisation at zero-load

The product is kept at nominal operating conditions without draw-offs during at least 12 hours.

Subject to a control cycle this stage ends at the first thermostat cut-out after 12 hours.

During this stage the total fuel consumption in kWh in terms of *GCV*, the total electricity consumption in kWh final energy and the exact time elapsed in hours are recorded.

(g) Mixed water at 40 °C (V40)

Mixed water at 40 °C (V40) is the quantity of water at 40 °C, which has the same heat content (enthalpy) as the hot water which is delivered above 40 °C at the output of the water heater, expressed in litres.

Immediately following measurement according to point (f) a quantity of water is withdrawn through the outlet by supplying cold water. The flow of water from open outlet water heaters is controlled by the inlet valve. The flow in any other type of water heaters is controlled by means of a valve fitted in the outlet or the inlet. The measurement is ended when the outlet temperature drops below 40 °C.

The rate of flow is adjusted to the maximum value according to the declared load profile

The normalised value of the average temperature is calculated according to the following equation:

$$\vartheta_p[°C] = (T_{set} - 10) \times \frac{(\vartheta'_p - \vartheta_c)}{(T_{set} - \vartheta_c)} + 10$$

Where:

— T_{set} in °C is the water temperature, without withdrawal of water, measured with a thermocouple placed inside the upper section of the tank. For metal tanks the thermocouple may be placed on the outer surface of the tank as well. This value is the water temperature measured after the last cut-out of the thermostat during the step set out in point (f),

— ϑc in °C is the average temperature of inlet cold water during the test,

— ϑ'p in °C is the average temperature of outlet water and its normalized value is named ϑp in °C.

Temperature readings are preferable taken continuously. Alternatively, they may be taken at equal intervals evenly spread over the discharge, for example every 5 litres (maximum). If there is a sharp drop in temperature, additional readings may be necessary in order to correctly calculate the average value ϑ'p.

Outlet water temperature is always ≥ 40 °C which is to be taken into account for the calculation of ϑp.

Quantity of hot water V_{40} in litres delivered with a temperature of at least 40 °C will be calculated by the following equation:

$$V_{40}[litres] = V_{40exp} \times \frac{(\vartheta_p - 10)}{30}$$

Where:

— the volume V_{40_exp} in litres corresponds to the quantity of water delivered at least 40 °C.

(h) Reporting of Q_{fuel} and Q_{elec}

$Q_{testfuel}$ and $Q_{testelec}$ are corrected for any energy surplus or deficit outside the strict 24-hour measurement cycle, i.e. a possible energy difference before and after is taken into account. Furthermore, any surplus or deficit in the delivered useful energy content of the hot water is taken into account in the following equations for Q_{fuel} and Q_{elec}:

$$Q_{fuel} = \left(\frac{Q_{ref}}{Q_{H_2O}}\right) \times \left\{Q_{test\,fuel} + \frac{1{,}163 \times C_{act} \times (T_3(t_3) - T_5(t_5))}{1000}\right\}$$

$$Q_{elec} = \left(\frac{Q_{ref}}{Q_{H_2O}}\right) \times \left\{Q_{testelec} + \frac{1{,}163 \times C_{act} \times (T_3(t_3) - T_5(t_5))}{1000}\right\}$$

Where:

— Q_{H_2O} in kWh is the useful energy content of the hot water drawn-off,

— T_3 and T_5 are water temperatures measured at the dome of water heater, respectively at the beginning (t_3) and at the end (t_5) of the 24 h measurement cycle.

— C_{act} in litres is the actual capacity of water heater. C_{act} is measured as stated in paragraph 4.5.c

4.4. Test procedure for fuel instantaneous water heaters

The test procedure for fuel instantaneous water heaters to establish the daily fuel consumption Q_{fuel} and the daily electricity consumption Q_{elec} during a 24-hour measurement cycle is the following:

(a) Installation

The product is installed in test environment according to manufacturer's instructions. Designated floor-standing appliances may be placed on the floor, on a stand supplied with the product, or on a platform for easy access. Wall-mounted products are mounted on a panel at least 150 mm from any structural wall with a free space of at least 250 mm above and below the product and at least 700 mm to the sides. Products designated to be built-in are mounted according to manufacturer's instructions. The product is shielded from direct solar radiation, except solar collectors.

(b) Stabilisation

The product is kept at ambient conditions until all parts of the product have reached ambient conditions ± 2 K;.

(c) Water draw-offs

For the declared *load profile*, draw-offs are made in accordance with the specifications of the appropriate 24 h tapping pattern. This stage starts directly after thermostat cut out from stabilisation part with the first tapping at the time-value according to the appropriate tapping load profile (see Regulation (EU) No 814/2013, Annex III point 2 and Delegated Regulation (EU) No 812/2013, Annex VII point (2). From end of last water draw-off until 24:00, no water is tapped

During the water draw-offs relevant technical parameters (power, temperature, etc.) are established. For dynamic parameters the overall sample rate is 60 s or less. During draw-offs the recommended sample rate is 5 s or less.

(d) Reporting of Q_{fuel} and Q_{elec}

$Q_{testfuel}$ and $Q_{testelec}$ shall be corrected in the following equations for Q_{fuel} and Q_{elec} by taking into account any surplus or deficit in the delivered useful energy content of the hot water.

$$Q_{fuel} = \left(\frac{Q_{ref}}{Q_{H_2O}} \right) \times Q_{test\,fuel}$$

$$Q_{elec} = \left(\frac{Q_{ref}}{Q_{H_2O}} \right) \times Q_{testelec}$$

Where:

— Q_{H_2O} in kWh is the useful energy content of the hot water drawn-off.

4.5. Test procedure for heat pump water heaters using electricity

(a) Installation

The product is installed in test environment according to manufacturer's instructions. Designated floor-standing appliances may be placed on the floor, on a stand supplied with the product, or on a platform for easy access. Wall-mounted products are mounted on a panel at least 150 mm from any structural wall with a free space of at least 250 mm above and below the product and at least 700 mm to the sides. Products designated to be built-in are mounted according to manufacturer's instructions.

Products with declared load profiles 3XL or 4XL may be tested on-site, provided test conditions are equivalent, possibly with correction factors, to the ones referenced here.

The installation requirements described in clauses 5.2, 5.4 and 5.5 of EN 16147 are respected.

(b) Stabilisation

The product is kept at ambient conditions until all parts of the product have reached ambient conditions ± 2 K (at least 24 h for storage heat pump water heater).

The purpose is to verify that the product is working at normal temperature after transport.

(c) Filling and storage volume (actual capacity C_{act})

The volume of the tank is measured as follows.

The empty water heater is to be weighted; the weight of taps on inlet and/or outlet pipes shall be considered.

Then the storage water heater is filled with cold water in accordance with the manufacturer's instruction at cold water pressure. The water supply is then cut off.

The filled water heater is to be weighted.

The difference of the two weights (m_{act}) is to be converted into the volume in litres (C_{act}).

$$C_{act} = \frac{m_{act}}{0,9997}$$

This volume is to be reported in litres to the nearest one-tenth litres. The measured value (C_{act}) shall not be more than 2 % lower than the rated value.

(d) Filling and heat-up

Products with storage-facilities are filled with cold water (10 ± 2 °C). Filling stops are at the applicable cold water pressure.

The product is energized to reach 'out of the box-mode' e.g. for storage temperature. The product's own means of control (thermostat) are used. The step is performed following the procedure of clause 6.3 of EN 16147. The next step starts at thermostat cut out.

(e) Standby power input

The standby power input is determined by measuring the electrical power input over an integral number of on-off cycles of the heat pump, initiated by the thermostat situated in the tank, when no hot water is drawn off.

The step is performed following the procedure of clause 6.4 of EN 16147 and the value of P_{stby} *[kW]* is determined as equal to

$$P_{stby}[kW] = CC \times P_{es}[kW]$$

(f) Water draw-offs

For the declared *load profile*, draw-offs are made in accordance with the specifications of the appropriate 24 h tapping pattern. This stage starts directly after thermostat cut out from stabilisation part with the first tapping at the time-value according to the appropriate tapping load profile (see Regulation (EU) No 814/2013, Annex III point 2 and Delegated Regulation (EU) No 812/2013, Annex VII point (2). From end of last water draw-off until 24:00, no water is tapped. The required useful energy content of the hot water is the total Q_{ref} [in kWh].

The step is performed following the procedure of clauses 6.5.2 to 6.5.3.5 of EN 16147. The $\Delta T_{desired}$ in the EN 16147 is defined using the value of T_p:

$\Delta T_{desired} = T_p - 10$

At the end of the step Q_{elec} [kWh] is determined as equal to

$$Q_{elec} = \frac{Q_{ref}}{Q_{TC}} \times W_{EL-TC}$$

W_{EL-TC} value is defined in the EN16147.

Products to be classified as off-peak products are energized for a maximum period of 8 consecutive hours between 22:00 and 07:00 of the 24 h tapping pattern. At the end of the 24 h tapping pattern the products are energized till the end of the step.

(g) Mixed water at 40 °C (V40)

The step is performed following the procedure of clause 6.6 of EN 16147, but avoiding compressor switching off at the end of the last measurement period for the tapping cycles; the value of *V40 [L]* is determined as equal to Vmax.

4.6. Test procedure for electric instantaneous water heaters

Thermal losses from heat transfer processes during operation and standby losses are neglected.

(a) Set points

User adjustable selectors are set as follows:

— If the appliance has a power selector, the selector shall be adjusted to the highest value.

— If the appliance has a flow independent temperature selector, the selector shall be adjusted to the highest value.

All non-user adjustable setpoints and other selectors shall be in the 'out of the box-mode'.

The prescribed minimum flow rate f_i of each individual draw off i of the tapping profile has to be used as defined in load profiles of water heaters. If the minimum flow rate f_i is not achievable, the flow rate is increased until the appliance is switching on and is able to run continuously at or above T_m. This increased flow rate has to be used for the individual draw off instead of the prescribed minimum flow rate f_i.

(b) Static efficiency

The static loss of the appliance P_{loss} at nominal load P_{nom} under steady state conditions is determined. The value of P_{loss} is the sum of all internal power losses (product of current and voltage losses between the terminals and heating elements) of the appliance after a minimum of 30 minutes of operation at nominal conditions.

This test result is in wide ranges independent from the water inlet temperature. This test can be carried out with a cold water inlet temperature in the range of 10 to 25 °C.

For electronically controlled instantaneous water heaters with semiconductor power switches, the voltage across the semiconductor power terminals is subtracted from the measured voltage losses, if the semiconductor power switches are thermally connected to the water. In this case, the heat developed by the semiconductor power switches is transferred to useful energy to heat up the water.

The static efficiency is calculated as:

$$\eta_{static} = \frac{P_{nom} - P_{loss}}{P_{nom}}$$

Where:

— η_{static} is the static efficiency factor of the appliance,

— P_{nom} is the nominal power consumption of the product in kW,

— P_{loss} are the measured internal static losses of the product in kW.

(c) Start up losses

This test determines the time $t_{start\ i}$ which elapses between energizing the heating elements and the delivery of useable water for each draw off of the declared load profile. The test method assumes that the power consumption of the appliance during the start-up period is equal to the power consumed in static mode. $P_{static\ i}$ is the static power consumption in steady state conditions of the appliance for the specific draw off *i*.

Three measurements are done for each different draw off *i*. The result is the mean value from these three measurements.

The start up losses $Q_{start\ i}$ are calculated as:

$$Q_{start_i} = P_{static_i} \times \frac{t_{start_i}}{3600}$$

Where:

— $Q_{start\ i}$ are the start-up losses in *kWh* for a specific draw off *i*.

— $t_{start\ i}$ is the mean value of the measured start up times in sec for draw off *i*,

— $P_{static\ i}$ is the measured steady state power consumption in kW for specific draw off *i*,

(d) Calculation of energy demand

The daily energy demand Q_{elec} is the sum of losses and useful energy of all individual draw off *i* per day in kWh. The daily energy demand is calculated as:

$$Q_{elec} = \sum_{i=1}^{n} \left(Q_{start_i} + \frac{Q_{tap_i}}{\eta_{static}} \right)$$

Where:

— $Q_{start\ i}$ are the start-up losses for the specific draw off *i* in kWh,

— $Q_{tap\ i}$ is the predefined useful energy per draw off *i* in kWh,

— η_{static} is the static efficiency of the appliance.

4.7. Smart control test procedure for water heaters

Smart control factor SCF and of smart control compliance smart shall be determined according to Annex IV point 4 of Regulation (EU) No 814/2013 and Annex VIII point 5 of Delegated Regulation (EU) No 812/2013. The condition for testing the smart control compliance (*smart*) of water heaters are indicated in Annex III point 3 of Regulation (EU) No 814/2013 and Annex VII point 3 of Delegated Regulation (EU) No 812/2013.

The parameters for determining SCF shall be based on real measurements of the energy consumption with the smart control enabled and disabled.

'smart control disabled' means the state, when the smart is activated, where the smart control function of the water heater is in the learning period.

'smart control enabled' means the state, when the smart is activated, where the smart control function of the water heater is modulating the outlet temperature in order to save energy.

(a) Electric storage water heaters

For Electric storage water heaters use the test methodology described in prEN 50440:2014

(b) Heat pump water heaters

For HPs WH, SCF is defined using the test methodology proposed by TC59X/WG4, this procedure follows the requirements of prEN 50440:2014 (paragraph 9.2) and shall be applied in conjunction with EN 16147:2011.

In particular:

— the value of $Q_{testelec}^{reference}[i]$ will be determined following the procedure of the EN16147 paragraphs from. §6.5.2 to § 6.5.3.4 and the time length of test cycle (t_{TTC}) shall be equal to 24 h. The value of $Q_{testelec}^{reference}[i]$ is:

$$Q_{testelec}^{reference}[i] = W_{EL-HP-TC} + Q_{EL-TC}$$

where $W_{EL-HP-TC}$ and Q_{EL-TC} are defined in EN16147.

— the value of $Q_{H_2O}^{reference}[i]$ will be determined as equal to Q_{TC} [kWh] described in §6.5.2 of the EN 16147.

— the value of $Q_{testelec}^{smart}[i]$ will be determined following the procedure of the EN16147 paragraphs from. §6.5.2 to § 6.5.3.4 and the time length of test cycle (t_{TTC}) shall be equal to 24h The value of $Q_{testelec}^{smart}[i]$ is:

$$Q_{testelec}^{smart}[i] = W_{EL-HP-TC} + Q_{EL-TC}$$

where $W_{EL-HP-TC}$ and Q_{EL-TC} are defined in EN16147.

— the value of $Q_{H_2O}^{smart}[i]$ will be determined as equal to Q_{TC} [kWh] described in §6.5.2 of the EN 16147.

4.8. Solar water heaters and solar-only systems, testing and calculation methods

For the assessment of the annual non-solar heat contribution Q_{nonsol} in kWh in terms of primary energy and/or kWh in terms of *GCV* the following methods are applicable:

— The SOLCAL method ([1])

— The SOLICS method ([2])

The SOLCAL method requires that the efficiency parameters of the solar collector are assessed separately and that the overall system performance is determined on the basis of the non-solar heat contribution to the solar system and the specific efficiency of a stand-alone water heater.

(a) Solar collector testing

For solar collectors at least 4 × 4 tests apply, with 4 different collector inlet temperatures t_{in} evenly spaced over the operating range and 4 test samples per collector inlet temperature are measured to obtain test values for the water outlet temperature t_e, the ambient temperature t_a, the solar irradiance G and the measured collector efficiency at the test point η_{col}. If possible, one inlet temperature is selected with $t_m = t_a \pm 3$ K to obtain an accurate assessment of the zero-load efficiency $\eta_{0.}$ With fixed collector (no automatic tracking) and test conditions permitting, two test samples are done before solar noon and 2 after. Maximum temperature of the heat transfer fluid should be chosen so that it reflects the maximum of the collectors operating range and results in a temperature difference between the inlet and the outlet collector $\Delta T > 1{,}0$ K.

For the instantaneous collector efficiency η_{col} a continuous efficiency curve of the format as in the following equation is obtained by statistical curve fitting of the test point results, using the least square method:

$$\eta_{col} = \eta_0 - a_1 \times T^*_m - a_2 \times G\ (T^*_m)^2$$

Where:

— T^*_m is the reduced temperature difference in m^2KW^{-1}, with

$$T^*_m = (t_m - t_a)/G$$

Where:

— t_a is the ambient or surrounding air temperature;

— t_m is the mean temperature of the heat transfer fluid:

$$t_m = t_{in} + 0{,}5 \times \Delta T$$

Where:

— t_{in} is the collector inlet temperature;

— ΔT is temperature difference between fluid outlet and inlet ($=t_e - t_{in}$).

All tests are performed according to EN 12975-2, EN 12977-2 and EN 12977-3. Converting so-called quasi-dynamic model parameters to a steady-state reference case to arrive at the parameters above is permitted. The Incidence Angle Modifier *IAM* is determined in accordance with EN 12975-2, from a test at 50° incidence angle to the collector.

(b) SOLCAL method

The SOLCAL method requires

— The solar collector parameters A_{sol}, η_0, a_1, a_2 and *IAM*;

([1]) EN15316-4-3, B based method
([2]) ISO 9459-5 based method

— The nominal volume of the storage tank volume (Vnom) in litres, the volume of the non-solar heat storage (Vbu) in litres and the specific standing loss (psbsol) in W/K (K expresses the difference between store and ambient temperature);

— The auxiliary electricity consumption at stabilised operating conditions Q_{aux};

— The standby power consumption *solstandby*;

— The pump power consumption *solpump*, according to EN 16297-1:2012.

The calculation assumes default values for the specific insulation of the collector loop pipes (= 6 + 0,3 W/Km²) and the heat capacity of the heat exchanger (100×W/Km²). m² stands for the collector aperture area. Furthermore, it is assumed that the solar heat store periods are less than one month.

For the purpose of establishing the total energy efficiency performance of solar-only system and conventional water heater or of a solar water heater, the SOLCAL method determines the annual non-solar heat contribution Q_{nonsol} in kWh with

Q_{nonsol} = SUM ($Qnonsol_{tm}$) in kWh/a

Where:

— SUM ($Qnonsol_{tm}$) is the sum of the all monthly non-solar heat contribution of the conventional water heater or the conventional heat generator being part of a solar water heater; with

$Qnonsol_{tm} = Lwh_{tm} - LsolW_{tm} + psbSol \times Vbu/Vnom \times (60 - Ta) \times 0{,}732$

The monthly heat demand for the solar thermal system is defined as:

$Lwh_{tm} = 30{,}5 \times 0{,}6 \times (Q_{ref} + 1{,}09)$

Where:

— 0,6 represents a factor to calculate the average heat demand from the load profile;

— 1,09 represents the average distribution losses.

The following calculations are performed:

$LsolW1_{tm} = Lwh_{tm} \times (1{,}029 \times Y_{tm} - 0{,}065 \times X_{tm} - 0{,}245 \times Y_{tm}^2 + 0{,}0018 \times X_{tm}^2 + 0{,}0215 \times Y_{tm}^3)$

$LsolW_{tm} = LsolW1_{tm} - Qbuf_{tm}$

The minimum value of $LsolW_{tm}$ is 0 and the maximum value is $Lwh_{tm.}$

Where:

— $Qbuf_{tm}$ is the solar storage tank correction in kWh/month; with

$$Qbuf_{tm} = 0{,}732 \times Psbsol \times \left(\frac{Vnom - Vbu}{Vnom}\right) \times \left(10 + \frac{50 \times LsolW1_{tm}}{Lwh_{tm}} - Ta\right)$$

Where:

— 0,732 is a factor that takes into account the average monthly hours (24 × 30,5);

— Psbsol is the specific standing loss of the solar heat store in W/K as determined in accordance with point 4.8(a);

— Ta is the monthly average air temperature surrounding the heat store in °C; with

— T_a = 20 when the heat store is inside the building envelope;

— T_a = $Tout_{tm}$ when the heat store is outside the building envelope;

— $Tout_{tm}$ is the average daytime temperature in °C for average, colder and warmer climate conditions.

X_{tm} and Y_{tm} are aggregated coefficients:

$X_{tm} = A_{sol} \times (Ac + UL) \times etaloop \times (Trefw — Tout_{tm}) \times ccap \times 0{,}732/Lwh_{tm}$

The minimum value of X_{tm} is 0 and the maximum value is 18.

Where:

— $Ac = a_1 + a_2 \times 40$;

— $UL = (6 + 0{,}3 \times A_{sol})/A_{sol}$ is loop losses in W/(m²K);

— etaloop is loop efficiency with $etaloop = 1 - (\eta_0 \times a_1)/100$;

— $Trefw = 11{,}6 + 1{,}18 \times 40 + 3{,}86 \times Tcold - 1{,}32 \times Tout_{tm;}$

— Tcold is the cold water temperature, default 10 °C;

— $Tout_{tm}$ is the *average daytime temperature in °C for average, colder and warmer climate conditions*;

— ccap is storage coefficient with $ccap = (75 \times A_{sol}/Vsol)^{0{,}25}$;

— Vsol is the solar storage tank volume, as defined in EN 15316-4-3;

$Y_{tm} = A_{sol} \times IAM \times \eta_0 \times etaloop \times QsolM_{tm} \times 0{,}732/Lwh_{tm}$

The minimum value of Y_{tm} is 0 and the maximum value is 3.

Where:

— $QsolM_{tm}$ is the *average global solar irradiance in W/m² for average, colder and warmer climate conditions.*

The auxiliary electricity consumption Q_{aux} is calculated as follows:

$Q_{aux} = (solpump \times solhrs + solstandby \times 24 \times 365)/1000$

Where:

— solhrs is the number of active solar hours in h; with

— solhrs = 2 000 for solar water heaters.

(c) SOLICS Method

The SOLICS method is based on the test method described in ISO 9459-5:2007. The procedure to determine the solar output is referenced as follows:

— Terms and definitions according to ISO 9459-5:2007, chapter 3;

— Symbols, units and nomenclature according to ISO 9459-5:2007, chapter 4;

— The system is mounted according to ISO 9459-5:2007, paragraph 5.1;

— The test facility, instrumentation and sensor locations are according to ISO 9459-5:2007, chapter 5;

— The tests are performed according to ISO 9459-5:2007, chapter 6;

— Based on the test results the system parameters are identified according to ISO 9459-5:2007, chapter 7. The dynamic fitting algorithm and simulation model as described in ISO 9459-5:2007, Annex A, are used;

— The annual performance is calculated with the simulation model as described in ISO 9459-5:2007, Annex A, the identified parameters and the following settings:

— *Average daytime temperature in °C for average, colder and warmer climate conditions and average global solar irradiance in W/m² for average, colder and warmer climate conditions*;

— Hourly values for global solar irradiance according to an appropriate CEC test reference year;

— Mains water temperature: 10 °C;

— Ambient temperature of the store (buffer inside: 20 °C, buffer outside: ambient temperature);

— Auxiliary electricity consumption: by declaration;

— Auxiliary set temperature: by declaration and with a minimum value of 60 °C;

— Auxiliary heater time control: by declaration.

Annual heat demand: $0,6 \times 366 \times (Q_{ref} + 1,09)$

Where:

— 0,6 represents a factor to calculate the average heat demand from the load profile;

— 1,09 represents the average distribution losses.

The auxiliary electricity consumption Q_{aux} is calculated as follows:

$Q_{aux} = (solpump \times \text{solhrs} + solstandby \times 24 \times 365)/1000$

Where

— solhrs is the number of active solar hours in h; with

— solhrs = 2 000 for solar water heaters.

For the purpose of establishing the total energy efficiency performance of solar-only system and conventional water heater or of a solar water heater, the SOLICS method determines the annual non-solar heat contribution Q_{nonsol} in kWh in terms of primary energy and/or kWh in terms of *GCV* as follows:

— For solar-only systems:

$Q_{nonsol} = 0,6 \times 366 \times (Q_{ref} + 1,09) - QL$

Where:

— QL is the heat delivered by the solar heating system in kWh/a.

— For solar water heater:

$Q_{nonsol} = Q_{aux,net}$

Where:

— $Q_{aux,net}$ is the net non-solar energy demand in kWh/a.

4.9. Storage tank test procedures

(a) Standing loss

The standing loss *S* of storage tanks can be assessed using any of the methods referenced in point 3, including the standing loss of the solar storage tank psbsol. Where the measurement results from the applicable standards are expressed in kWh/24 hours, the result will be multiplied by (1 000/24) to arrive at values for *S* in W. For the specific standing loss – per degree of temperature difference between store and ambient — of solar storage tanks psbsol, the heat loss can be determined in W/K directly by using EN 12977-3 or it can be found indirectly by dividing the heat loss in W by 45 (Tstore = 65 °C, Tambient = 20 °C) to arrive at a value in W/K. Where the results of EN 12977-3, expressed in W/K, are used for the assessment of *S* they are multiplied by 45.

(b) Storage volume

The volume of the tank in a storage electric water heater is measured as stated in paragraph 4.5.c.

4.10. Solar pump power test procedure

The solar pump power is rated as the electrical consumption under nominal operating conditions. Start-up effects under 5 minutes are disregarded. Solar pumps that are continuously controlled, or controlled in at least three steps, are rated as 50 % of the rated electrical power of the solar pump.