ANNEX IV
on Eco-design implementing measures for dedicated water heaters.

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NOTICE

Note that Annex IV may contain parts that are not in harmonised standards approved by the European Commission. As soon as these standards are available, the European Commission will undertake to incorporate references to these standards into revisions of the Annex IV text, in as much as is legally feasible.

Content

1. DEFINITIONS

1.1. Product

- A **Product** in this document is a *Dedicated Water Heater*. Only Products using electricity and/or gaseous or liquid fossil fuels are in the scope of this regulation.
- A **Water Heater** is a device that is connected to a given external supply of sanitary water and is equipped to generate heat and transfer the heat to sanitary water at desired temperature levels, desired quantities, flow rates during desired intervals. A ***Dedicated*** Water Heater means that the Product has no other primary function.
- A **Heat Generator** is the part of the *Product* that accomodates a heat generation process as mentioned below:
  - combustion of gaseous and/or liquid fossil fuels
  - use of the Joule effect in electric resistance heating elements
  - capturing solar thermal energy
  - capturing ambient and/or waste heat, including but not limited to transformation processes to bring the heat to a higher exergy level (heat pump technology).

  The Product shall include one or more of the Heat Generators mentioned above. *Products* with multiple Heat Generators, including cascades of the same type of *Heat Generators*, are explicitly within the defintion of a Product.

  For the purpose of this regulation, all Products using as primary or secondary (back-up) heat generation process the combustion of gaseous or liquid fossil fuels the *Basic Product Type* shall be classified as **Gas Products** or **Oil Products** respectively. All other Products will be classified as **Electric Products**.[1]

  Products capturing solar, ambient and/or waste heat shall be referred to as **Renewable Products**; Products not including these processes are referred to as **Conventional Products.** Products (also) capturing solar solar heat are referred to as **Solar Products**. If the Products use ambient and/or waste heat as described above they will be referred to as **Heat Pump Products.**

  The characteristics of the Heat Generators and relevant input values for testing are given in section 3.
- The **primary function** of the Product is the capability to reach and maintain the supply of hot water at desired temperature levels, desired quantities and flow rates during desired intervals, subject to *specific ambient conditions*.
- ***Load Profile*** is a set of parameters, specifying the primary function in terms of output performance for testing purposes. The Load Profile specifies a 24h water tapping pattern to be used for testing with a cold water temperature of 10 ± 2 ºC **.** Per draw-off the following parameters are specified.
  - start time of draw-off, in time **h** [hh:mm] elapsed from the start of the tapping pattern
  - useful energy content of hot water to be achieved in the draw-off, **Qtap** [in kWh]
  - minimum flow rate, **f** [in l/min]
  - useful temperature of hot water from which counting of useful energy content starts, **Tm** [in ºC]
  - minimum (peak) temperature to be achieved during tapping, **Tp** [in ºC]

  The sum of Qtap for all individual draw-offs in the 24h pattern is denominated **Qref** [in kWh].

  Tests with a Load Profile are subject to **specific ambient conditions,** given in section 3 and their application in Test Procedures described in section 4. For Products using solar or outdoor-air source ambient heat, tests shall not only be performed at average climate test conditions [**Avg**], but also under Colder [**C**] and Warmer [**W**] climate test conditions as defined in Tables 5 and 7.

[1] Note that both Gas/Oil Products and Electric Products may include Solar Products and Heat Pump Products. Products that use neither fossil fuels not electricity are outside the scope of the regulation.

The manufacturer shall declare one or more Load Profiles for the Product, to be selected from the nine (9) Load Profiles given in Table 2. The Load Profiles are denominated *XXS, XS, S, M, L, XL, XXL, 3XL* and *4XL*.

For each Load Profile the Product shall be tested for Load Profile Fuel Consumption and/or Load Profile Electricity Consumption as well as Load Profile performance assessment, i.e. whether the Product is capable of realizing the specifications.

- The ***useful energy content*** *of hot water* during a draw-off is defined as the product of
  - the time elapsed [in h] between
    - the moment that in a tapping the useful temperature ***Tm*** is reached and at least maintained during the rest of the tapping and
    - the end of the tapping, to be determined dynamically during the test following the requirement for Qtap as specified in Table 2.
  - the energy content of the hot water in above time period, given by the Product of
    - tapped hot water volume [in dm³],
    - the average temperature difference between cold and hot water over the elapsed time above [in K] and
    - the specific heat of water [in K/dm³].
- **Load Profile Test Procedure** is a sequence of activities to be performed when testing the Product according to the specification of Load Profile. Types of Load Profile test procedures are:
  - **Standard Test Procedure,** where the equilibrium situation depends on the energy demand. In other words, the energy consumption at zero-demand (no draw-off) represents an equilibrium situation of which the energy consumption can be readily established. Subsequently a tapping pattern can be tested. After that, the Product will return to the equilibrium situation. Energy consumption must be measured before, during and after the 24h tapping pattern, to ensure that no residual energy surplus or deficit crosses to the tapping test from periods before and after. This procedure applies to most Conventional Products and is described in par. 4.1.
  - **Iterative Test Procedure**, where the equilibrium situation is a balance between energy demand (hot water) and energy supply, i.e. from solar or ambient heat induced during the test. This test procedure requires subsequent, iterative testing with the 24h tapping pattern to establish the energy consumption in an equilibrium situation. This procedure applies to Renewable Products and is described in par. 4.2.
  - **Simplified Test Procedure,** which is only allowed for conventional electric instantaneous water heaters (EIWHs). EIWHs are a relatively homogenous Product group, where differences in test results between individual Products are small and in the order of magnitude of allowable tolerances. Therefore the procedure is a simplified, static test with a focus on electric losses and thermal inertia, allowing more accuracy and better repeatability to differentiate between the Products. Differentiation on heat transfer losses is to be taken into account through a simplified smart control test. This procedure is described in par. 4.3.
  - **Smart Control Test Procedure,** where an efficiency bonus shall be applied to Products that are capable of operating at a 10% reduced energy consumption with respect of the outcome of the standard or iterative test procedure, after a “learning period” of 1 week at several 24h tapping patterns. This procedure applies to all Products except EIWHs and is described in par. 4.4.
  - **Simplified Smart Control Test Procedure,** which is only allowed for EIWHs and gives an efficiency bonus to Products capable of delivering hot sanitary water leaving the Product at the required temperature, i.e. without or almost without cold water mixing at the tapping point. This is favourable for heat losses not captured by the simplified test procedure for EIWHs mentioned above. Exact requirements are described in par. 4.5.
- **Load Profile fuel consumption** is the fuel consumption during a test with a specific Load Profile, expressed in kWh on Gross Calorific Value of the fuel, taking into account

corrections on energy input and output as specified in Sections 3 and 4. For average climate (test) conditions indicated in section 3 this value is denominated as ***Qfuel***. For fuel consumption tested under *Colder* and *Warmer* climate test conditions denominations are ***QfuelC*** and ***QfuelW*** respectively.

- **Load Profile electricity consumption** is the electricity consumption during a test with a specific Load Profile, expressed in kWh electric, taking into account corrections on energy input and output as specified in Sections 3 and 4. For average climate (test) conditions indicated in section 3 this value is denominated as ***Qelec***. For electricity consumption from tests at Colder and Warmer climate conditions denominations are ***QelecC*** and ***QelecW*** respectively.
- **Load Profile primary energy consumption *Qnet* (in kWh)** is the sum of Qfuel and Qelec, with a correction for power generation losses (conversion factor 2,5 applicable to Qelec) and a possible smart control bonus. The equation is given in section 5.
- **Secondary functions** of the Product in the context of this regulation are the pre-disposition to distribute the heated sanitary water to tapping points with low energy loss and the predisposition to contribute to the useful space heating of buildings. This predispositions depends on Secondary Product Characteristics. Another possible secondary function is the capability to contribute to electric power generation (CHP Product), which is taken into account directly in the test procedure, i.e. the outcome of Qelec.
- **Secondary Product Characteristics** are
  - the designated Product position ***boilpos*** (options *indoors/outdoors*);
  - the Product volume ***volumeb*** (in m³ volume of the smallest cuboid or cylinder fitting the Product envelope, accuracy ± 5%) ;
  - the combustion air intake system, ***air-intake*** (options *room-sealed/open/ none*) ;
  - noise power level, ***noisew*** (in dB-A);
  - envelope losses (in kWh), which in turn can be determined with
    - Combustion efficiency ***etacomb*** (in %, on Net Calorific Value)
    - Flue gas temperature ***Tflue*** (in ºC)
    - the fueldewpoint ***dpt*** (options *gas/ oil/ LP*, see Table 10)
    - Collector aperture area ***A*** (in m²)
    - Designated solar tank posistion solpos (options *indoors/ outdoors*)
    - Nominal volume of heat pump storage tank ***Vhp*** (in ltr.)

    used as inputs in the appropriate test and calculation procedures in Sections 4 and 5, based on reference conditions in Section 3.

  The assessment of the above characteristics is described in section 2. The first three parameters (boilpos, volumeb and air-intake) are relevant for the Distribution Penalty ***Qdistr*** (in kWh/d). All above parameters may be used in the determination of a Heat Recovery Bonus ***Qrecover*** (in kWh/d) in section 5. Look-up tables are given in section 3 , Tables 9, 10, 11.
- The **Specific Energy Efficiency** of a Product with a defined Load Profile ***etawh*** under average climate test conditions is defined in Section 5. It is the ratio of the minimum theoretical energy consumption to realize the Load Profile ***Qref*** versus the actual primary energy consumption, where the latter takes into account the Load Profile primary energy consumption ***Qnet*** (including smart control correction) as well as bonus/ penalty values for the predisposition of the Product to contribute to useful space heating and energy-efficient distribution of the hot water to the tapping points. The equivalent for Colder and Warmer climate test conditions is ***etawhC*** and ***etawhW*** respectively.
- The following Products are explicitly <u>not</u> included in the scope:
  - Water heating devices that do not meet minimum output performance of any Load Profile, i.e. not even the requirements of the smallest Load Profile ('XXS'), as defined in Table 2.
  - Water heating devices that are within the scope of Directive 2001/80/EC on Large Combustion Plants (LCPD).

- Water heating devices that consume no fossil fuel or electricity for the primary function (e.g. solar only water heating devices)
- Water heating devices using solid fuels and/or bio-fuels (>10% of primary energy consumption)
- Water heating devices driven by District Heating ("DH"). These are systems fuelled by waste heat from power plants, waste incineration plants, larger industrial installations, etc..
- Product components, i.e. devices that are not capable of performing the *primary function*. This includes but is not limited to burners, heat exchangers, storage tanks as well as controls or other provisions for heat generation technologies that are not part of the Product offered for CE-marking.

1.2. Other definitions

- Product **Cascade**: configuration of more than one Heat Generator, whereby the Heat Generators are operating consecutively or in parallel to supply heat to the sanitary hot water.
- **Back-up** heating: Any conventional heat generation and heat transfer technology that is used to fulfill the remaining heat demand after the application of the renewable heat (solar and/or heat pumps).
- **CHP** (Combined Heat and Power) Product: Any Product that produces a surplus of electricity, i.e. beyond what is needed for driving the electrical components within the Product .
- **Outdoors**: Applies to any Product or part of a product that is designated by the manufacturer to operate only outdoors. **Indoors** is defined as the complementary concept of outdoors, i.e. indoors is not outdoors. Declared indoors/ outdoors parameters are boilpos and solpos. ***Boilpos*** relates to the Product as a whole, i.e. also indluding back-up heaters in case of a Solar or Heat Pump Product. ***Solpos*** applies to the designated position of the preheat storage tank. For Products that consist of both an indoor and an outdoor part (e.g. solar, heat pump), the indoor/ outdoors positon is taken into account in the test. Unless all parts of the Product (condensor, back-up heater, etc.) are designated to be positioned outdoors, these Products shall be marked as indo*ors* (parameter boilpos)
- ***Combustion Air-intake***. Characterization of the method of combustion air supply to a Product using fossil fuels. Options are
  - **open**, taking combustion air directly from the room where the Product is installed.
  - **room-sealed**, taking combustion air from outdoors through a duct.
  - **none,** indicating that the Product does not use combustion air (electric)
- **Smart control** Product: Any Product that complies with the conditions as described in par. 4.4 or –for EIWH only—par. 4.5 shall obtain the 10% smart control bonus.
- **Off-peak** Product: Any Product that is designed to fulfill the requirements of the tapping pattern between 7:00h and 22:00h without external energy supply, e.g. to enable operation at off-peak/ low-tariff periods and/or to operate in conditions of insecurity of energy supply. A product qualifies as " Off-peak" if it is only energized for a maximum of 8 consecutive hours anywhere between 22:00 and 7:00h during the test with the 24h tapping pattern.
- **Default**: Any feature or parameter value of the Product that is used as a basic reference. It does not require verification, i.e. it does not require the feature to be implemented and/or the parameter value to be valid.

2. DATA REPORT

2.1. General

Each application for CE-marking shall be accompanied by a *DATA REPORT* on specific performance characteristics of the Product, as defined in the table on the following page. Also the manufacturer is required to keep further technical documentation on file.

The *DATA REPORT* is a minimum requirement for information that manufacturers shall supply with the Product (user's manual, installation instruction). Note that a Data Report, possibly combined with others in a table format, is due for each Load Profile that the manufacturer specifies for the Product.

Table 1 DATA REPORT

1.	Manufacturer			
2.	Model & ID			
3.	Date	dd-mm-yy		
4.	Basic Product Type	Gas/ Oil/ Electric		
5.	Subtype	Conventional/ Solar/ Heat Pump		
6.	Load Profile	XXS/ XS/S/ M/ L/ XL/ XXL/ 3XL/ 4XL		
		C	**Avg**	**W**
7.	Fuel consumption **Qfuel**, in kWh/d GCV	999,99	**999,99**	999,99
8.	Electricity consumption **Qelec**, in kWh/d electric	999,99	**999,99**	999,99
9..	smart control **dhwsmart**	yes/'no		
10.	**night-tariff**	yes/'no		
11.	Designated in-/outdoors **boilpos**?	indoors/ outdoors		
12.	Combustion **airintake**	open/ room-sealed/ none		
13.	Env. Volume **volumeb**, in m³	9,99		
14.	noise **noisew**, in dB-A	99		
15.	combustion efficiency eta**comb**, in %	9,99		
16.	avg. flue gas temp. at tapping **Tflue**, in ºC	999		
17	Fueldewpoint **dpt**	gas/ oil/ LPG		
18.	Solar collector area **A**, in m²	999,99		
19.	Designated solar tank position **solpos**	indoors/ outdoors		
20.	Volume heat pump storage tank **Vhp**, in ltr.	999		
21.	Distribution Penalty ***Qdistr***, in kWh/d	999,99		
22.	Heat Recovery Bonus ***Qrecover***, in kWh/d	999,99		
		C	**Avg**	**W**
23	Specific Energy Efficiency **etawh** %	999%	**999%**	999%
24.	annual primary energy use **Qatot** kWh/a	999	**999**	999
25.	Energy label classification			

Note that values are fictitious and used to indicate the precision (number of decimals) required.

2.2. Inputs and intermediate outputs

Parameters in rows 1 to 6 are identity parameters. By stating the ***Load Profile*** parameter the manufacturer declares that the Product meets the performance requirements (flow-rates, temperatures, etc.) of the selected load profile. Parameters in rows 7 to 10 relate to the primary function of the Product, i.e. the fuel and electricity consumption during the test according to the given Load Profile, as specified in Section 1 and corrected for smart control and night-tariff..

For solar-assisted Products and air-source assisted heat pump the tests shall be performed with specifications for Average (Avg), Colder (C) and Warmer (W) climate conditions, resulting in values for ***QfuelC, QfuelW*** in row 7 and ***QelecC***, ***QelecW*** in row 8. Energy input values for Colder and Warmer climate test conditions are given in Tables 5 and 7.

A special marking for ***smart control*** shall be reported if the appliance complies with the relevant test procedures in par. 4.4 and 4.5.

A special marking for ***Off-peak*** shall be reported if the appliance is tested at Off-peak conditions, i.e. energized only for a maximum of 8 consecutive hours anywhere between 22:00 and 7:00h during the test with the 24h tapping pattern (see section 4).

Parameters in rows 11 to 22 relate to the secondary function of the Product.

Assessments for

- the designated Product position ***boilpos*** (options indoors/outdoors)
- the combustion ***air intake*** system (options room-sealed/open/ none)
- the Product volume ***volumeb*** (in m³ volume of the smallest cuboid or cylinder fitting the Product envelope, accuracy ± 5%) and
- the fueldewpoint ***dpt*** (options gas/ oil/ LP, see Table 3.9)
- Collector aperture area ***A*** (in m²)
- Designated solar preheat tank position ***solpos*** (options indoors/outdoors)
- Nominal volume of heat pump storage tank ***Vhp*** (in ltr.)

are all Product characteristics based on self-declaration.

The noise power level ***noisew*** (in dBA) during operation shall be determined according to best practice equivalent to harmonized or national standards.[2]

Flue gas temperature ***Tflue*** and combustion efficiency ***etacomb*** shall be determined according to best practice equivalent to harmonized or national standards.[3]
Combustion efficieny shall be expressed in Net Calorific Value (NCV). These parameters are relevant only for water heaters where combustion technology is involved, either in the primary or secondary ("back-up") Heat Generator.

The Distribution Penalty ***Qdistr*** and Heat Recovery Bonus ***Qrecover*** are outputs, calculated in Section 5. They are mentioned here to facilitate their use/ correction in installation-oriented legislation.

2.2. Aggregated parameters

Parameters in rows 23 to 25 are aggregated parameters. The Specific Energy Efficiency ***etawh*** is defined in section 1 and builds on data and procedures in sections 2 to 5. It is the main subject for mandatory minimum requirements.

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[2] In practice the noise measurement involves (at least) the following steps:

- Mounting of the Product in a sound-proof room in accordance with manufacturer's instructions (see par. 4.1.1 for analogy). If indicated this may imply that the Product is built-in in a cupboard.
- Positioning of a sound power meter at 1 meter distance from the front center of the Product and directed towards the Product
- Measuring background noise during cold water tapping with Product off
- Measuring noise-level with Product in operation (e.g. 30 s after start of tapping).
- If necessary correction of the measured value for the influence of the background noise. The resulting value is reported as noisew in the DATA REPORT

A measurement accuracy of ± 1,5 dB-A is acceptable.

In case the Product contains no moving parts (e.g. electric resistance heater), no noise measurement is necessary but a default value of 35 dB-A may be declared.

[3] In practice, ***Tflue*** and***etacomb*** **can be determined with a well-calibrated (mobile) flue gas analyzer which samples temperature aqnd composition of the flue gas through an appropriate connection point in the flue gas duct. The analyzer then contains the algorhytm to translate test values directly into values for** ***Tflue*** and***etacomb.***

All other parameters are mainly for informative purposes. The annual primary energy use Qatot is indicative consumer information. As the Specific Energy Efficiency it is based on the daily primary energy use (*Qnet* = *Qfuel* + *Qelec* * 2,5), corrected for smart control (-10% if applicable) as well as the predisposition for efficient distribution *Qdistr* (negative) and possible waste heat recovery *Qrecover*, as calculated in section 5. But for *Qatot* this daily primary energy consumption is multiplied by a factor 220 (=0,6 * 366), indicating a year-round use at an average 60% of the Load Profile performance.

In case of solar-assisted and/or air-source heat pump water heaters also the results ***etawhC, etawhW QatotC***, ***QatotW***, ***QatotC*** and ***QatotW*** for Warmer and Colder climate test conditions shall be reported (see Section 5).

The energy label classification, is reserved for the energy labeling class(es) as will be indicated in the future legislation under 92/75/EC.

3. REFERENCE CONDITIONS

3.1. Load Profile

Table 2 specifies the tapping patterns for the chosen Load Profile, as defined in Section 1.

Parameters in the table are:

- ***Load Profile*** [XXS-4XL, in header row of table]
- ***h*** hour [hh:mm] starting at 0:00 h.
- **Qtap** useful energy content of water withdrawal to be achieved in the draw-off, [in kWh]
- **f** minimum flow rate to be reached during tapping [in l/min]
- **Tm**, temperature from which counting of useful energy content starts [in ºC]
- **Tp**, minimum (peak) temperature to be achieved during tapping [in ºC]
- **Qref**, daily (24h) useful energy content of all water draw-offs [in kWh/d, effectively the sum of all Qtap]

For all tests a cold water temperature of 10 ± 2 ºC shall be used.

As much as possible, the test method uses a 'black-box' approach, i.e. largely technology independent. This means amongst others that the manufacturer uses the original appliance thermostat, in the position specified by manufacturer, and at the factory settings. If the Product requires manual thermostat operation to obtain the temperatures in Table 2, this shall be done during the test.

Table 2: Water heater load patterns (reference test tapping patterns)

	XXS				XS				S			
	Qtap	f	Tm	Tp	**Qtap**	f	Tm	Tp	**Qtap**	f	Tm	Tp
h	**kWh**	l/min	ºC	ºC	**kWh**	l/min	ºC	ºC	**kWh**	l/min	ºC	ºC
07.00	**0,105**	2	25						**0,105**	**3**	**25**	
07.05												
07.15												
07.26												
07.30	**0,105**	2	25		**0,525**	**4**	**35**	**-**	**0,105**	**3**	**25**	
07.45												
08.01												
08.05												
08.15												
08.25												
08.30	**0,105**	2	25						**0,105**	3	25	
08.45												
09.00												
09.30	**0,105**	2	25						**0,105**	3	25	
10.00												
10.30												
11.00												
11.30	**0,105**	2	25						**0,105**	3	25	
11.45	**0,105**	2	25						**0,105**	3	25	
12.00	**0,105**	2	25									
12.30	**0,105**	2	25									
12.45	**0,105**	2	25		**0,525**	4	35	-	**0,315**	4	10	55
14.30												
15.00												
15.30												
16.00												
16.30												
17.00												
18.00	**0,105**	2	25						**0,105**	3	25	
18.15	**0,105**	2	25						**0,105**	3	40	
18.30	**0,105**	2	25									
19.00	**0,105**	2	25									
19.30	**0,105**	2	25									
20.00	**0,105**	2	25									
20.30					**1,050**	4	35	-	**0,420**	4	10	55
20.45	**0,105**	2	25									
20.46												
21.00	**0,105**	2	25									
21.15	**0,105**	2	25									
21.30									**0,525**	5	45	
21.30	**0,105**	2	25									
21.45	**0,105**	2	25									
Qref	**2,100**				**2,100**				**2,100**			

	M				L				XL			
	Qtap	f	Tm	Tp	**Qtap**	f	Tm	Tp	**Qtap**	f	Tm	Tp
h	**kWh**	l/min	ºC	ºC	**kWh**	l/min	ºC	ºC	**kWh**	l/min	ºC	ºC
07.00	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
07.05	**1,400**	6	40		**1,400**	6	40					
07.15									**1,820**	6	40	
07.26									**0,105**	3	25	
07.30	**0,105**	3	25		**0,105**	3	25					
07.45					**0,105**	3	25		**4,420**	10	10	40
08.01	**0,105**	3	25						**0,105**	3	25	
08.05					**3,605**	10	10	40				
08.15	**0,105**	3	25						**0,105**	3	25	
08.25					**0,105**	3	25					
08.30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
08.45	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
09.00	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
09.30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
10.00									**0,105**	3	25	
10.30	**0,105**	3	10	40	**0,105**	3	10	40	**0,105**	3	10	40
11.00									**0,105**	3	25	
11.30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
11.45	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
12.00												
12.30												
12.45	**0,315**	4	10	55	**0,315**	4	10	55	**0,735**	4	10	55
14.30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
15.00									**0,105**	3	25	
15.30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
16.00									**0,105**	3	25	
16.30	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
17.00									**0,105**	3	25	
18.00	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
18.15	**0,105**	3	40		**0,105**	3	40		**0,105**	3	40	
18.30	**0,105**	3	40		**0,105**	3	40		**0,105**	3	40	
19.00	**0,105**	3	25		**0,105**	3	25		**0,105**	3	25	
19.30												
20.00												
20.30	**0,735**	4	10	55	**0,735**	4	10	55	**0,735**	4	10	55
20.45												
20.46									**4,420**	10	10	40
21.00					**3,605**	10	10	40				
21.15	**0,105**	3	25						**0,105**	3	25	
21.30	**1,400**	6	40		**0,105**	3	25		**4,420**	10	10	40
21.30												
21.45												
Qrer	**5,845**				**11,655**				**19,070**			

	XXL				3XL				4XL			
	Qtap	f	Tm	Tp	**Qtap**	f	Tm	Tp	**Qtap**	f	Tm	Tp
h	**kWh**	l/min	ºC	ºC	**kWh**	l/min	ºC	ºC	**kWh**	l/min	ºC	ºC
07.00	**0,105**	3	25		**11,2**	48	40		**22,4**	96	40	
07.05												
07.15	**1,820**	6	40									
07.26	**0,105**	3	25									
07.30												
07.45	**6,240**	16	10	40								
08.01	**0,105**	3	25		**5,04**	24	25		**10,08**	48	25	
08.05												
08.15	**0,105**	3	25									
08.25												
08.30	**0,105**	3	25									
08.45	**0,105**	3	25									
09.00	**0,105**	3	25		**1,68**	24	25		**3,36**	48	25	
09.30	**0,105**	3	25									
10.00	**0,105**	3	25									
10.30	**0,105**	3	10	40	**0,84**	24	10	40	**1,68**	48	10	40
11.00	**0,105**	3	25									
11.30	**0,105**	3	25									
11.45	**0,105**	3	25		**1,68**	24	25		**3,36**	48	25	
12.00												
12.30												
12.45	**0,735**	4	10	55	**2,52**	32	10	55	**5,04**	64	10	55
14.30	**0,105**	3	25									
15.00	**0,105**	3	25									
15.30	**0,105**	3	25		**2,52**	24	25		**5,04**	48	25	
16.00	**0,105**	3	25									
16.30	**0,105**	3	25									
17.00	**0,105**	3	25									
18.00	**0,105**	3	25									
18.15	**0,105**	3	40									
18.30	**0,105**	3	40		**3,36**	24	25		**6,72**	48	25	
19.00	**0,105**	3	25									
19.30												
20.00												
20.30	**0,735**	4	10	55	**5,88**	32	10	55	**11,76**	64	10	55
20.45												
20.46	**6,240**	16	10	40								
21.00												
21.15	**0,105**	3	25									
21.30	**6,240**	16	10	40	**12,04**	48	40		**24,08**	96	40	
21.30												
21.45												
Qref	**24,530**				**46,760**				**93,520**			

3.2. Energy Inputs

3.2.1. Conventional

Table 3. Electricity and Fossil Fuels

Measured quantity	Unit	Value	Permissible deviation (average over test period)	Uncertainty of measurement (accuracy)	Notes
Electricity					
power	W			± 1 %	
energy	kWh			± 1 %	
voltage, *test-period > 48 h*	V	230/ 400	± 4 %	± 0,5 %	[1]
voltage, *test-period < 48h*	V	230/ 400	± 2 %		
voltage, *test-period < 1 h*	V	230/ 400	± 1 %	± 0,2 %	
electrcic current	A			± 0,5 %	
frequency	Hz	50	± 1 %		
Gas					
types	-	Test gases GAD			[2]
net calorific value (NCV)	MJ/ m³	Test gases GAD		± 1 %	[3]
temperature	K	288,15		± 0,5	[3]
pressure	mbar	1013,25		± 1 %	[3]
density	dm³/kg			± 0,5 %	
flow rate	m³/s or l/min			± 1 %	
Oil					
Heating gas oil					
composition, *Carbon/ Hydrogen/ Sulfur*	kg/kg	86/ 13,6/ 0,2 %			
N-fraction	mg/kg	140	± 70		[4]
net calorific value (NCV, Hi)	MJ/kg	42,689			[5]
gross calorific value (GCV, Hs)	MJ/kg	45,55			[6]
density **ρ15** at 15 °C:	kg/dm³	0,85			
Kerosene					
composition, *Carbon/ Hydrogen/ Sulfur*	kg/kg	85/ 14,1/ 0,4 %			
N-fraction	mg/kg	140	± 70		[4]
net calorific value (NCV, Hi)	MJ/kg	43,3			[5]
gross calorific value (CGV, Hs)	MJ/kg	46,2			[6]
density **ρ15** at 15 °C:	kg/dm³	0,79			

NOTES

[1] Test periods >48 h apply to heat pump and/or solar assisted Products. Test periods <48 h apply to conventional Products. Test period <1 h applies to the simplified test procedures for electric instantaneous water heaters

[2] Test gases as in the essential requirements of the Gas Appliances Directive ("GAD") 90/396/EEC with amendments as in 93/68/EC

[3] A factor ***K*** has to be applied to correct the calorific value for the actual average atmospheric pressure ***pa*** and gas pressure ***pg*** as well as the average gas temperature ***Tg*** over the test period.
$$K = (pa + pg)/1013{,}25 + 288{,}15/(273{,}15+Tg)$$

[4] In case of low Sulfur test fuels,N-fractions lower than 70 mg/kg and lower S fractions are allowed

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

[6] Calculated from net calorific value with multiplier 1,067. GCV=1,067 * NCV

Table 4. Characteristics of reference test gases, Dry gas at 15 °C and 1 013,25 mbar (illustrative) **[1]**

Gas family and group	Desig-nation	Composition by volume %	Net calorific value **Hi** in MJ/m³	Gross calorific value **Hs** in MJ/m³	Wobbe-index net **Wi** in MJ/m³	Wobbe-index gross **Ws** in MJ/m³	density in kg/m³	Test pressure **[2]** nominal, minimum and maximum in Pa		
								pn	pmin	pmax
1st family										
Group a	**G 110**	CH_4 = 26 H_2 = 50 N_2 = 24	13,95	15,87	21,76	24,75	0,411	8	6	15
2nd family [3]										
Group H and Group E	**G 20**	CH_4 = 100	34,02	37,78	45,67	50,72	0,555	20	17	25
Group L	**G 25**	CH_4 = 86 N_2 = 14	29,25	32,49	37,38	41,52	0,612	25	20	30
3 rd family										
Groups B/P and B **[4]**	**G 30**	n-C_4H_{10} = 50 i-C_4H_{10} = 50	116,09	125,81	80,58	87,33	2,075	29	25/ 20	35
								50	42,5	57,5
Group P	**G 31**	C_3H_8 = 100	88,00	95,65	70,69	76,84	1,550	37	25	45
								50	42,5	57,5

Notes:

[1] The definition, preparation and use of test gases is determined by the Essential Requirements of the Gas Appliances Directive. The table above reflects a momentary situation that may be subject to change and is for illustrative purposes only It does not include limit gases and gases distributed nationally or locally.

[2] Test supply pressures when no test coupling exists. Note that for Groups B/P and P two sets of test pressures are available

[3] Not shown is Group N (category I2N), which are as appliances using only second family gases at the prescribed supply pressure and that automatically adapt to all gases of the second family. They are tested with both G20 and G25 gases and both sets of pressure specifications

[4] pmin = 25 Pa applies to group B/P; pmin=20 Pa applies to group B. Note That "LPG" is a mixture of 3rd family gases, usually tested with test gas Group B/P or B

3.2.2. Solar

Table 5. Global solar irradiance in W/m² at hours of the day (in h) for a 24h test cycle, at a fixed 'outdoor' temperatures and at average (A), colder (C) and warmer (W) climate conditions

h	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Gtotal
A	0	0	0	0	0	0	95	171	237	303	351	393	436	474	512	455	218	47	0	0	0	0	0	0	**3691**
C	0	0	0	0	0	0	78	141	196	250	290	325	360	391	423	376	180	39	0	0	0	0	0	0	**3049**
W	0	0	0	0	0	0	122	219	305	390	451	506	561	609	658	585	280	61	0	0	0	0	0	0	**4747**

Notes:

[1] Accuracy of measurement 10 W/m². Maximum permissable deviation for single period 5%. Maximum permissable deviation for Gtotal 5%. Correction factor **KG** shall be applied to the output, to correct for difference between actual and required irradiance. **KG= Gtotal [required]/ Gtotal [actual test]**

[2] Applicable outdoor temperatures thoughout the 24 h test for the 3 climate test conditions

A	10 ºC	C	5,5 ºC	W	16 ºC

Accuracy of measurement 0,5 K. Maximum permissable deviation from set values ± 2 K (average over test period). Maximum permissable deviation from average ± 1 K.

The 24h test cycle for global solar irradiance may be realized through a solar collector simulator. This is a device –e.g. an electric resistance immersion heater in the circuit replacing the solar collector—that mimicks the heat output of a solar collector when exposed to the solar cycle mentioned above.

For this, first the characteristics of the solar collector have to be established thorugh a test. Secondly, from the relevant characteristics the net output power of the simulator for any given time of the solar cycle (synchronous with the tapping cycle) is calculated according to equation) has to calculated.

The appropriate equations and parameters for this calculation are given below

$$Q_{sim,HE} = A_a \, .eta \, . \, G^* \qquad [1]$$

where

- $Q_{sim,\,HE}$ is the necessary heating performance of the heating element to simulate the real solar collector field, in W;
- A_a is the collector aperture area, in m²;
- ***eta*** is the instantaneous collector efficiency, with reference to T*m
- G^* is the global radiation on collector (solar cycle data), in W/m²;

with

$$eta = eta_0 - a_1.T^*_m - a_2.G\,(T^*_m)^2 \qquad [2]$$

where

- eta_0 is the zero-loss collector efficiency (*eta at* T^*_m,=0), reference to T^*_m [-] ;
- a_1 is the heat loss coefficient at (Tm-Ta) = 0 (first order coefficient), in $Wm^{-2}K^{-1}$;
- a_2 is the temperature dependence of the heat loss coefficient (second order coefficient) , in $Wm^{-2}K^{-1}$;
- T^*_m is the reduced temperature difference in m^2KW^{-1}

with

$$T^*_m = (\,t_m - t_a\,)/\,G \qquad [3]$$

where

- t_a is the ambient or surrounding air temperature
- t_m is the mean temperature of the heat transfer fluid

with

$$t_m = t_{in} + 0{,}5.\Delta T \qquad [4]$$

where

- t_{in} is the collector inlet temperature
- ΔT is temperature difference between fluid outlet and inlet (= $t_e - t_{in}$) [4]

A continuous efficiency curve of the format as in equation [2] for the instantaneous collector efficiency ***eta*** shall be obtained by statistical curve fitting, using the least square method. For this, at least 16 test-points, with 4 different collector inlet temperatures t_{in} evenly spaced over the operating range and 4 tests per collector inlet temperature are measured to obtain test values for t_e, t_a, G and ***eta***[5] . If possible, one inlet temperature shall be selected with $t_m = t_a$ ± 3K to obtain an accurate assessment of eta_0. With fixed collector (no automatic tracking) and test conditions permitting half of tests should be done before solar noon and 2 after. Maximum temperature heat transfer fluid (i.e. the top of the operating range) should be >80 ºC. [6]Recommended maximum value of T^*_m : >0,09.

[4] t_e is the collector outlet (exit) temperature. Note: t_{in} and t_e were previously known as $T_{c,in}$ and $T_{c,out}$ in the 2001 version of EN 12975-2

[5] the instantaneous efficiency ***eta*** in a test is measured from the product of flowrate, temperature increase over the collector and the specific heat of water divided by the solar irradiance input during the test.

[6] For instance, with water filled collectors and a test at Ta = 10 °C appropriate test values of T_{in} could be 10-35-60-85 °C

For (glazed) solar collector tests the following conditions apply:

TABLE 6. PARAMETER TESTS FOR SOLAR SIMULATOR. Set values and tolerances

Measured quantity	Unit	Value	Permissible deviation of the arithmetic mean values from set values	Permissible deviations of individual measured values from set values	Uncertainty of measurement (accuracy)	Notes
Solar collector (glazed)--> *eta0, a1, a2 through least square curve fit for 4 x 4 test results; Asol*						
Test solar irradiance (global G, short wave)	W/m²	>700 W/m²	± 50 W/m² (test)		± 10 W/m² (indoors)	[1]
Diffuse solar irradiance (fraction of total G)	%	<30%				[2]
Thermal irradiance variation (indoors)	W/m²				± 10 W/m²	
Fluid temperature at collector inlet/outlet	°C/ K	range 0-99 ºC	± 0,1 K		± 0,1 K	[3]
Fluid temperature difference inlet/outlet					± 0,05 K	[4]
Incidence angle (to normal)	°	<20°	±2 % (<20°)			[5]
Air speed parallel to collector	m/s	3 ± 1 m/s			0,5 m/s	[6]
Fluid flow rate (also for simulator)	kg/s	0,02 kg/s per m² collector aperture area	± 10 % between tests	± 1 % (max dev in 1 test)		
Tilt angle	°	latitude (or 45°)				[7]
Orientation	NESW	S ± 45°				
Collector area A (absorber, gross, aperture)	m²				± 0,3 %	
Pipe heat loss of loop in test	W/K	<0,2 W/K				

[1] Measured by pyranometer, equivalent to Class I (ISO 9060) or better. With shading ring or pyrheliometer and provided with a dessicator. Regular inspection of the desiccator shall be observed. Test sample rate 30 s.

Pyranometer stays fixed in one test-point before data recording begins. Sensor shall be co-planar to collector ± 1°, at midheight of collector and receiving the same levels of direct, diffuse and reflected solar radiation as collector. When used with solar irradiance simulator minimize effect of infrared radiation at wavelength > 3µ

[2] If <30% can then be ignored (from EN 12975-2)

[3] Measure within 200 mm of collector connection

[4] Preferable accuracy .± 0,02 K

[5] Measured by simple device: spike normal to collector and reference circles on collector plane to read spike shadow

[6] Measure 10 to 50 mm above collector, use artifical wind generator if < 2m/s. Check uniform distribution with anemometer. Temperature of artificial wind is ambient ± 1K.

[7] EN 12976 ENV for Factory Made solar systems uses 45°, others use the latitude

After the collector tests and the calculation a table should result in a similar format as the solar cycle in Table 5 but now with the required net power output of the simulator replacing the solar collector in the test configuration. The net power output is given for the whole collector aperture area A.The sum of net power output per hour is summed over 24h and the outcome is ***Qsolsim*** in kWh for the average climate. For Colder and Warmer climate conditions it is referred to as ***QsolsimC*** and ***QsolsimW*** respectively.

Note that the manufacturer shall determine the actual power input of the simulator for electric losses and thermal losses of the simulator in the test rif. The method to determine the correction and the applied input power values shall be reported.

The simulator –and storage vessels or other parts designated by the manufacturer to be used outdoors--shall be tested at outdoor conditions (temperatures) as specified in Table 5 for the 3 climate test conditions. Unless the manufacturer indicates that all parts of the Product are to be used outdoors (parameter boilpos), the storage vessels and back-up heaters will be tested at indoors conditions.

3.2.3. Ambient heat

Table 7. Energy inputs and related parameters ambient heat/ heat pumps

Measured quantity	Unit [climate conditions]	Value	Permissible deviation (average over period	Permissible deviations of individual measured values	Uncertainty of measurement (accuracy)	Notes
Heat pump assistance: Liquid (heat transfer media: brine or water)						
brine inlet temperature	°C	2,5	± 0,2	± 0,5	± 0,1	
water inlet temperature	°C	11,5				
volume flow	m³/s or l/min		± 2 %	± 5 %	± 5 %	
static pressure difference	Pa		--	± 10 %	± 5 Pa/ 5%	[1]
Heat pump assistance: Air (as heat source)						
outdoor air temperature (dry bulb)	°C **[A]**	10	± 0,3	± 1	± 0,2	[2]
(***Toutair***)	°C **[C]**	5,5				
	°C **[W]**	16				
vent exhaust air temperature (***Tex***)	°C	20	± 0,3	± 1	± 0,2	
mixed air temperature (***Tmix***)	°C	see note	± 0,3	± 1	± 0,2	[3]
inlet air humdity *[A, C, W]*	g H2O/ m³	5,5			± 5 %	[4]
volume flow	dm³/s		± 5 %	± 10 %	± 5 %	
static pressure difference	Pa		--	± 10 %	± 5 Pa/ 5%	[5]

[1] maximum value according to manufacturer instructions shall be set at at liquid pump outlet, at nominal flow rate specified. Accuracy of measurement is ± 5 Pa if value < 100 Pa and 5% if value >100 Pa.

[2] Set values apply to average [A], colder [C] and warmer [W] climate conditions

[3] In order to avoid over-ventilation a maximum availability of ventilation exhaust air at a temperature of 20 ºC is assumed, depending on the Load Profile. This parameter ***ventex*** [in m³/h] is given below. If the actual nominal inlet air flow rate ***ventreal*** [in m³/h] exceeds this value, the heat pump shall use the mixed air temperature ***Tmix*** [in ºC] for testing. ***Tmix*** is determined from the relative proportion of exhaust air temperature ***Tex*** [in ºC] and exhaust air flow rate ***ventex*** versus outdoor air temperature ***Toutair*** and the surplus air flow (ventreal-ventex). In formula: **Tmix= { Tex * ventex + Tout * (ventreal-ventex) } / ventreal.**

Table . Default values *ventex* per water load profile

parameter	unit	1 -XXS	2 -XS	3 -S	4 -M	5 -L	6 -XL	7 -XXL	8 -3XL	9 -4XL
ventex	m³/h	109	136	128	159	190	870	1021	2943	8830

Note that if ventreal is not known a default value of 300 m³/kW nominal power of heat pump can be used.

[4] Note that an aboslute humidity of 5,5 g/m³ results in 37% Relative Humidity at 20 ºC dry bulb (12 ºC wet bulb), 65% RH at 10 ºC dry bulb (9 ºC wet bulb), etc.

[5] maximum value according to manufacturer instructions shall be set at duct outlet, with heat pump not operating. Nominal air flow shall be verified. Accuracy of measurement is ± 5 Pa is value is < 100 Pa and 5% if value >100 Pa.

3.3. Test conditions and tolerances on outputs

In as much as not defined in the previous paragraph, the table below gives additional test conditions and tolerances for test outputs (i.e. thermal energy).

TABLE 8. TEST CONDITIONS AND OUTPUTS. Set values and tolerances

Measured quantity	Unit	Value	Permissible deviation (average over test period)	Permissible deviations of individual measured values	Uncertainty of measurement (accuracy)	Notes
Ambient						
ambient temperature indoors *HP*	°C/ K	20 ± 5 °C	± 1 K	± 2 K	± 1 K	
ambient temperature indoors *gasfired*	°C/ K	20 ± 3 °C			± 1 K	
ambient temperature indoors *other*	°C/ K	20 ± 2 °C			± 1 K	
air speed *HP* (at WH off)	m/s	<1,5 m/s				
air speed *other*	m/s	<0,5 m/s				
Time						
Time *EIWH*	s				± 0,1 s	
Minimum sample rate SOLAR tests	s	30s			± 0,2 %	
Sanitary water						
cold water temperature *solar*	°C/ K	10 °C	± 1 K	± 1 K	± 0,2 K	
cold water temperature *other*	°C/ K	10 °C	± 2 K	± 2 K	± 1 K	
cold water pressure *gasfired WH*	bar	2 bar		± 0,1 bar		
cold water pressure *other (except EIWH)*	bar	3 bar			± 5 %	
hot water temperature *gasfired WH*	°C/ K	pattern			± 0,5 K	[1]
hot water temperature *electric instantaneous*	°C/ K	pattern			± 1 K	[2]
water temperature (in-/outlet) *other*	°C/ K				± 0,5 K	
volume flowrate *HP*	dm³ /s	pattern	± 5 %	± 10%	± 2 %	
volume flowrate *other WH*	dm³ /s	pattern			± 1 %	
volume measurements *HP*	dm³				± 2 %	
volume measurements *other*	dm³				± 0,5 %	
thermal energy	kWh	pattern	± 2 % (overall)	± 2 % (or ±10Wh)	± 2 % (or ±10Wh)	[3]

[1] To be measured by "rapid response thermometer", meaning an instrument that registers within 1 s. at least 90% of the final temperature rise from 15 to 100 °C when the sensor is plunged in still water.

[2] Thermocouple with a maximum diameter of 0,5mm, centered in stream, directly at outlet

[3] Apart from the maximum deviation a correction factor ***Qref/QH2O*** is applied, whereby ***Qref*** is taken from Table 2 and ***QH2O*** is the energy content of the useful water actually delivered during the test. "Useful water" is water with a temperature higher than a threshold value ***Tm*** for tappings in a profile specified in Table 2. (see text)

"Energy content" of one draw-off ***QH2O[i]*** follows from average in-/outlet temperature difference ***ΔT[i]*** during the useful tapping period in K, the tapped useful water volume ***V[i]*** in ltr. and the specific heat of water ***cw*** (1,163 Wh/ltr):
QH2O[i] = ΔT[i] * V[i] * cw. For all the ***n*** draw-offs of one tapping profile the energy content is the sum***:***
QH2O=∑QH2O[i] for ***i***=1 to ***i=n.*** Note that this formula can have many formats, e.g. more dynamic formats using flowrate and instantaneous temperature differences, but it comes down to the same result for the legislation.

3.4 Heat recovery and distribution losses

Table 9 gives a look-up table of the heat recovery percentage on the basis of boilpos, air_intake, volumeb and noise.

Table 9. Determination of heat recovery parameters

boilpos	air_intake	volumeb	noiseh (noisew)	qrecovb_winter Oct.-Apr.	qrecovb_summer June-Aug.	(qrecov) All year
[-]	[-]	[m³]	[dB(A)]	[%]	[%]	[%]
indoor (= 1)	3 (electric)	≤ 0.5	≤ 35	85%	-71%	32%
			>35, ≤ 44	55%	-46%	21%
			> 44	25%	-21%	9%
		> 0.5	any value	25%	-21%	9%
	1 or 2 (fossil fuel)	≤ 0.15	≤ 44	85%	-71%	32%
			> 44	25%	-21%	9%
		≤ 0.5, > 0.15	≤ 44	55%	-46%	21%
			> 44	25%	-21%	9%
		> 0.5	any value	25%	-21%	9%
outdoor (= 0)	any value	any value	any value	0%	0%	0%

Note 1: qrecovb_transit (May + Sept.)=0

Note 2: qrecov= (7/12)*qrecovb_winter + (3/13)*qrecovb_summer but with noisew instead of noiseh

For Products using combustion technology, the recoverable losses depend on the fuel dewpoints. Releavnt values are given in the table below

Table 10. Look-up table fueldewpoint (param. nr. 6.2)

fueldewpoint (param. nr. 6.2)		dpt
value	description	dew point
1	1-gas	58
2	2-oil	47
3	3 –LPG	54

The general formula for the dewpoint corrected for air-factor ***dptc***:

dptc= dpt – (lambda-1)*20

where for the dedicated water heater the air-factor lambda is chosen as a constant with value lambda=1,3. This means that ***dptc= dpt*** - 6.

The table below is used to determine distribution losses on the basis of air intake and Product volume.

Table 11. Determination of distribution losses *Qdistr* in kWh per day

parameter = Qwdistr [kWh/a]										
air_intake	volumeb	Load profile								
[–]	[m³]	XXS	XS	S	M	L	XL	XXL	3XL	4XL
none (electric)	<=0,5	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
	>0,5	0,36	0,36	0,55	1,09	1,09	1,09	1,09	2,19	4,37
room sealed	<=0,1	0,07	0,07	0,36	0,55	1,09	1,09	1,09	2,19	4,37
	>0,1, <0,15	0,36	0,36	0,55	0,73	1,09	1,09	1,09	2,19	4,37
	>=0,15	0,36	0,36	0,55	1,09	1,09	1,09	1,09	2,19	4,37
open	any value	0,36	0,55	1,09	1,09	1,09	1,09	1,09	2,19	4,37

4. TEST PROCEDURES

4.1. Standard Test Procedure

The following describes the test procedure for Conventional Products to establish the fuel and electricity consumption ***Qfuel*** and ***Qelec*** during a 24h test, as described in section 1.

4.1.1 Installation

Install Product in test environment according to manufacturer's instructions and in accordance with the requirements in Section 3. 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 shall be 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 shall be mounted according to manufacturer's instructions. The Product shall be shielded from direct solar radiation (except of course solar collectors).

Products with declared Load Profiles 3XL and/or 4XL may be tested on-site, provided test conditions are equivalent, possibly with correction factors, to the ones referenced here and in section 3. A separate test report is required.

4.1.2 Stabilisation

Keep Product at ambient conditions (test room) until all parts of the Product have reached ambient conditions ± 5 K. (at least 24h for storage type Products).
Purpose: Ascertain that Product is at more or less 'normal' temperature after transport.

4.1.3 Filling and heat-up (Storage only)

Products with storage-facilities shall be filled with cold water. Filling stops at the applicable cold water pressure (see Section 3).

The Product is energized to reach "out-of-the-box" factory settings, e.g. for storage temperature. The Product's own means of control (thermostat) shall be used. The next stage starts at thermostat cut out.

4.1.4 Stabilisation at zero-load (Storage only)

Keep the Product at normal operating conditions as specified by the manufacturer without draw-offs during at least 12 h.

For Products with storage-facilities subject to a control cycle this stage ends --and next stage starts-- at the first thermostat cut-out after 12h.

During this stage the total fuel consumption [in kWh on Gross Calorific Value of the fuel], the total electricity consumption [in kWh electric] and the exact time elapsed [in h] are recorded. The ratio between fuel consumption and elapsed time is ***P0antefuel*** [in kW with 3 digit accuracy]. The ratio between electricity consumption and elapsed time is ***P0anteelec*** [in kW with 3 digit accuracy]. .

4.1.5 Tapping

For the selected Load Profile, draw-offs are made in accordance with the specifications of the appropriate 24h tapping pattern in Table 2. Tapping pattern starts anywhere between 22:00 and 7:00h time-value as implied in Table 2. The tapping period ends 24h later. The required useful energy content of the hot water is the total **Qref** [in kWh] in Table 2.

During the tapping stage technical parameters (power, temperature, etc.) are established in accordance with specifications in Section 3. For dynamic parameters the overall sample rate is 10s or less. During draw-offs the recommended sample rate is 5s or less. Recorded values shall be part of the technical test report.

Fossil fuel consumption over the 24h test **Qtestfuel** [in kWh Gross Calorific Value of fuel], corrected for possible fuel temperature and pressure deviations as specified in Section 3
Electricity consumption over the 24h test **Qtestelec** [in kWh electricity], as specified in Section 3
Useful energy content of the hot water drawn-off **QH2O** [in kWh, determined as described in Section 3].

Products that want to be classified as **"Off-peak"** appliances shall be energized for a maximum period of 8 consecutive hours during 22:00h and 7:00h of the 24h tapping pattern as specified in Table 2.

4.1.6 Re-stabilisation at zero-load (Storage only)

This stage doesn't apply to Products without any hot water storage facilities.

Keep Product at nominal operating conditions without draw-offs during at least 12 h.

For Products with storage-facilities subject to a control cycle this stage ends at the first thermostat cut-out after 12h.

During this stage the total fuel consumption [in kWh on Gross Calorific Value of the fuel], the total electricity consumption [in kWh electric] and the exact time elapsed [in h] are recorded. The ratio between fuel consumption and elapsed time is ***P0postfuel*** [in kW with 3 digit accuracy]. The ratio between electricity consumption and elapsed time is ***P0postelec*** [in kW with 3 digit accuracy].

4.1.7 Reporting of Qfuel and Qelec

Qtestfuel and ***Qtestelec*** shall be corrected for any energy surplus or deficit outside the strict 24h tapping period, i.e. a possible energy difference before and after the tapping cycle 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 Qfuel and Qelec.

Qfuel = (***Qref/QH2O***) * {***Qtestfuel*** + 24*(***P0antefuel*** – ***P0postfuel***) }
Qelec = (***Qref/QH2O***) * {***Qtestelec*** + 24*(***P0anteelec*** – ***P0postelec***) }

In case of instantaneous water heaters the values of P0antefuel, P0postfule, P0anteelec and P0postelec are assumed to be zero (0).

4.2. Iterative Test Procedure

The following describes the applicable test procedure for Products using solar and/or ambient heat. It differs from the procedure for Conventional Products in the following ways:

- *Additional installation prescriptions apply.*
- *Test set-ups for the energy inputs are more complex than the ones for conventional energy sources. For solar-assisted Products this requires the use of simulators.*
- *Steady-state operating conditions for these Products are not known at the beginning of the test, but are a part of the outcome of the test procedure. This requires repetitive testing to establishe these steady state conditions.*
- *Testing at Colder and Warmer conditions is required.*

4.2.1 Installation

Requirements of par. 4.1.1 apply.

For Heat Pump Products consisting of several parts (split units) the following installation conditions shall be used for the tests:

- The refrigerant line shall be installed in accordance with the manufacturer's instructions with the maximum stated length or 8 m, whichever is shorter,
- the lines shall be installed so that the difference in elevation does not exceed 1 m;
- thermal insulation shall be applied to the lines in accordance with the manufacturer's instructions.

- Unless constrained by the design at least half of the interconnecting lines shall be exposed to the outdoor conditions with the rest of the lines exposed to the indoor conditions.

For indirect Heat Pump Products[7] the water line shall be installed in accordance with the manufacturer's instructions to the maximum stated length or 5 m, whichever is shorter. Otherwise instructions above shall be followed.

Air-source Heat Pump Products should have a minimum distance of 1 m between the air-inlet/ outlet of the Product and surface of the test room.

For Solar Products the following preparatory actions shall be undertaken.

- Clean collector surface.
- Remove moisture by running collector at heat transfer fluid circulating at 80 ºC.
- Vent collector pipework (remove trapped air).
- Expose empty collector to irradiation for 5h at > 700 Wm^{-2} (performance test).
- Mount Product with lower edge >0,5 m above local ground surface. Warm air currents from near walls or roofs of buildings shall not be allowed to pass over collector surface. When mounted on roof: >2 m from the edge.

For the testing of Solar Products, direct outdoor testing is not possible and the manufacturer can select two types of simulator set-ups can be used:
1.
Solar irradiance simulator. This is an indoor test set-up whereby the solar irradiance is mimicked by one or more lamps with solar wavelength characteristics, emitting the irradiance levels as indicated in Section 3.
2.
Solar collector simulator. For this, first the collector must be the tested [or test data from OEM must be acquired] . This type of testing may be done outdoors or indoors with a solar irradiance simulator (e.g. a lamp or set of lamps). The test determines the main efficiency parameters of the solar collector. These parameters, together with the solar cycle irradiance values from Table 4, are then "translated" into a power output of an electric resistance immersion heater that replaces the solar collector in the Product.

The second method is more economical and is described in paragraph 3.2.

4.2.2 Stabilisation

Requirements of 4.1.2 apply

4.2.3 Filling and heat-up

Products with storage-facilities shall be filled with cold water. Filling stops at the applicable cold water pressure (Section 3).

The Product is energized to reach the set temperature for possible hot water storage facilities according to the manufacturer's instruction. This applies only to storage facilities that are subject to a control cycle.[8]
The Product's own means of control (thermostat) shall be used. The next stage starts at thermostat cut out. Alternatively, e.g. if there is a significant heat transfer between the controlled (part of the) storage tank and the preheat (part of the) storage tank, the heat up can also be interrupted prematurely at a temperature that would be most advantageous for reaching a steady-state condition at the tapping cycles.

Likewise, in order to speed up the procedure, the preheat tank can be heated or filled with warm water of a temperature that is believed to be respresentative of the steady-state conditions.

4.2.4 Stabilisation

This stage can be skipped. If steady-state conditions are reached the standby-losses before and after the tapping cycle should be in balance.

4.2.5 Initial tapping cycle

[7] Heat Pump Products using a heat transfer fluid (water or brine) to the transfer the heat to the hot water . This is very rare, but not excluded.
[8] Safety devices, e.g maximum thermostats, excluded.

For the selected Load Profile, draw-offs are made in accordance with the specifications of the appropriate 24h tapping pattern in Table 2. Tapping pattern starts anywhere between the 22:00 and 7:00h time-value in Table 2. The tapping period ends 24h later. The required useful energy content of the hot water is the total **Qref** [in kWh] in Table 2.

During the tapping stage technical parameters (power, temperature, etc.) are established in accordance with specifications in Section 3. For dynamic parameters the overall sample rate is 30s or less. During draw-offs the recommended sample rate is 5s or less. Recorded values shall be part of the technical test report.

Fossil fuel consumption over the 24h test **Qtestfuel** [in kWh Gross Calorific Value of fuel], corrected for possible fuel temperature and pressure deviations as specified in Section 3.
Electricity consumption over the 24h test **Qtestelec** [in kWh electricity], as specified in Section 3
Useful energy content of the hot water drawn-off **QH2O** [in kWh, determined as described in Section 3].

Qtestfuel and ***Qtestelec*** shall be established, corrected for any surplus or deficit in the delivered useful energy content of the hot water is taken into account in the following equations:

Qfuel [test 1] = (***Qref/QH2O***) * ***Qtestfuel***
Qelec [test 1] = (***Qref/QH2O***) * ***Qtestelec***

4.2.6 Repitive tapping cycles

The tapping cycle indicated above will continuously be repeated for consecutive 24h measurement periods until the total primary energy consumption ***Qtap***= ***Qfuel*** + 2,5****Qelec*** [in kWh] between two consecutive 24h measurement periods shall not differ by more than 5%. If the above criterion is not fulfilled after 6 measurement periods, testing stops.

4.2.7 Reporting of Qfuel and Qelec

In case the 5% criterion mentioned above is fulfilled, the Qfuel and Qelec of the final measurement period shall be used as an input in the Data Report.
If the above criterion is not fulfilled after 6 measurement periods, the reported value of Qfuel and Qelec in the Data Report shall be the average value of Qfuel and Qelec during the last 3 measurement periods.

4.2.8 Colder and Warmer climate conditions

For Renewable Products, input values for the fuel and electricity consumption in “Colder”and “Warmer” conditions as specified in Section 3 are required. For this, the steps of the procedure above shall be repeated but with the appropriate “Colder”and “Warmer” parameters.

4.2.9 Simplified Test Procedure Standby Heat Loss (heat pump Products only)

This part of the procedure applies only to Heat Pump Products equipped with one or more hot water storage tanks. The outcome is to be used exclusively for taking into account waste heat recovery as part of the assessment of the Specific Energy Efficiency of a simplified test procedure. The procedure determines the standby heat loss of storage tanks in a quick, easy to perform and non-disruptive way. Accuracy is limited but deemed acceptable given the relatively small influence of waste heat recovery on the specific energy value. The procedure is as follows:

1. Immediately after the last 24h tapping cycle in the Iterative Test Procedure turn of the power and fuel supply and perform a tapping until the hot water temperature is stable [± 1 K] during 1 minute (recommended sample rate during tapping ≤ 10 s).. The hot water temperature at the end of this tapping is recorded as ***Tini*** [in ºC]
2. Repeat a tapping with the same characteristics every 30 minutes until the recorded temperature Tend [in ºC] reaches a value ***Tend*** [in ºC] lower than or equal to at *Tini* – 5. The time elapsed between the initial and the final tapping is recorded as ***tfive*** [in h].
3. The standby heat loss power ***Phpstby*** is calculated from recorded parameters above, the declared nominal storage volume ***Vhp*** [in ltr.] and the specific heat of water ***wh***= 0,00116 kWh/ltr.K using the following equation[9]:

[9] Note: the factor 0,8 takes into account a tank that 2/3 is fully mixed at the tapped temperature and 1/3 where the temperature varies between the tapped temperature and the cold water inlet temperature.

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$$Phpstby = \{ (Tini - Tend) * 0{,}8 * Vhp * wh \} / tfive$$

The value of Phpstby is used in section 5 to calculate the recoverable waste heat for this type of Product.

4.3. Simplified Test Procedure EIWH (electric instantaneous water heater)

Scope

Electric instantaneous water heaters (EIWH) are a relatively homogenous Product group, where differences in test results between individual Products are small and in the order of magnitude of allowable tolerances. For that reason a simplified, but more accurate test method with a better repeatability will be allowed to generate the value ***Qelec*** for a selected tapping pattern. Thermal losses from heat transfer processes during operation and standby (zero-load) losses are neglected.

First, static electric power losses are measured (Product of voltage and current) for the transformation from mains power supply to the electric resistance heating element at nominal load after at least 30 minutes of operation at this nominal load. For electronic instantaneous water heaters the voltage between the power terminals of the triacs is subtracted from the measured voltage. The measuring equipment should respond fast enough to enable correct measurement of power, including reactive power. Measurement can be done with measuring devices shall operate in their optimal measurement range and use a measurement time interval as long as necessary to attain reliable results

Second, the time t_{start_i} is measured, which elapses between energizing the heating element and the moment the Product delivers useful water, i.e. reaches specific Tm_i values at flowrates f_i , for each draw-off ***i*** for the selected tapping pattern as indicated in Table 2. For each combination of Tm_i and f_i at least three measurements shall be done; the resulting t_{start} is the mean value from these measurements.

The value of ***Qelec*** shall be calculated as follows:

$$Qelec = \frac{V1 * I1}{V2 * I2} * \left(Qref + \sum_{i=1}^{n} wh * t_{start_i} * (Tm_i - Tcold) * f_i \right)$$

where

Qelec is 24h electricity consumption (parameter 12.2 in DATA REPORT), in kWh/d (electric);

V1, V2 are voltages of mains power supply (V1) and electric heating element (V2) respectively, measured across the terminals and the connectors of the heating elements, in V;

I1, I2 are electric currents of mains power supply (I1) and electric heating element (I2), measured for each phase, in A;

Qref is useful hot water energy content of the selected 24h tapping pattern (from Table 2), in kWh/d

wh is specific heat of water: 0,00116 kWh/ltr.K;

n is total number of draw-offs in the selected tapping pattern (from Table 2);

i is index of draw-off in the selected tapping pattern (from Table 2);

t_{start_i} is time elapsed between energizing the heating element and the moment the Product delivers useful water for draw-off ***i***, in h;

Tm_i is the temperature from which counting of useful energy content starts for draw-off ***i***, in ºC;

Tcold is the cold water inlet temperature 10 ºC .

f_i [in kg/h] is the flowrate specified for draw-off ***i*** in the selected tapping pattern (from Table 2, with 1 l/min= 1/3600 kg/h). If this flowrate is lower than the minimum flowrate of the appliance specified by the manufacturer, the latter shall be used. This will be specified in the test report.

Permissable deviations from General conditions for measurement are specified in Section 3. Water pressure (dynamic) at the water inlet shall be within the range indicated by the manufacturer. Mounting /

positioning of appliance shall be done according to manufacturers instructions. The minimum measurement accuracies are specified in Section 3

4.4. Smart Control Test Procedure

Measurement procedure

Each manufacturer asking smart control bonus shall demonstrate that the Product with smart control feature enabled saves 10% primary energy, compared to the same appliances not equipped with smart control feature, following the procedure described hereafter

- The appliance shall be submitted to the same test procedure as for a usual efficiency test, but using at least for one week a daily tapping profile as shown in following table, in order to allow consumer behavior learning and/or to measure energy consumption without smart control activation. The manufacturer may choose to perform the test for a longer period than the minimum one week period.
- In a second step, the test is performed for the same period as for the first step, using the same repetition of tapping profile, but with smart control function activated (following manufacturer instructions for end-user in case of not automatic functioning).. The energy consumption is measured during the second step and compared to the energy consumption of the first step. The second step value has to be at least 10% lower than the first step value.
- The tapping profile by day has to follow the table below, where WHL is the Load Profile chosen by the manufacturer corresponding to the Product tested without the smart control feature enabled. And WHL-1 is the WHL corresponding to the immediate lower Load Profile. In the (unlikely) case that WHL is the smallest Load Profile XXS, the immediate higher Load Profile WHL+1 shall replace WHL-1 in the table below.

Table 12

Learning week	**“smart” week**
Day 1: WHL	Repetition in the same order
Day 2: WHL-1	
Day 3: WHL	
Day 4: WHL-1	
Day 5: WHL	
Day 6: no tapping	
Day 7: no tapping	

The complete procedure has to be performed without activation of eventual specific national requirements

Rating process

First step : Manufacturer has to test the smart control technology as described above, in order to demonstrate a 10% saving.

Second step : Manufacturer has to test the Product according to the selected Load Profile to assess the primary energy consumption (Qfuel+2,5*Qelec), but with the smart control feature disabled.

Third step : Efficiency is calculated by manufacturer as a result of the test (without smart control activation) and applying smart control bonus to the result obtained.

Verification process

Market surveillance authorities, to verify the declaration of water heaters using smart controls should set randomly the sequence of tapping during the first step. This should avoid that simple pre-programmed appliances are sold as smart controls, but are not able to save energy or to satisfy real end-user needs.

4.5. Simplified smart control procedure for EIWHs

This procedure applies only to Electric Instantaneous Water Heaters (EIWHs)
Comprises sophisticated control to supply the desired/required power to the water heating system by means of:

1. Power control capable of switching any required power between at least 50% and maximum rated power with a maximum power resolution of 200W depending on flow rate and water temperature to minimize power consumption;
2. devices to detect at least the flow rate and the inlet or outlet temperature;
3. device which calculates without user intervention the power required to stabilize the temperature of the outlet water at the desired level in-between switch on flow rate and power limit, regardless of flow rate, water pressure and inlet temperature.

Compliance is checked by measurement of the input power at minimum 5 different operating points (outlet water temperature and flow rate) within the specified operating range whereas the operating points should be selected at equidistant points in terms of input power, distributed over the variable power part at a tolerance of ± 10%. At compliance a smart control bonus can be applied (parameter dhwsmart=1=yes). A test report shall be provided.

5. EFFICIENCY CALCULATION

The efficiency of a water heater is the ratio between the delivered energy in the hot water for the tapping pattern for its size (XXS - 4XL, see Table 2) and the consumed energy converted to primary energy. The consumed energy is the result of the test of the water heater with adjustments for:

- Waste heat from the heater that contributes to space heating
- Smart controls that can increase water heater efficiency, in this method with 10%
- Distribution losses that is different for different types of water heaters

The efficiency of the water heater is then

$$\boldsymbol{etawh} = \frac{\boldsymbol{Qref}}{\boldsymbol{Qnet} + \boldsymbol{Qwdistr} - \boldsymbol{Qrecover}} \quad (1)$$

where:

Qref is the delivered energy for the 24 h tapping pattern for the size of the water heater (XXS - 4XL) from Table 2, in kWh.

Qnet is primary energy consumption, with conversion factor 2,5 for power generation, from test with correction for smart controls

$$\boldsymbol{Qnet} = (\boldsymbol{Qfuel}+2,5*\boldsymbol{Qelec})*(1-0,1\boldsymbol{dhwsmart}) \quad (2)$$

Qdistr is the annual distribution loss that is typical of this water heater depending on its size and type. It is given in the table 11. Values take into account only distribution losses inside dwellings. For collective/centralized systems as well as circulation systems extra distribution losses and –in case of an extra store—storage losses are to be taken into account in application-oriented measures.

Qrecover is waste heat from the water heater that is useful as space heating,

$$\boldsymbol{Qrecover} = \boldsymbol{qrecov}*\ \boldsymbol{Qrwaste} \quad (3)$$

The declared efficiency of electric water heaters must be limited to 40% (***etawh*** <= 0.40 for ***Qfuel*** = 0), which is a necessary condition to apply because the formula could give a higher eficiency for electric (instantaneous) water heaters with smart controls.

The water heater efficiency can thus also be described as:

$$\boldsymbol{etawh} = \frac{\boldsymbol{Qref}}{(\boldsymbol{Qfuel}+2,5*\boldsymbol{Qelec})*(1-0,1\boldsymbol{dhwsmart}) + \boldsymbol{Qdistr} - \boldsymbol{qrecov}*\ \boldsymbol{Qrwaste}} \quad (4)$$

where

Qfuel is the consumption of fuel (oil and gas) during test with relevant 24 h tapping pattern in kWh;

Qelec is the consumption of electricity during test with relevant 24 h tapping pattern in kWh;

dhwsmart is indicating the presence of smart controls from par. 4.4 and 4.5 (yes = 1, no = 0);

Qdistr is the annual distribution loss as indicated above

qrecov is the percentage of waste heat recovered for space heating. It depends on boiler position, noise level, outer volume, and air intake. It is given in Table 9. It varies from 0 (for outdoor installations) to 32% (for small electric water heaters).

Qrwaste is the recoverable waste heat in the room of the water heater. For conventional Products it is the total heat loss minus the heat in the flue gas, ***Qfluegas***. It can be expressed as:

Qrwaste [conventional] **= *Qfuel* + *Qelec* - *Qref* - *Qfluegas*,** **5a**

where ***Qfluegas* = 0** for electric water heaters

For Solar Products the net power output of the solar collector simulator ***Qsolsim*** is added and if the designated position of the solar tank is outdoors (***solpos***= outdoors = 0; ***solpos***=indoors=1 in the Data Report) the recoverable waste heat is only half.[10] Note that for Solar Products Qrwaste has to be determined with Colder and Warmer climate conditions too, using ***QsolsimC*** and ***QsolsimW*** respectively

Qrwaste[solar] = (0,5 + 0,5***solpos***) * { ***Qfuel* + *Qelec* + *Qsolsim* – *Qref* – *Qfluegas* },** **5b**

For Heat Pump Products only the 24h standby losses of the storage tank Phpstby, from test procedure described in par. 4.2.9,are taken into account. This value is used for all climate conditions.

Qrwaste[heat pump] = 24 * Phpstby**,** **5c**

For water heaters with flue gas temperature ***Tflue*** (from DATA REPORT) more than 20 ºC above the corrected dew point temperature (***dptc***, see Section 3) the heat in the flue gas is calculated as

Qfluegas = ***Qfuel*** **(**1-***etacomb*** - ***LHL***), **6a**

where:

etacomb is combustion efficiency with reference to the net caloriferic value of the fuel from the DATA REPORT.

LHL is latent heat in fuel, set to 10% for gas and 6% for oil

dptc is taken from Table 10 for the relevant fuel and then corrected

For water heaters with flue gas temperature lower than 20 ºC above corrected dewpoint temperature (***dptc***) the heat in the flue gas is calculated as

$$Qfluegas = Qfuel\,(1 - etacomb - LHL * \frac{Tflue-20}{dptc})$$ **6b**

The typical annual primary energy consumption for the load profile ***Qatot*** can be calculated with the value found for ***etawh:***

$$Qatot = \frac{0{,}6*366Qref}{etawh}$$ **7**

With solar-assisted and air-source heat pump water heaters the efficiency in “Colder” or “Warmer” conditions –***etawhC*** and ***etawhW-*** - can be calculated by substituting ***Qfuel*** and ***Qelec*** with ***QfuelC*** and ***QelecC*** or ***QfuelW*** and ***QelecW*** in the above equations. Likewise the typical annual energy consumption values for ***QatotC*** and ***QatotW*** shall be calculated as in equation [7] using the ***etawhC*** and ***etawhW*** efficiency values. [11]

[10] This assumes that the back-up heater is still placed indoors. If also the back-up heater is placed outdoors (e.g. an electrc resistance heater in an Integrated Collector Storage unit) the Product will be marked as boilpos=outdoors and this is taken into account in factor qrecov.

[11] Note that for “Colder” or “Warmer” climate conditions –by definition-- equations [5b] or [5b] and not equation [5a] apply.