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Efficiency of domestic electrical storage water-heaters

Efficacité des chauffe-eau électriques à accumulation

Wirkungsgrad von elektrischen Warmwasserspeichern für den Hausgebrauch

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CENELEC

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Foreword

This draft European Standard was prepared by the Technical Committee CENELEC TC 59X, Consumer information related to household electrical appliances. It is submitted to the CENELEC enquiry.

This European Standard will supersede EN 60379:2004, Methods for measuring the performance of electric storage water-heaters for household purposes.

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1 Scope

This European Standard applies to thermally insulated domestic storage water-heaters with 5 l or more of rated capacity.

The purpose of this European Standard is to define the methods to be used for measuring energy consumption of thermally insulated domestic electric storage water-heaters taking into account the efficiency of the appliance related to standing loss and the energy consumption when withdrawing standardized quantities of water. This European Standard is concerned neither with safety nor with performance requirements.

2 Normative references

No normative references are given.

3 Symbols and definitions

3.1 Symbols

$\dot{v}$	[l/min]	Water flow during draw-off cycles
η		Performance ratio of the appliance
θ	[°C]	Temperature indicated on thermostat dial
θ_{in}	[°C]	Water temperature after reference thermostat cut-in (as measured with the thermocouple reference)
$\theta_{in\ M}$	[°C]	Mean water temperature after reference thermostat cut-in (as measured with the thermocouple reference)
θ_M	[°C]	Mean water temperature without withdrawal
θ_{out}	[°C]	Water temperature after reference thermostat cut-out (as measured with the thermocouple reference)
$\theta_{out\ M}$	[°C]	Mean water temperature after reference thermostat cut-out (as measured with the thermocouple reference)
θ'_p	[°C]	Mean water temperature for the determination of θ_p, measured at the outlet
θ_{AA}	[°C]	Hot water temperature before beginning of the draw-off cycle (testing procedure 2)
θ_{AH}	[°C]	Temperature of the water inside of the water-heater after the first cut out of the thermostat
θ_{amb}	[°C]	Ambient temperature during the tests
θ_C	[°C]	Temperature of inlet cold water
θ_p	[°C]	Mean water temperature at the outlet
θ_S	[°C]	Water temperature during measurement, measured at the outlet
A	[°C] or [K]	Deviation of dial calibration
C_{act}	[l]	Actual capacity
C_R	[l]	Rated capacity

E	[kWh/24 h]	Energy consumption per 24 h
E_1	[kWh]	Measured value of standing loss
E_2	[kWh]	Calculated energy consumption for a 8 hours period when maintaining hot conditions with test conditions [kWh]
E_3	[kWh]	Calculated corrected energy E_2 according to required design temperature for test.
E_{ab}	[kWh]	Corrected energy consumption during test according to tapping cycle n° [1, 3]
E_{HEAT}	[kWh]	Energy added to the water-heater by reheating after the water withdrawal [kWh]
$E_{HEAT\ corr}$	[kWh]	Corrected E_{HEAT} according to required design temperature
E_v	[kWh]	Measured energy consumption when maintaining water-heater in hot conditions after heating up (8.2.1.4)
E_{v_small}	[kWh]	Measured energy consumption during 24 h cycle for small appliances (8.2.1.4)
E_{WATER}	[kWh]	Thermal energy withdrawn during 24 h cycle
Q_{pr}	[kWh/24 h]	Standing loss per 24 h and temperature difference 45 °C
Q_{pr_cal}	[kWh]	Standing loss per 24 h, calculated from E_1
t	[s]	Measurement time
t_0	[s]	Time to fill the water-heater
t_1	[s]	Start up measurement time of heating (Step 2)
t_2	[s]	Start-up measurement time of Step 3
t_3	[s]	Start-up measurement time of Step 4
t_4	[s]	Start-up measurement time of Step 5
t_5	[s]	Start-up measurement time of Step 6
t_6	[s]	Start-up measurement time of Step 7
t_7	[s]	Start-up measurement time of Step 8
t_h	[s]	Correction value for heating up duration according to experimental data
t_{h_exp}	[s]	Measured duration for heating up
t_R	[s]	Reheating-time
V_{40_exp}	[l]	Measured volume delivered at a mean water temperature of θ_p
V_{40}	[l]	Mixed water quantity delivered at 40 °C
W_u	[l]	Quantity of water used during the 24 h cycle (8.2.1.4.2 or 8.2.2.4.2)

3.2 Definitions

3.2.1
storage water-heater
appliance intended for heating water in a thermally insulated container, for the long-term storage of heated water and provided with a device to control the water temperature

3.2.2
rated capacity (C_R)
water capacity assigned to the water-heater by the manufacturer and marked on it

3.2.3
actual capacity (C_{act})
water capacity determined by measurement

3.2.4
standing loss per 24 h (Q_{PR})
energy consumption of a filled water-heater, when connected to the electrical supply, after steady state conditions have been reached, during any 24 h period when no water is withdrawn

3.2.5
mixed water quantity delivered at 40 °C (V_{40})
quantity of water at 40 °C which has the same heat content (enthalpy) as the content of the storage water-heater at a water temperature of 65 °C

3.2.6
reference thermostat
device used to increase precision of the measurement of stand-by loss

4 Appliances categories

Category 1: Rated capacity from 5 l to < 45 l

Category 2: Rated capacity of 45 l or more than 45 l

5 List of measurements

- measurement of the actual capacity C_{act}
- standing loss per 24 h Q_{pr}
- mixed water output V_{40}
- electric consumption relevant to the usage $E_{HEAT\ corr}$
- energy loss per cycle E_3
- duration for heating up [s] t_{h_exp}
- water used during the 24 h cycle W_u

6 General conditions for measurements

Unless otherwise specified measurements are carried out on the water-heater operating

- in a substantially draught-free room,
- at an ambient temperature θ_{amb} = (20 ± 2) °C.

The ambient temperature is calculated from measurements at a number of locations half-way between the water-heater and the walls of the room or 1 m distant from the water-heater, whichever is less, and at half the height of the water-heater.

Measurements shall be carried out with a supply voltage of 230/400 V ± 2 %.

The water is supplied at a temperature θ_C = (15 ± 2) °C and provided from a source having a substantially steady pressure.

All other installation requirements are made according to the manufacturer's instructions.

7 Preparation of the storage water-heater

7.1 Mounting of the storage water-heater

Wall-mounted water-heaters are mounted on a panel situated at least 150 mm from any structural wall.

There shall be a clear space of at least 250 mm above and below the heater and at least 700 mm at the sides and front.

Floor-mounted water-heaters are placed on the floor or on any stand supplied with them. A false floor may be used to facilitate measurements.

Water-heaters for building-in are built in according to the manufacturer's instructions.

The water-heater is connected to the water system by means of a pressure hose.

7.2 Reference thermostat

7.2.1 Role of reference thermostat

The role of this device is to manage the repetition of the course of the heating cycles in order to ensure their stability. The substitution of the original thermostat by this device makes it possible to become free from the random behaviour of the thermostat which often significantly influences the results of the test.

7.2.2 Properties of reference thermostat

7.2.2.1 Function of reference thermostat

To ensure the switching on- and off-level of the heater.

7.2.2.2 Position of reference thermostat

The position of the temperature probe of the reference thermostat is indicated in Figure 1.

7.2.2.3 Tests where the reference thermostat is used

For standing loss per 24 h (Q_{pr}) see 8.2.1.5 and 8.2.2.7.

For hot water output and mixed water output (V_{40}) see 8.2.1.6 and 8.2.2.8.

7.2.2.4 Reference thermostat characteristics

The characteristics of the reference thermostat are as follows:

– switch-on at a reference temperature of 65 °C -0/+1 °C;

– switch-off at a reference temperature of 60 °C -0/+1 °C.

7.2.2.5 Application of reference thermostat

The device may be carried out with various techniques. For instance the reference thermocouple, already used for the measurement of the heating thresholds of release and interlocking (Figure 1), can be associated with software designed to detect these thresholds in order to manage the heating periods.

8 Methods of measurement

8.1 Measurement of the actual capacity: C_{act}

The water-heater is disconnected from the water mains.

The water-heater is filled in accordance with the manufacturer's instructions. It is then emptied through the water inlet or – if not possible – through the drain plug opening. Alternatively the actual capacity can be calculated from the difference of weights of the empty and the filled appliance.

For measurements of capacity water from separate feed cisterns is not taken into account. The actual capacity measured is recorded as C_{act} to the nearest one-tenth litre and shall not be less than the rated capacity C_R as stated by the manufacturer.

8.2 Energy consumption relevant to usage

8.2.1 Water-heaters with a rated capacity < 45 l (testing sequence see Figure 2)

8.2.1.1 Step 1: Filling

Water-heater is filled with water of a temperature of 15 ± 2 °C.

The time to fill the water-heater t_0 is recorded.

8.2.1.2 Step 2: Heating up

t_1: time the water-heater is powered ON $(t_1 - t_0) < 15$ min

t_2: time when the thermostat cuts off the first time

Result of Step 2 : heating up time t_h

Initial temperature of the water inside of the water-heater: θ_C [°C]

Water temperature at the first cut out of the thermostat: θ_{AH} [°C]

Heating up time: $t_{h\_exp} = t_2 - t_1$