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Soft ice cream machines — Performance and evaluation of energy consumption

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National foreword

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European foreword

This document (EN 16764:2016) has been prepared by Technical Committee CEN/TC 44 “Commercial and Professional Refrigerating Appliances and Systems, Performance and Energy Consumption”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2016, and conflicting national standards shall be withdrawn at the latest by July 2016.

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1 Scope

This European Standard specifies requirements and test conditions of soft ice cream machines for processing ice cream and similar frozen desserts.

It defines machines performance characteristics and energy consumption, measured under specified conditions and test methods, using a reference test mix.

This European Standard applies to the following types of soft ice cream machines: commercial ice cream, soft serve and shake freezers, which freeze and dispense frozen product (e.g. dairy, yogurt), included are conventional operation and pasteurization phase. The equipment may include separate refrigeration systems for the frozen product and fresh mix and may be either air-cooled or water-cooled.

The soft ice cream machines are evaluated for the following performance:

— maximum energy input rate, or maximum current draw,

— production capacity,

— overrun,

— initial freeze-down energy consumption and duration,

— production energy consumption,

— idle energy consumption,

— stand-by energy consumption,

— pasteurization energy consumption (if applicable).

2 Normative references

Not applicable.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
compression type machines
machines where the cooling is performed by means of a refrigerant liquid at low pressure in a heat exchanger (evaporator), the steam thus formed becomes a liquid by a mechanical compression higher pressure and cooling in another heat exchanger (condenser)

3.2
condenser
heat exchanger in which after compression, the vaporized refrigerant is liquefied, giving off heat to external cooling system

3.3
evaporator
heat exchanger in which, after the reduction of pressure, the refrigerant is vaporized by absorbing heat from the medium which is cooled

3.4
pasteurization phase energy consumption
phase during which test mix is heated for a time fixed to different type of pasteurization and then immediately cooled to conservation temperature, to avoid the bacteria's development

3.5
soft ice cream
frozen soft and creamy dessert usually made with ready mixes that can be liquid or dry to be rehydrated

3.6
overrun
percentage increase in volume due to the addition of air to frozen product; the calculation of the overrun is the ratio between the liquid mix and the frozen mix

3.7
initial freeze down energy consumption
time and energy consumption required for a soft ice cream machine to be ready to serve when loaded with unfrozen product

3.8
idle energy consumption
rate of energy consumed by the soft ice cream machine while maintaining the product in a ready-to-serve state without dispensing product

3.9
stand-by energy consumption or night conservation
rate of energy consumed by the soft ice cream machine while maintaining the product without dispensing

3.10
freeze-down energy consumption
amount of energy consumed by the soft ice cream machine while cooling the product to a servable temperature

3.11
freeze-down time
time required for the soft ice cream machine for cooling the product to a servable temperature

3.12
reference test mix
product specifically prepared for testing

3.13
production capacity
number of reference portions drawn-off per hour

3.14
reference portion
mass of drawn-off soft ice cream equal to 150 g

3.15
hopper
reserve tank for the liquid reference test mix, which is feeding the freezing cylinder of the machine

3.16
soft ice cream machine
multifunction machine to pasteurize, conserve and freeze liquid mix

Note 1 to entry: On demand the soft ice cream is immediately distributed.

3.17
product temperature (extrusion temperature)
temperature of the mix in the hopper and temperature of frozen product immediately after extrusion

4 Performance characteristics

4.1 General

In order to carry out the performance characteristics of a soft ice cream machine, start by loading with a non operating empty soft ice cream machine at the test room temperature (24 °C ± 3 °C). The reference test mix shall be refrigerated prior to any testing. Fill the hopper with refrigerated reference test mix (5 °C ± 1 °C) to the manufacturer's recommended level. Switch on the soft ice cream machine. Fill the cylinder(s) and start the initial freeze down phase.

4.2 Initial freeze down

Record energy consumption, elapsed time and water consumption (if applicable) of the initial freeze down. When the machine is ready, according to the instructions of the manufacturer, dispense four portions of 75 g of soft ice cream and measure the temperature at the centre of the mass of the fourth portion.

The soft ice cream characteristics shall be the following:

— temperature < –5 °C;

— overrun with gravity machines > 20 %;

— overrun with pressurization pump machines > 40 %.

4.3 Production capacity

Production capacity of the soft ice cream machine declared by the manufacturer shall be verified (see 5.4.2.2) by the number of reference portions and the mass of soft ice cream obtained per hour.

The soft ice cream characteristics shall be the following:

— temperature < –5 °C;

— overrun with gravity machines > 20 %;

— overrun with pressurization pump machines > 40 %.

4.4 Production energy consumption

Production energy consumption of the soft ice cream machine shall be measured (see 5.4.2.3) by drawing-off 150 g reference portions respecting time intervals of 60 s. Soft ice cream draw-off shall be done for 30 min.

The soft ice cream characteristics shall be the following:

— temperature < –5 °C;

— overrun with gravity machines > 20 %;

— overrun with pressurization pump machines > 40 %.

4.5 Idle energy consumption

Idle energy consumption of the soft ice cream machine shall be measured (see 5.4.3) checking that hopper mix temperature and energy consumption of the soft serve machine maintains product temperature for a minimum of 2 h.

4.6 Stand-by energy consumption

Stand-by energy consumption of the soft ice cream machine shall be measured (see 5.4.4) checking that hopper mix temperature and energy consumption of the soft serve machine maintains product temperature for a minimum of 4 h.

4.7 Pasteurization phase energy consumption

The machine shall be operated as long as necessary so that the reference mix reaches the heating temperature > 65 °C for 30 min and then proceed to the cooling phase to the storage temperature −5 °C. Record the elapsed pasteurization times, the pasteurization temperature and the energy consumption. Record the water consumption, if applicable.

4.8 Product temperature (extrusion temperature)

The product temperature of the frozen reference test mix (Clause 6) depends on the adjusting and setting of the freezing equipment and is directly related to the characteristics of the final product.

The extrusion temperature of the frozen reference test mix (Clause 6) affects the energy consumption of the soft ice cream machine.

4.9 Overrun

Generally during the freezing of the reference test mix (Clause 6) air enters in the freezing chamber and is blended into the frozen product.

The overrun of the frozen product (Clause 6) depends on the adjusting and setting of the freezing equipment and is directly related to the characteristics of the final product. The overrun obtained with the operation of the beater and the operation of the pressurization pumps (if foreseen) affects the energy consumption of the soft ice cream machine.

5 Energy consumption test

5.1 Test room

5.1.1 General design, walls, floor and radiant heat

The test room shall be a parallelepiped space in which two of the opposite side walls, referred to as the discharge technical side wall and the return technical side wall, are designed to create an even, horizontal air flow within the test room. By convention, the distance separating these two technical side walls is referred to as the “length” of the test room.

The minimum useful dimensions (length, width, height) of the test room shall be dependent on the overall dimensions (length, depth, height) of the machine to be tested.

The ceiling and the two non-technical side walls of the room shall be thermally insulated and shall be equipped with an inner metal skin.

A minimum insulation level equivalent to 60 mm of rigid polyurethane foam $\lambda = 0{,}03$ W/(m K) should be used for the building of a new test room.

The floor shall be made of concrete or of thermally equivalent material and/or shall be sufficiently insulated to ensure that external climatic conditions do not affect the floor temperature.

5.1.2 Thermal characteristics

An experimental evaluation of the test-room performances shall be carried out minimum once per year.

Air temperature measured at different points shall not deviate from the rated temperature of the test-room by more than ± 2 K.

The test room shall be capable of maintaining values of humidity within ± 5 units of the relative humidity percentage figures of the rated humidity of the test room temperature class at the specified measuring points.

The surface temperatures of the walls shall remain within a tolerance of ± 2 K in relation to the air temperature measured in the test room.

The point for measurement of ambient temperature and relative humidity shall be midway along the length of the machine.

5.1.3 Ambient temperature and humidity

The ambient temperature in the test room shall be 22 °C. Ambient temperatures shall be kept constant within ± 3K both during the periods required for obtaining stable operating conditions and during the tests. Unless otherwise specified, relative humidity shall not exceed 75 %.

5.2 Apparatus

All the test apparatus, listed below, shall be calibrated at least once every two years.

5.2.1 Balance, with a resolution of at least 2 g.

5.2.2 Stop watch, with a 1 s resolution.

5.2.3 Thermometer probe, capable of immersion with a resolution at least of 0,5 °C.

5.2.4 Watt-hour meter, for measuring the electrical energy consumption, having a resolution of at least 10 Wh and a maximum uncertainty no greater than 1,5 % of the measured value for any demand greater than 100 W. For any demand less than 100 W, the meter shall have a resolution of at least 1 Wh and a maximum uncertainly no greater than 10 %.

5.2.5 Water meter having a resolution of 1 l.

5.2.6 Water pressure gauge having a resolution of 10 kPa.

5.3 Installation

Install the machine in test room according to the manufacturer's instructions. It has to be ensured that the soft ice cream machine has reached the test room temperature before starting.

Machine placement from the walls of the test room shall be indicated in the test report. Connect the machine to a calibrated energy test meter. A voltage regulator may be required during tests if the voltage supply is not within ± 2,5 % of the manufacturer's nameplate voltage. Confirm (while the machine compressor(s) are energized) that the supply voltage is within ± 2,5 % of the operating voltage specified by the manufacturer. Record the test voltage for each test and indicate the value in the test report.

5.4 Test cycle

5.4.1 Initial freeze down phase

The initial freeze down cycle of the reference test mix is the following:

— start the test with a non operating and empty machine;

— add the reference test mix at 5 °C ± 1 °C;

— switch the power on and operate the soft ice cream machine following the instructions of the manufacturer;

— start recording time, water consumption and energy consumption.

When the machine is ready, according to the instructions of the manufacturer, verify the characteristics dispensing five portions of 150 g of soft ice cream and measure the temperature at the centre of the mass of the fifth portion and the overrun (5.4.6).

The soft ice cream characteristics shall be the following:

a) temperature < −6 °C;

b) overrun with gravity machines > 20 %;

c) overrun with pressurization pump machines > 40 %;

— record the final time of the freeze down phase;

— record the water and energy consumption.

5.4.2 Production phase

5.4.2.1 General

At the end of the initial freeze down phase (5.4.1) the production phase starts.

In soft ice cream machines with 2 cylinders, the draw off shall be done with the central lever.

5.4.2.2 Production capacity

The production capacity shall be determined as follows:

— calculate the number of reference portions (150 g) to draw-off dividing the weight capacity as declared by the manufacturer (expressed in g), by the reference portion;

— calculate the time intervals for testing dividing 3 600 s by the number of reference portions obtained;

— start the draw-off and continue for 30 min;

— measure the temperature at the centre of the mass of the fifth, fifteenth and twenty-fifth portion and the overrun (5.4.6).

The soft ice cream characteristics shall be the following:

a) temperature < −6 °C;

b) overrun with gravity machines > 20 %;

c) overrun with pressurization pump machines > 40 %.

5.4.2.3 Production energy consumption

Production energy consumption shall be determined as follows:

— start recording time, water consumption and energy consumption;

— draw-off ≥ 150 g reference portions respecting time intervals of 60 s for 30 min;

— measure the temperature at the centre of the mass of the fifth, fifteenth and twenty-fifth portion and the overrun (5.4.6).

The soft ice cream characteristics shall be the following:

a) temperature < −6 °C;

b) overrun with gravity machines > 20 %;

c) overrun with pressurization pump machines > 40 %;

d) record energy consumption, elapsed time and water consumption (if applicable).

5.4.3 Idle energy consumption

Idle energy consumption shall be determined as follows:

— place the machine in its ready-to-serve idle mode;

— start recording time, water consumption and energy consumption;

— monitor the elapsed time for a minimum of 2 h;

— record energy consumption and water consumption (if applicable);

— check the temperature of the mix in the hopper. The temperature shall be ≤ 5 °C;

— after 2 h draw-off five 150 g reference portions and check if the fifth reference portion has the following characteristics:

  a) temperature < −6 °C;

  b) overrun with gravity machines > 20 %;

  c) overrun with pressurization pump machines > 40 %.

5.4.4 Stand-by energy consumption

Stand-by energy consumption shall be determined as follows:

— place the machine in stand-by mode;

— start recording time, water consumption and energy consumption;

— monitor the elapsed time for a minimum of 4 h;

— record energy consumption and water consumption (if applicable);

— check the temperature of the mix in the hopper. The temperature shall be ≤ 5 °C.

5.4.5 Pasteurization phase energy consumption

Pasteurization phase energy consumption shall be determined as follows:

— place the machine in pasteurization mode;

— start recording time, water consumption and energy consumption;

— operate the soft ice cream machine as long as necessary so that the reference mix reaches the heating temperature > 65 °C;

— record the starting heating temperature measuring it directly in the hopper and in a drawn-off reference test mix (150 g) from the cylinder;

— maintain the heating temperature > 65 °C for 30 min;

— record the final heating temperature measuring it directly in the hopper and in a drawn-off reference test mix (150 g) from the cylinder;

— proceed to the cooling phase to the storage temperature ≤ 5 °C;

— record the cooling temperature measuring it directly in the hopper and in a drawn-off reference test mix (150 g) from the cylinder;

— record energy consumption and water consumption (if applicable).

5.4.6 Overrun determination

Fill a transparent cup of at least 200 ml with the liquid reference test mix at a temperature ≤ 5 °C. The liquid reference test mix is filled to the upper rim of the transparent cup with a spatula.

— determine the mass of the liquid reference test mix in the transparent cup (mass A expressed in grams);

— the fifth, fifteenth and twenty-fifth portion shall be drawn-off in the transparent cup, minimizing the presence of air bubbles, made it even with a spatula at the upper rim of the transparent cup;

— determine the mass of the frozen product in the transparent cup (mass B expressed in grams);

— the overrun is calculated with the following formula:

$$\%\ overrun = \left[\left(Mass\ A / Mass\ B\right) - 1\right] \times 100 \quad (1)$$

5.4.7 Test evaluation

In case of failure of one or more of the tests carried out according to clauses from 5.4.1 to 5.4.6, the whole test shall be considered as failed and shall be repeated following the procedure from 5.4.1 to 5.4.6.

6 Reference test mix

Soft ice cream Mix, liquid mix shall consist of nominally 4 % milk fat and have a vanilla flavour only.

Mix may be either hermetically sealed in storage bags or stored in cartons and shall be refrigerated to 1,5 ± 0,5 °C prior to all tests.

The reference test mix used for the tests shall have the composition indicated in Table 1.

Table 1 — Reference test mix

Ingredients	**Quantity to be prepared** kg			
	1	10	60	120
Water	0,655	6,55	39,3	78,6
Saccarose	0,170	1,70	10,2	20,4
Dry milk	0,100	1,00	6,0	12,0
Nonfat dry milk	0,040	0,40	2,4	4,8
Dry coconut fat (refined and hydrogenated)	0,030	0,30	1,8	3,6
Stabilizer and emulsifier	0,005	0,05	0,3	0,6
TOTAL	1,000	10,00	60,0	120,0

The composition of the stabilizer and emulsifier is indicated in Table 2.

Table 2 — Stabilizer mix

Ingredients	**Quantity to be prepared** kg
	1
E410 Locust Bean Gum	0,100
E412 Guar Gum	0,250
E466 Carboxymethyl cellulose (CMC) or cellulose gum (viscosity 2000 cP)	0,100
E473 Sucrose esters of edible fatty acids sp70	0,085
Icing sugar	0,465
TOTAL	1,000

7 Test report

The test report shall contain at least the following information:

— the manufacturer's name or trademark;

— type and serial number of the machine;

— production capacity found by test (kg/h);

— performance and evaluation of energy consumption:

a) initial freeze down phase energy consumption (kWh/kg);

b) initial freeze down phase water waste (dm^3);

c) initial freeze down time (s);

d) production phase energy consumption (kWh/kg);

e) production phase water waste (dm^3);

f) idle energy consumption (kWh/kg);

g) idle water waste (dm^3);

h) stand-by energy consumption (kWh/kg);

i) stand-by water waste (dm^3);

j) pasteurization phase energy consumption (kWh/kg);

k) pasteurization phase water waste (dm^3);

l) total energy consumption (kWh/kg);

m) total water consumption (dm^3).

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