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Australian/New Zealand Standard™

Household refrigerating appliances — Characteristics and test methods

Part 3: Energy consumption and volume



AS/NZS IEC 62552.3:2018

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Australian/New Zealand Standard™

Household refrigerating appliances — Characteristics and test methods

Part 3: Energy consumption and volume

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Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-060, Household Refrigerating Appliances, to supersede part of AS/NZS 4474.1:2007, *Performance of household electrical appliances—Refrigerating appliances*, Part 1: *Energy consumption and performance*.

A1 Amendment No. 1 to this Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-060, Household Refrigerating Appliances. **A1**

The objective of this Standard is to specify the essential characteristics of household and similar refrigerating appliances cooled by internal natural convection or forced air circulation, and establishes test methods for checking these characteristics. This part of AS/NZS IEC 62552 describes the methods for the determination of energy consumption characteristics and defines how these can be assembled to estimate energy consumption under different usage and climate conditions. This part of AS/NZS IEC 62552 also defines the determination of volume.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**HOUSEHOLD REFRIGERATING APPLIANCES –
CHARACTERISTICS AND TEST METHODS –****Part 3: Energy consumption and volume****FOREWORD**

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IEC 62552-3 edition 1.1 contains the first edition (2015-02) [documents 59M/63/FDIS and 59M/66/RVD] and its amendment 1 (2020-11) [documents 59M/128/FDIS and 59M/134/RVD].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

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Standard IEC 62552-3 has been prepared by subcommittee 59M: Performance of electrical household and similar cooling and freezing appliances, of IEC technical committee 59: Performance of household and similar electrical appliances

IEC 62552-1, IEC 62552-2 and IEC 62552-3 together constitute a technical revision and include the following significant technical changes with respect to IEC 62552:2007:

- a) All parts of the standard have been largely rewritten and updated to cope with new testing requirements, new product configurations, the advent of electronic product controls and computer based test-room data collection and processing equipment.
- b) In Part 1 there are some changes to test room equipment specifications and the setup for testing to provide additional flexibility especially when testing multiple appliances in a single test room.
- c) For more efficient analysis and to better characterise the key product characteristics under different operating conditions, the test data from many of the energy tests in Part 3 (this part) is now split into components (such as **steady state** operation and defrost and recovery). The approach to determination of energy consumption has been completely revised, with many internal checks now included to ensure that data complying with the requirements of the standard is as accurate as possible and of high quality.
- d) Part 3 (this part) now provides a method to quantify each of the relevant energy components and approaches on how these can be combined to estimate energy under different conditions on the expectation that different regions will select components and weightings that are most applicable when setting both their local performance and energy efficiency criteria while using a single set of global test measurements.
- e) For energy consumption measurements in Part 3 (this part), no thermal mass (test packages) is included in any compartment and compartment temperatures are based on the average of air temperature sensors (compared to the temperature in the warmest test package). There are also significant differences in the position of temperature sensors in unfrozen compartments.
- f) The energy consumption test in Part 3 (this part) now has two specified ambient temperatures (16°C and 32°C).
- g) While, in Part 2 test packages are still used for the storage test to confirm performance in different operating conditions, in Part 1 they have been standardised to one size (100 mm × 100 mm × 50 mm) to simplify loading and reduce test variability. A clearance of at least 15 mm is now specified between test packages and the compartment liner.
- h) A load processing energy efficiency test has been added in Part 3 (this part).
- i) A tank-type ice making energy efficiency test has been added in Part 3 (this part).
- j) A cooling capacity test has been added in Part 2.
- k) A pull-down test has been added in Part 2.
- l) Shelf area and storage volume measurement methods are no longer included. In Part 3 the volume measurement has been revised to be the total internal volume with only components necessary for the satisfactory operation of the refrigeration system considered as being in place.
- m) Tests (both performance (Part 2) and energy (Part 3 – this part)) have been added for wine storage appliances.

The following print types are used in this international standard:

- requirements: in roman type;
- test specifications: in *italic type*;
- notes: in small roman type.
- Words in **bold** are defined in IEC 62552-1:2015, Clause 3 or in this part.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62252 series, published under the general title *Household refrigerating appliances – characteristics and test methods*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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INTRODUCTION

IEC 62552 is split into 3 parts as follows:

- IEC 62552-1: Scope, definitions, instrumentation, test room and set up of refrigerating products;
- IEC 62552-2: General performance requirements for **refrigerating appliances** and methods for testing them;
- IEC 62552-3: **Energy consumption** and **volume** determination (this part).

HOUSEHOLD REFRIGERATING APPLIANCES – CHARACTERISTICS AND TEST METHODS –

Part 3: Energy consumption and volume

1 Scope

This part of IEC 62552 specifies the essential characteristics of household and similar **refrigerating appliances** cooled by internal natural convection or forced air circulation, and establishes test methods for checking these characteristics.

This part of IEC 62552 describes the methods for the determination of **energy consumption** characteristics and defines how these can be assembled to estimate **energy consumption** under different usage and climate conditions. This part of IEC 62552 also defines the determination of **volume**.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62552-1:2015, *Household refrigerating appliances – Characteristics and test methods – Part 1: General requirements*

IEC 62552-2:2015, *Household refrigerating appliances – Characteristics and test methods – Part 2: Performance requirements*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62552-1, as well as the following apply.

3.1.1

specified auxiliaries

functions or features that affect the **energy consumption** of a **refrigerating appliance** and where their actual **energy consumption** depends on the conditions of use or operation

Note 1 to entry: This standard makes optional provision for determining the **energy consumption** impacts of these functions or features in accordance with regional requirements.

Note 2 to entry: Test requirements for specified auxiliaries, where applicable, are set out in Annex F and their application specified in 6.8.4. The only specified auxiliaries in this edition of the standard are ambient controlled anti-condensation heaters and tank type automatic icemakers.

3.1.2

defrost interval

the measured or estimated length of a **defrost control cycle**, starting from the point of initiation of one **defrost control cycle** to the point of initiation of the subsequent **defrost control cycle**, expressed in hours of elapsed (clock) time

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3.2 Symbols

For the purposes of this document, the following symbols apply.

E	electrical energy consumption over a specified period (day, year, etc.) in Wh or kWh
P	average steady power consumption over a defined period in W
T	compartment temperature average over a specified period in degrees Celsius (°C)
TMP_n	temperature measurement position of a specific temperature sensor
t	time at a specific moment
Δt	time interval in hours between two defined times or for a defined period
ΔE_{df}	additional energy associated with a defrost and recovery period , over and above the relevant steady state power consumption at the same temperature control settings , in Wh
ΔTh_{df-i}	the accumulated temperature difference over time (relative to the steady state temperature) during a defrost and recovery period in Kh for compartment i
Rt	actual compressor run time in hours for a defined period (actual compressor on period)
CRt	percentage of compressor run time for a defined period ($Rt/\text{total time interval}$ as %)
P_{Hi}	average heater power associated with an ambient controlled anti-condensation heater at a specified temperature and humidity in W (Annex F)
M	mass of water used for a processing load (Annex G) or the mass of water or ice during an ice making test (Annex F)

4 Applicable test steps for determination of energy and volume

4.1 Setup for energy testing

Prior to the measurement of **energy consumption** for a **refrigerating appliance**, it shall be set up in a test room as specified in Annex A.

4.2 Steady state power consumption

The **steady state power consumption** of the **refrigerating appliance** shall be determined in accordance with Annex B.

4.3 Defrost and recovery energy and temperature change

For products with one or more defrost systems (each with its own **defrost control cycle**), the incremental **defrost and recovery** energy for a representative number of **defrost and recovery periods** shall be determined in accordance with Annex C for each system. The temperature change associated with **defrost and recovery** shall also be determined in accordance with Annex C for each system.

4.4 Defrost frequency

For products with one or more defrost systems (each with its own **defrost control cycle**), the **defrost interval** for each system shall be determined in accordance with Annex D, depending on the control type.

4.5 Number of test points and interpolation

Where the **energy consumption** of a **refrigerating appliance** is interpolated in accordance with Clause 6, one of the methods specified in Annex E shall be used.

4.6 Load processing efficiency

Where the **load processing efficiency** of a **refrigerating appliance** is claimed or determined, it shall be measured in accordance with the method specified in Annex G.

4.7 Specified auxiliaries

Where a **refrigerating appliance** contains a specified auxiliary, the energy impact of this auxiliary shall be determined in accordance with Annex F.

4.8 Volume determination

The **volume** of each **compartment** of the **refrigerating appliance** shall be determined in accordance with Annex H.

5 Target temperatures for energy determination

5.1 General

The **energy consumption** of an appliance is determined from measurements taken when tested as specified in Clause 6 in an **ambient temperature** of 32 °C and an **ambient temperature** of 16 °C. The value for **energy consumption** determined in accordance with this standard shall be for a **temperature control setting** (or equivalent point) where all average **compartment** air temperatures are at or below the **target temperatures** specified in Table 1 for each **compartment** type claimed by the supplier. Values above and below **target temperatures** may be used to estimate the **energy consumption** at the **target temperature** for each relevant **compartment** by interpolation, as specified in Clause 6.

NOTE Refer to the requirements in Annex B of IEC 62552-1:2015 and IEC 62552-1:2015/AMD1:2020 for **variable temperature compartments**. For energy testing, these are operated on the function (continuous temperature operating range) that uses the most energy.

Table 1 – Target temperatures for energy determination by compartment type

Compartment type	Target average air temperature °C
Pantry	17
Wine storage	12
Cellar	12
Fresh food	4
Chill	2
Zero-star	0
One-star	–6
Two-star	–12
Three-star and Four-star	–18

For energy testing, each **compartment** shall be operated as the claimed **compartment** type, except as set out below.

If a **compartment** operating range spans none of the **target temperatures** for the defined **compartment** types in Table 1 at either an **ambient temperature** of 16 °C or 32 °C (because it has no **user-adjustable temperature control** or a limited range of active control), then it shall be classified as the **compartment** type with the next warmest **target temperature** (based on the warmest test result for both **ambient temperatures**) and operated at its warmest setting while still staying at or below the **target temperature** of the next warmest **target temperature** (where adjustable) for the energy test at both **ambient temperatures**. The test report shall note that the claimed **compartment** type and the **compartment** type assumed for energy testing.

Where the **compartment** is a **variable temperature compartment** type (that spans the operating range of several compartment types), the primary configuration for energy testing shall be the **compartment** type that has the highest **energy consumption**. A **variable temperature compartment** can be set and tested as other **compartment** types, if required, in addition to the primary configuration for energy testing. The test report shall note that the **compartment** is the **variable temperature compartment** type and the **compartment** type selected for each energy test.

5.2 Temperature control settings for energy consumption test

When tested for **energy consumption** in accordance with Clause 6, the **refrigerating appliance** shall have at least one **temperature control setting** (or combination of **temperature control settings**) at which the average temperatures of each **compartment** is concurrently at or below the **energy consumption target temperatures** specified in Table 1. The data points used for **energy consumption** determination should demonstrate that the product is capable of meeting this requirement, but this specific point need not be measured directly.

Where an appliance has no **user-adjustable temperature controls**, **energy consumption** shall be determined from the results of one measurement test run of the appliance as supplied.

6 Determination of energy consumption

6.1 General

The key **energy consumption** components as specified in Clause 6 shall be determined for each **refrigerating appliance** tested in accordance with this standard. This shall be based on data measured in accordance with Annexes B to H, as applicable.

Clause 6 also specifies the method to be used to determine the components of **energy consumption** for a **refrigerating appliance** when tested in accordance with this standard.

The main components of **energy consumption** determined in accordance with this standard are:

- **Steady state power consumption** – this is determined at **ambient temperatures** of 16 °C and 32 °C – see Annex B.
- **Defrost and recovery** energy and temperature change – for products with one or more defrost systems (each with its own **defrost control cycle**), the **defrost and recovery** energy for a representative number of **defrost and recovery periods** for each system shall be determined – see Annex C.
- Defrost frequency – for products with one or more defrost systems (each with its own **defrost control cycle**), the **defrost interval** shall be determined for each system under a range of conditions – see Annex D.
- Specified auxiliaries – Where a **refrigerating appliance** contains a specified auxiliary, the energy impact of this auxiliary shall be determined – see Annex F.
- **Load processing efficiency** – where a **load processing efficiency** is measured or claimed, the specified method shall be used – see Annex G.

The lowest conceivable value of **energy consumption** for a **refrigerating appliance** under this standard (i.e. the theoretical optimum), is the value where the temperature of every **compartment** is exactly equal to its **target temperature** for **energy consumption** (see Clause 5). Not every appliance is capable of operating at this condition, nor is it practicable for a laboratory to continue testing in an attempt to precisely obtain this condition during a specific set of tests. Under this standard there is the option of undertaking several tests with different **temperature control settings** (where available). This is to facilitate interpolation to estimate the **energy consumption** for a point where all **compartments** are at or below their relevant target for **energy consumption** (see 6.3).

6.2 Objective

In order to determine the characteristics of a household **refrigerating appliance** in accordance with this standard, it is necessary to measure the temperature and **energy consumption** for a representative period of **steady state** operation that complies with the relevant requirements (i.e. **compartment** temperatures at or below their target for **energy consumption**). Several test points at different **temperature control settings** may be required to obtain the most favourable (optimal) result for **energy consumption**.

In the case of products with **automatic defrost** functions that affect the power consumption of the product (i.e. has a **defrost control cycle**), the incremental energy during **defrost and recovery** (i.e. the additional energy ΔE_{df} over and above the underlying **steady state** power) shall be determined for a specified number of representative and valid **defrost and recovery periods**.

These values are measured at each of the specified **ambient temperatures** for energy determination.

To assess whether a proposed period of test data is acceptable for the determination of **energy consumption**, the data are analysed and examined to assess whether changes in internal temperatures and power consumption are within acceptable limits. In terms of energy assessments, there are two alternative approaches to the determination of **steady state** power consumption:

- **SS1: Steady state** power and internal temperature determination where there is no **defrost control cycle** or where **steady state** conditions according to Annex B can be established between **defrost and recovery periods** (generally where defrost events are widely spaced);
- **SS2: Steady state** power and internal temperature determination where **steady state** conditions according to Annex B cannot be established between **defrosts and recovery periods** (generally where defrost events are more closely spaced).

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The incremental **energy consumption** and temperature change during a **defrost and recovery period** also needs to be assessed (relative to the **steady state** power and internal temperatures before and after the **defrost and recovery period**).

In each case, criteria are established to determine whether the periods are representative of the operation of the appliance.

6.3 Number of test runs

The **energy consumption** shall be determined at **ambient temperatures** of 16 °C and 32 °C either:

- a) directly from the results of a single test run during which the temperatures of all **compartments** of the appliance are at or below the **target temperatures** specified in Table 1; or
- b) by interpolation between the results of two or more test runs, conducted at different settings of one or more **user-adjustable temperature controls**, as follows:
 - Where results have been measured at two **temperature control settings**, interpolation in accordance with Clause E.3.
 - Where the appliance has at least two independent **user-adjustable temperature controls** and results have been measured at three **temperature control setting combinations**, interpolation in accordance with Clause E.4.
 - Options for interpolating using three or more independent **user-adjustable temperature controls** are also set out in Clause E.4.

In the case of b) above, test results shall demonstrate that the temperatures of all **compartments** in the **refrigerating appliance** are at or below the **target temperatures** specified in Table 1 at the point of interpolation. There are several requirements associated with interpolation to ensure that this has been achieved.

6.4 Steady state power consumption

For a **refrigerating appliance** that does not have a **defrost control cycle**, the **steady state** power consumption at each **temperature control setting** selected and for each **ambient temperature** shall be determined in accordance with Annex B.

For a **refrigerating appliance** with one or more **defrost control cycles**, the **steady state** power consumption between **defrost and recovery periods** at each **temperature control setting** selected and for each **ambient temperature** shall be determined in accordance with Annex B.

The **steady state** power consumption is reported in watt (W).

6.5 Defrost and recovery energy and temperature change

For a **refrigerating appliance** with one or more defrost systems (each with its own **defrost control cycle**), the additional energy and temperature change associated with **defrost and recovery** shall be determined for each system for a representative number of **defrost and recovery periods** in accordance with Annex C, at **ambient temperatures** of both 16 °C and 32 °C.

Where there is more than one defrost system (each with its own **defrost control cycle**), the characteristics of each system shall be documented.

The additional energy associated with **defrost and recovery** is reported in watt-hour (Wh).

The temperature change associated with **defrost and recovery** is reported in degree Kelvin-hour (Kh).

6.6 Defrost interval

For a **refrigerating appliance** with one or more defrost systems (each with its own **defrost control cycle**), the estimated **defrost interval** shall be determined in accordance with Annex D at an **ambient temperature** of 16 °C and at an **ambient temperature** of 32 °C.

Where there is more than one defrost systems (each with its own **defrost control cycle**), the **defrost interval** for each system shall be documented.

The **defrost interval** shall be expressed in hours, rounded to the nearest 0,1 h. Depending on the defrost control type, the **defrost interval** may be a function of a number of parameters.

6.7 Specified auxiliaries

Where the **refrigerating appliance** contains a specified auxiliary, the impact of this device shall be determined in accordance with Annex F.

The impact of specified auxiliaries is expressed in watt or watt-hour for a range of ambient conditions. These values are then weighted in accordance with regional requirements and conditions in order to provide a relevant estimate of energy associated with the auxiliary.

6.8 Calculation of energy consumption

6.8.1 General

The individual components of **energy consumption** and **steady state** power measured in accordance with this standard shall be combined using the following rules.

6.8.2 Daily energy consumption

All values of **energy consumption** and power shall be converted to daily **energy consumption** values in accordance with the following equations for each **temperature control setting** and **ambient temperature**.

For **refrigerating appliances** without a **defrost control cycle**, the daily **energy consumption** for each **ambient temperature** and each **temperature control setting** is given by:

$$E_{\text{daily}} = P \times 24 \quad (1)$$

Where

E_{daily} is the energy in Wh over a period of 24 h

24 is h/d

P is the **steady state** power in watt for the selected **temperature control setting** as per Annex B.

The measured **steady state** temperature for each **compartment** shall be recorded with this value (for the test report and/or for interpolation).

For **refrigerating appliances** with one defrost system (with its own **defrost control cycle**), the daily **energy consumption** for each **ambient temperature** and each **temperature control setting** is based on the **steady state** power consumption as determined in accordance with Annex B, the incremental **defrost and recovery** energy determined in accordance with Annex C and the **defrost interval** determined in accordance with Annex D as follows:

$$E_{\text{daily}} = P \times 24 + \frac{\Delta E_{df} \times 24}{\Delta t_{df}} \quad (2)$$

Where

E_{daily} is the energy in Wh over a period of 24 h

24 is h/d

P is the **steady state** power in watt for the selected **temperature control setting** as per Annex B.

ΔE_{df} is the representative incremental energy for **defrost and recovery** in Wh in accordance with Annex C (see C.5).

Δt_{df} is the estimated **defrost interval** in hours in accordance with Annex D.

Where there are additional defrost systems (each with its own **defrost control cycle**), the value of term based on ΔE_{df} and Δt_{df} is also added in Formula (2) for each additional defrost system.

The average temperature for each **compartment** for this **temperature control setting** and **energy consumption** is given by:

$$T_{\text{average}} = T_{ss} + \frac{\Delta Th_{df}}{\Delta t_{df}} \quad (3)$$

Where

T_{average} is the average temperature for the **compartment** over a complete **defrost control cycle**.

T_{ss} is the average **steady state** temperature in the **compartment** for the **temperature control setting** in ° C in accordance with Annex B.

ΔTh_{df} is the representative accumulated temperature difference over time for **defrost and recovery** (relative to the **steady state** temperature) in degree Kelvin-hour (Kh) for the relevant **compartment** in accordance with Annex C (see Clause C.5).

Δt_{df} is the estimated **defrost interval** in hours in accordance with Annex D.

The value of ΔTh_{df} may be positive (if the temperature is warmer during **defrost and recovery**) or negative (if it is cooler, due to a pre-cool and low heat leakage during defrost).

Where there are additional defrost systems (each with its own **defrost control cycle**), the value of term based on ΔTh_{df} and Δt_{df} is also added in Formula (3) for each additional defrost system.

6.8.3 Interpolation

Where interpolation is performed in order to obtain a more optimum estimate of the daily **energy consumption** for a given **ambient temperature**, the calculations for each **compartment** temperature and **energy consumption** determined in accordance with 6.8.2 shall be used as set out in Annex E.

6.8.4 Specified auxiliaries

Where the **refrigerating appliance** contains specified auxiliaries, the increase in **energy consumption** associated with these auxiliaries is calculated according to the relevant local regional operating schedule specified and using the parameters set out in Annex F. The impact of these auxiliaries is typically estimated over a year, so care is required when attempting to add these to other energy values calculated in this standard – annual values need to be determined for the other energy values before these figures can be added.

6.8.5 Total energy consumption

The total **energy consumption** of an appliance can be estimated from the following values:

E_{daily16C} at an **ambient temperature** of 16 °C

E_{daily32C} at an **ambient temperature** of 32 °C

The value of E_{daily} at **ambient temperatures** of 16 °C and 32 °C may be calculated by interpolation in accordance with Annex E. Annex I provides some examples of how these two values can be combined to provide an annual energy estimate.

E_{aux} expressed as an integrated energy value over a year.

NOTE 1 The ice-making test is performed at **ambient temperatures** of 16 °C and 32 °C so E_{aux} is a regional function of $f\{E_{\text{aux16C}}, E_{\text{aux32C}}\}$.

The total annual **energy consumption** of a **refrigerating appliance** can be given by:

$$E_{\text{total}} = f\{E_{\text{daily16C}}, E_{\text{daily32C}}\} + E_{\text{aux}} \quad (4)$$

Where

f is a regional function to give the annual energy based on daily energy at 16 °C and 32 °C. This function is not defined in this standard and may vary by region. See Annex I for examples.

NOTE 2 Energy associated with load processing arising from user interactions is not included in these calculations. See Annex G for measurements and associated energy calculations.

7 Circumvention devices

A circumvention device is any control device, software, component or part that alters the refrigerating characteristics during any test procedure, resulting in measurements that are unrepresentative of the appliance's true characteristics that may occur during **normal use** under comparable conditions. Generally, circumvention devices save energy during an energy test but not during **normal use**. Examples of circumvention may include, without limitation, any variation to normal operation when the appliance is subjected to testing, and includes devices that

- alter **compartment** temperature set points during the test; or
- activate or de-activate heaters or other energy-consuming devices during the test; or
- manipulate compressor cycle time or other operating parameters during the test; or
- manipulate the **defrost interval**.

Devices that operate over a restricted range of conditions and which are:

- required for the maintenance of satisfactory food preservation temperatures within **compartments** (e.g. temperature compensation heaters in **fresh food compartments** that operate at low ambient conditions); or
- intended to reduce **energy consumption** during **normal use**

will generally not be treated as circumvention devices where the legitimate basis for their operation during **normal use** and under the test procedure for **energy consumption** is declared and can be demonstrated by the supplier.

Where the operation of a circumvention device is suspected, a laboratory should subject the appliance to measures such as door openings or other appropriate actions in an attempt to detect presence and operation of any such devices. Details of any such action and their effect

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shall be included in the test report. Where a circumvention device is suspected or detected during testing, a laboratory shall report that information to the client.

Circumvention devices, where present, may be subject to regional regulations and requirements. Such devices may be prohibited in some jurisdictions. Other jurisdictions may require the circumvention device to be defeated for energy tests or the product to be tested in such a way to obtain an assessment of the energy impact of the circumvention device operation. Any additional **energy consumption** associated with the circumvention device may be added to the measured **energy consumption** and there may be penalty factors associated with the additional energy associated with the circumvention device.

8 Uncertainty of measurement

For all energy measurements, the uncertainty of measurement of the measured value should be determined and stated with the measured result.

Where less stringent validity criteria have been applied to obtain an approximate result in a shorter time, the resulting increase in uncertainty shall be taken into account in any statement of uncertainty.

Verification tests should take into consideration the measurement uncertainty when assessing the energy result against any relevant validity criteria.

NOTE The calculation of uncertainty of measurement is not specified in this standard. Further guidance on this issue can be obtained from the ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*.

9 Test report

A test report should be prepared that includes all of the relevant information listed in Annex F of IEC 62552-1:2015/AMD:2020 for tests undertaken in accordance with this document.

Annex A (normative)

Set up for energy testing

A.1 General

For the purposes of energy determination in accordance with this standard, the **refrigerating appliance** shall be set up as specified below.

The **refrigerating appliance** shall be installed in a test room and with instrumentation as specified in IEC 62552-1:2015, Annex A.

The **refrigerating appliance** shall be prepared and set up in accordance with the requirements of IEC 62552-1:2015, Annex B.

The **refrigerating appliance** shall have air temperature sensors installed at the positions specified in Annex D of IEC 62552-1:2015 and IEC 62552-1:2015/AMD1:2020. The determination of **compartment** air temperature during energy testing shall be as specified in Annex D of IEC 62552-1:2015 and IEC 62552-1:2015/AMD1:2020.

A.2 Additional set up requirements for energy testing

A.2.1 Ice making trays

Any **ice cube trays** with a dedicated position, as specified in the instructions, shall remain in place but shall be empty for energy tests (except as specified in Annex G).

A.2.2 User adjustable controls

User-adjustable temperature control(s) that are not used for energy interpolations in accordance with Annex E shall be set in a single position that meets the relevant **compartment** temperature requirements set out in Clause 5 (**target temperatures**) for all test runs. Where interpolation between the results of two or more test runs is to be performed in accordance with Annex E, the only setting(s) to be changed between test runs shall be the relevant **user-adjustable temperature control(s)** used for interpolation. The position of all baffles and **user-adjustable temperature control(s)** not used for interpolation shall be recorded in the test report.

Where a **wine storage compartment** has setting options for both uniform temperature and multiple temperature zones, the uniform temperature setting shall be selected for testing.

A.2.3 Ambient temperature

For **energy consumption** determination, the nominal test room temperatures are 16 °C and 32 °C. The operational requirements for test room **ambient temperatures** are specified in IEC 62552-1.

A.2.4 Accessories and shelves

Any accessories, loose trays, bins or containers that have no dedicated position or essential function during **normal use**, as specified in the instructions, shall be removed.

Any thermal storage devices (e.g. ice-bricks or similar) that are removable without the use of a tool shall be removed for all tests, irrespective of instructions.

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A.2.5 Anti-condensation heaters

Anti-condensation heaters which are permanently on during **normal use** shall be tested with the heater(s) operating for all energy tests.

Anti-condensation heaters that can be switched 'on' or 'off' by the user shall be tested at both the 'on' and 'off' setting.

Anti-condensation heaters that have a number of possible settings that can be selected by the user shall be tested at both the 'highest energy' and the 'lowest energy' setting.

Sufficient data shall be collected so that the additional power consumption associated with the anti-condensation heater(s) at each specified setting can be estimated with the **compartment(s)** operating at the same temperature(s). The additional power consumed by the **refrigerating appliance** when the anti-condensation heater(s) are operating at each **ambient temperature** shall be determined. Energy test values shall be separately reported for each specified setting.

NOTE A number of possible approaches can be used to determine the incremental impact of manually switched anti-condensation heater(s) as set out in Annex F (for example, measure energy without heaters then add calculated energy, measure energy with heaters then subtract actual energy before adding calculated energy). If there is any doubt about the most expedient method, the optimum energy in accordance with Annex B (using interpolation where necessary) should be determined with and without the anti-condensation heater(s) operating in order to determine this value (noting that their operation may have a small impact on **compartment** temperatures).

Anti-condensation heaters which are automatically controlled and vary in response to ambient conditions (e.g. temperature and/or humidity) are classified as specified auxiliaries and shall be tested in accordance with Annex F.

Anti-condensation heaters which are automatically controlled and vary in response to ambient conditions but are configured so that the user can select the underlying or base level of heater power shall be tested at highest and lowest user setting in accordance with Annex F (refer F.2.8).

A.2.6 Automatic icemakers – ice storage bins

A.2.6.1 General

Where an appliance includes an automatic ice-making feature that produces, harvests and stores ice, the space that the ice storage bin occupies shall be specifically treated as a separate **sub-compartment** for the purposes of energy testing.

Any automatic ice-making bin shall be separately declared under '**Compartment** Details' in the test report.

For all energy tests, the ice delivery mechanism shall remain functional, i.e. all chutes and throats required for the delivery of ice shall be free of packing, covers or other blockages that may be fitted for shipping or when the ice-maker is not in use.

Where the ice storage space occupies a complete **compartment**, the temperature sensor placements shall be in accordance with Annex D of IEC 62552-1:2015 and IEC 62552-1:2015/AMD1:2020 (not A.2.6.5 of this document).

A.2.6.2 Intent and overview for energy testing

The intent is to make sure that during an **energy consumption** test to this standard the automatic ice-maker and its associated equipment behaves in a manner that is consistent with a value that would be obtained while the system is running but is not making new ice.

In order to achieve this condition during an energy test, automatic ice-makers shall function normally but shall not produce any new ice (but should be in a state that would automatically produce new ice on demand without any user intervention if some ice were removed). Only devices or components directly associated with the production or harvesting of new ice shall be inoperative during the energy test. All components not explicitly associated with the production or harvesting of new ice shall operate normally during the energy test and shall be energized in a manner consistent with the duty cycle necessary to perform their respective functions. The cooling of the icemaker area(s) shall remain unchanged from normal ice-storage conditions.

Other than for verification tests as specified in A.2.6.4, connection to a water supply may be omitted if it can be demonstrated that the absence or presence of a connection to a water supply will make no difference to the measured **energy consumption**.

A.2.6.3 Ice storage bin configuration

The ice storage bin shall remain in place and empty for all energy testing, except where otherwise specified in A.2.6.4. The automatic ice-making bin shall be treated as a **sub-compartment** and shall be fitted with a temperature sensor as specified in A.2.6.5.

Any action taken by the test laboratory (including settings or configuration) during the energy test to make the automatic ice-maker operative but to cease production of ice due to an ice-bin-full condition in accordance with A.2.6 shall be included in the test report.

A.2.6.4 Verification of energy consumption with an automatic ice-maker

For the purposes of verification of **energy consumption** of an appliance, the setup of the automatic icemaker should be configured in accordance with the setup specified by the manufacturer.

In order to detect whether there are any undeclared circumvention devices in operation during an energy test, irrespective of instructions, a test laboratory may undertake tests, including the test as set out below to assess the normal operation of the automatic ice-maker and its associated controls against the requirements of Clause 7 and the intent of A.2.6.2.

The purpose of this test, where undertaken, is to assess the normal operation of the automatic ice-maker against the configuration used for energy testing as set out in A.2.6.4. The ice-maker is connected to a water supply, the ice-making function is operated until the bin is full and ice production has automatically stopped under its own control prior to commencing an energy test. To shorten the test time, pre-made ice cubes may be used to partially fill the ice storage bin before the start of the test, but only to a level that allows the icemaker to continue producing ice to fill the bin.

The automatic ice-making bin shall be fitted with a temperature sensor as specified in A.2.6.5.

The temperature in the ice-making storage bin should remain well below freezing during all stages of operation. As a guide, the **energy consumption** with the ice storage bin full of ice under this clause should not exceed by 2 % the **energy consumption** measured during energy testing for the same (or equivalent) **temperature control settings** and internal temperatures but with the ice storage bin empty.

A.2.6.5 Position of the temperature sensor in automatic ice-makers

An automatic ice-maker bin shall have a single temperature sensor located in the position specified as follows for all energy tests:

- a) Vertical placement: Approximately 50 mm below the top of the estimated maximum ice storage level while maintaining at least 20 mm clearance from the base of the bin.

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- b) Horizontal placement: Approximately 20 mm clearance from the vertical centre line of the side of the bin that is closest to an external surface or warmer **sub-compartment** (e.g. door or wall or gasket or **sub-compartment**) or, where the bin is more than 50 mm from an external surface, approximately 20 mm clearance from the vertical centre line of the largest side of the bin (i.e. where the bin is wholly within the **compartment**).
- c) Where the position specified in b) is affected by a direct air stream, it shall, as far as possible, be relocated to an alternative position that has 20 mm clearance from the side of the bin but away from a direct air stream that is colder than the bin contents.

If the position of the temperature sensor is moved so that it is away from the preferred positions specified in a) and b) above, the position of the sensor shall be noted in the test report.

NOTE In a verification test in accordance with A.2.6.4, ice will usually touch the temperature sensor in the storage bin. See A.2.6.1 regarding the placement of temperature sensors in separate **compartments** that are dedicated to ice storage.

Annex B (normative)

Determination of steady state power and temperature

B.1 General

This Annex specifies the method to be used to determine the power consumption and temperature for a **refrigerating appliance** during stable operation that is tested in accordance with this standard.

B.2 Setup for testing and data collection

The objective is to select a representative period of operation in order to determine the average power and average internal temperatures (for all relevant **compartments**) for the selected **temperature control setting** and test **ambient temperature**.

The **refrigerating appliance** under test shall be set up and operated in accordance with Annex A.

There are two possible cases with respect to the determination of **steady state** power consumption:

- Case SS1 (see Clause B.3) applies to products without a **defrost control cycle** and products with a defrost system (with its own **defrost control cycle**) where the **defrost control cycle** is long and the **steady state** test period of interest may not be bounded by **defrost and recovery periods**. Quite stringent internal validity criteria are applied to the data to ensure that a representative period of operation is selected.
- Case SS2 (see Clause B.4) applies to products with a defrost system (with its own **defrost control cycle**) where the **steady state** test period of interest commences with a valid **defrost and recovery period**. Case SS2 shall be used where stability between defrosts cannot be established using Case SS1. In Case SS2 the whole period from defrost to defrost is used to determine the **steady state** power consumption by deduction of initial incremental **defrost and recovery** energy (see DF1 in Annex C). In Case SS2, the **steady state** operation before the initial defrost and before the following defrost are compared and they shall meet the relevant stability criteria. The initial defrost shall also meet the validity requirement of DF1 as specified in Annex C.

B.3 Case SS1: no defrost control cycle or where stability is established for a period between defrosts

B.3.1 Case SS1 approach

Case SS1 applies to all products without a **defrost control cycle**. It also can apply to products with a defrost system (with its own **defrost control cycle**) where the **defrost control cycle** is long and the **steady state** test period of interest is not bounded by **defrost and recovery periods**. In this case, no **defrost and recovery period** (or part thereof) shall occur during the selected test period under Case SS1.

Where the **steady state** power is determined under Case SS1, a **steady state** test period that is made up of 3 internal blocks of test data is selected that are adjacent but not overlapping. Each block of test data shall contain an equal number (n) of whole **temperature control cycles**. The minimum number of **temperature control cycles** per block is 1. A test period is selected where all relevant criteria for internal spread and slope for temperature and power can be established.

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A block size of 1 **temperature control cycle** will have a total test period of 3 **temperature control cycles**, a block size of 2 **temperature control cycles** will have a test period of 6 **temperature control cycles**, and so on. The definition of **temperature control cycle** in IEC 62552-1:2015 should be considered carefully. It is generally recommended that for more complex refrigeration systems alternative **temperature control cycles** based on temperature maxima in each **compartment** be examined in addition to compressor cycles (where present) to see which one provides the most stable estimate of power over time. Selecting the most stable **temperature control cycle** can shorten the required testing time to achieve a valid result.

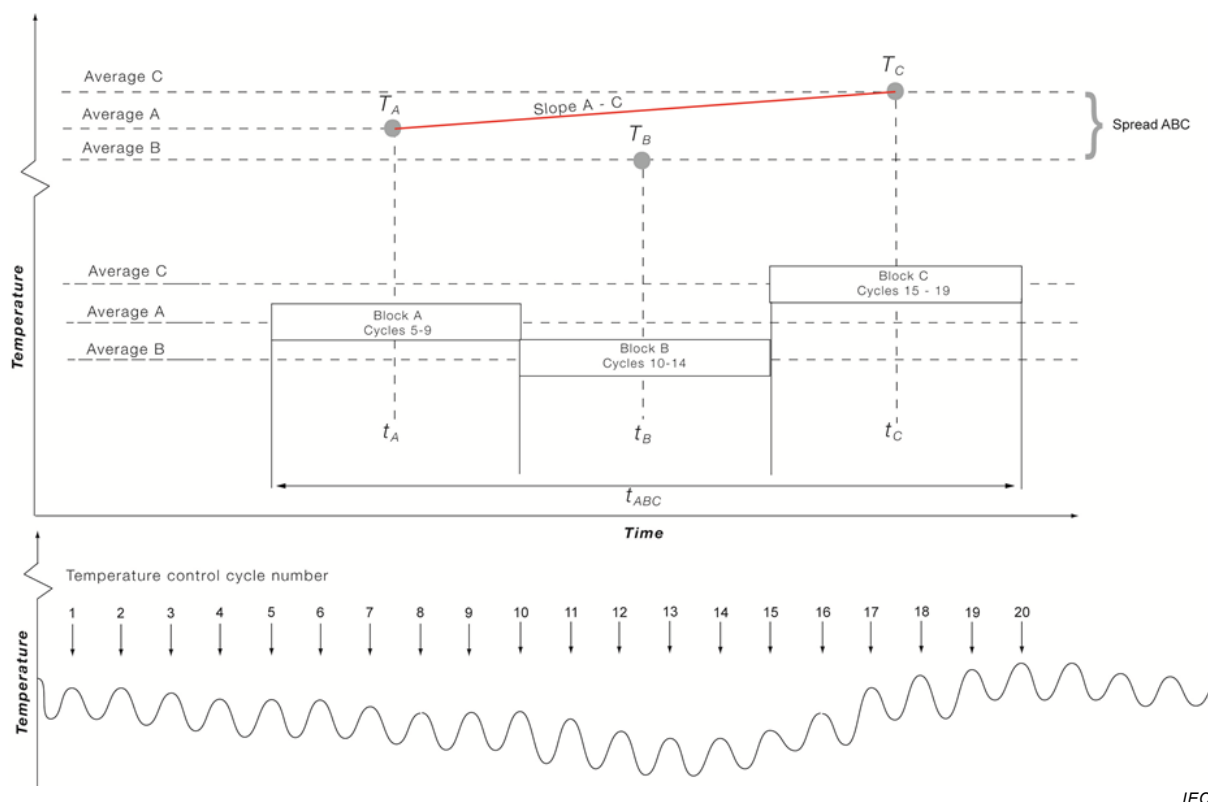
Where there are no discernable changes in temperature or power consumption over time, a test period that is made up of 3 internal blocks of test data is selected. Each block of test data shall be equal in length, adjacent and no less than 4 h in duration.

As an alternative to using **temperature control cycles**, fixed length periods may be used (referred to as fixed time slices) to make up each block.

A trial test period shall be made up of 3 blocks of data called A, B and C.

NOTE There is no maximum number of **temperature control cycles** per block, but a value of 10 is considered to be unusually long.

An example test period made up of blocks of 5 **temperature control cycles** is illustrated in Figure B.1.



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Figure B.1 – Illustration of a test period made of blocks of 5 temperature control cycles – temperatures for Case SS1

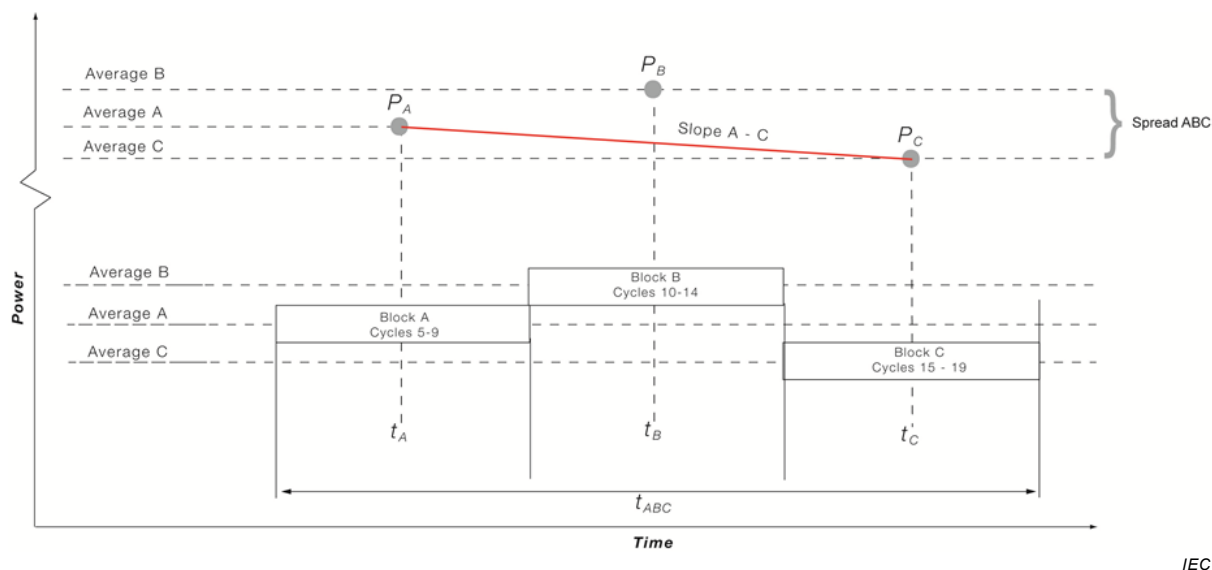


Figure B.2 – Illustration of a test period made of blocks of 5 temperature control cycles – power for Case SS1

For each block of data (A, B and C), calculate the average power and the average temperature in each relevant **compartment**.

Calculate the following characteristics across the test Blocks A, B and C:

- Spread of temperature for each **compartment**: calculated as the difference between the average temperature of the warmest Block (A, B or C) and the average temperature of the coldest Block (A, B or C). All temperature differences (spread) are in K. Refer to Equation (5).
- Slope of temperatures from Block A to Block C: calculated as [the absolute value of the difference between the average temperature of Block A and the average temperature of Block C] divided by [the test time at the middle of Block C minus the test time at the middle of Block A]. All temperature slopes are in K/h. Refer to Equation (6).
- Spread of power (watt): calculated as the difference between the average power of the highest power Block (A, B or C) and the average power of the lowest power Block (A, B or C) divided by [the average power for the whole test period (A, B and C)], expressed as a percentage. Refer to Equation (7).
- Slope of power from Block A to Block C: calculated as [the absolute value of the difference between the average power of Block C and the average power of Block A] divided by [the test time at the middle of Block C minus the test time at the middle of Block A] and divided by [the average power for the whole test period (A, B and C)]. All power slopes are expressed as a percentage per hour (%/h). Refer to Equation (8).

$$\text{Spread of temperature} = T_{\max(A,B,C)} - T_{\min(A,B,C)} \text{ (K)} \quad (5)$$

$$\text{Slope of temperature} = \frac{ABS[T_C - T_A]}{[t_C - t_A]} \text{ (K/h)} \quad (6)$$

$$\text{Spread of power} = \frac{P_{\max(A,B,C)} - P_{\min(A,B,C)}}{P_{av(A,B,C)}} \text{ (%) } \quad (7)$$

$$\text{Slope of power} = \frac{ABS[P_C - P_A]}{[t_C - t_A] \times P_{av(A,B,C)}} \quad (\%/h) \quad (8)$$

Where for each block A, B and C:

T is the temperature

t is the test time (the centre point of the block)

P is the power

% is the result of the quotient (expressed as a percentage, where 1,0 = 100 %)

B.3.2 Case SS1 acceptance criteria

Based on the characteristics calculated in B.3.1, assess the validity of the whole test period (made up of 3 blocks, each consisting of n **temperature control cycles**). The test period shall be valid if all of the following criteria are met:

- Total test period t_{ABC} (sum of length of Blocks A, B and C) is no less than 6 h where there are **temperature control cycles** and no less than 12 h where there are no **temperature control cycles** (or where fixed time slices are used);
- Spread of temperature (across Blocks A, B, C) is less than 0,25 K for each **compartment**;
- Slope of temperature (from Block A to Block C) is less than 0,025 K/h for each **compartment**;
- Spread of power (across Blocks A, B, C) where **temperature control cycles** are present is less than: for a total test period t_{ABC} of 12 h or less, a spread of not more than 1 %; for a total test period t_{ABC} from 12 to 36 h, a spread of not more than 1 % + $(t_{ABC} - 12) / 1\,200$; for a total test period t_{ABC} of 36 h or more, a spread of not more than 3 %;
- Spread of power (across Blocks A, B, C) where no **temperature control cycles** are present or where fixed time periods are selected is less than 1 %, irrespective of the total test period;
- Slope of power (from Block A to Block C) is less than 0,25 %/h;
- Where **temperature control cycles** are present, the two comparable test periods that start one and two **temperature control cycles** earlier than the period selected also meet all of the above criteria (i.e. the selected test period is the third possible period that meets all other validity criteria);
- Where **temperature control cycles** are not present (or where fixed time slices are used), the two comparable test periods that start one hour and two hours earlier than the period selected also meet all of the above criteria.

The requirement for the test period to remain valid when moved along for 3 consecutive **temperature control cycles** ensures that compliance with all criteria for the selected period is not a chance or random occurrence. In the example illustrated in Figure B.1, if the test period starting at **temperature control cycle** 5 and ending at **temperature control cycle** 20 was the first period to meet the above criteria 1 to 5, the test period from 6 to 21 and 7 to 22 would also have to meet all criteria. In this case the test period from 7 to 22 is the first valid test period.

NOTE 1 The full set of criteria above were developed on the basis of extensive testing and review of data for more than 100 **refrigerating appliances**.

The **temperature control setting(s)** shall remain unchanged for all the test period used to determine the value for SS1 (Blocks A, B and C).

Where there are more than two **compartments**, assessment of temperature stability as set out above is required for:

- The largest **unfrozen compartment** and largest **frozen compartment** (where applicable), or
- The largest two **compartments** (where all **compartments** are **frozen** or **unfrozen**).

In addition, temperature stability shall be achieved as specified above for all **compartments** that are used for interpolation for **energy consumption** in accordance with Annex E.

If the above criteria cannot be met, the size of n is increased (and therefore the length of the test period is increased) and/or more test data is collected until all criteria can be met simultaneously.

The recommended approach during the collection of test data is to continually look (backwards) at all of the data collected to that moment in order to assess all possible test periods for all possible block sizes (n) to establish the earliest possible point in the test data that can meet the above validity criteria. While it is not generally recommended that data from a warm start (pull down when the power is first connected) be included in these assessments, these criteria should ensure that any pull down prior to the establishment of stable operation is automatically excluded from a valid test period.

Where there are a number of possible test periods that meet the above criteria, the test period with the minimum spread of power from the available test data should be selected.

Where the criteria of power spread cannot be met by extending the total test period (with or without **temperature control cycles**), a valid result may be obtained by using 3 blocks of data with each block no less than 36 h in length (total test period no less than 108 h).

NOTE 2 A worked example to select the optimum test period characteristics is included in Annex I.

B.3.3 Case SS1 calculation of values

Where a test period, made up of Blocks A, B and C, meets the relevant acceptance criteria in B.3.2, then the temperature T_i for each **compartment** i and the average power P_{SSI} is determined as the average of all measured values included in the time period covered by Blocks A, B and C.

The **steady state** power used for subsequent energy calculations P_{SS} is determined by modifying the value of P_{SSI} using Formula (15) in Clause B.5 where the measured **ambient temperature** is not equal to the nominal **ambient temperature** during the test.

The total test time for Blocks A, B and C shall be reported.

The **steady state** compressor run time CRt_{SS} is calculated as the percentage of time that the compressor is on during the total time for all **temperature control cycles** in Blocks A, B and C.

B.4 Case SS2: steady state determined between defrosts

B.4.1 Case SS2 approach

Case SS2 applies to products with one or more defrost systems (each with its own **defrost control cycle**) where the **steady state** test period of interest is bounded by **defrost and recovery periods**. While it may be used for all products with one or more defrost systems, Case SS2 shall be used if stability cannot be established using Case SS1.

For products with long **defrost intervals**, the use of Case SS1 may considerably shorten the required test time.

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Case SS2 uses all data between the start of two **defrost and recovery periods** to calculate the **steady state** power (see Formula (12)). Checks are undertaken to compare the characteristics of the **steady state** operation prior to each **defrost and recovery period** (Periods X and Y in Figure B.3) to ensure that they meet the relevant stability requirements before undertaking any further analysis. The initial **defrost and recovery period** within the test period SS2 shall comply with the validity requirements of Annex C and the incremental energy associated with this **defrost and recovery period** shall be determined in accordance with Annex C (DF1) in order to determine the value for P_{SS2} (which is the whole test period less the value for DF1).

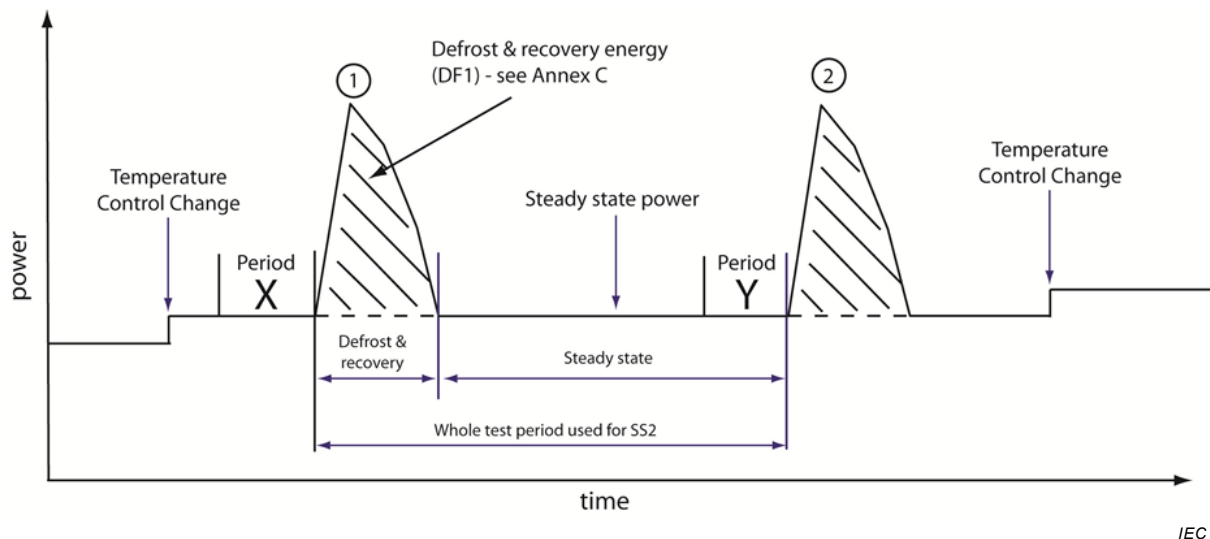


Figure B.3 – Case SS2 – typical operation of a refrigerating appliance with a defrost control cycle

A period of **steady state operation** (called Period X), ending at the start of a **defrost and recovery period** and made up of no less than 4 whole **temperature control cycles** (where **temperature control cycles** are present) and no less than 4 h in length, is selected. A second period of **steady state** operation (called Period Y), ending at the start of the next **defrost and recovery period** and made up of no less than 4 whole **temperature control cycles** (where **temperature control cycles** are present) and no less than 4 h in length, is selected. Periods X and Y shall always consist of the same number of **temperature control cycles** (where **temperature control cycles** are present) and should be approximately the same length. Periods X and Y shall be exactly the same length where no **temperature control cycles** are present.

Where no subsequent **defrost and recovery period** has been initiated within 48 h, Period Y may be selected at a point during **steady state** operation where the elapsed time from the end of Period X to the end of Period Y exceeds 48 h but where Period Y is not adjacent to a subsequent **defrost and recovery period**. Where Period Y is selected in this manner, it shall be noted in the test report.

The temperature in each **compartment** and power for Period X are then compared to the temperature in each **compartment** and power for Period Y.

Calculate the following characteristics across the Periods X and Y:

- Spread of temperature for each **compartment**: calculated as the difference between the average temperature of the warmer period (X or Y) minus the average temperature of the colder period (X or Y). All temperature differences (spread) are in degrees K. Refer to Equation (9).
- Spread of power: calculated as the difference between the average power of the higher power period (X or Y) minus the average power of the lower power period (X or Y) divided

by the average power for the Periods X and Y. The spread of power is expressed as both a percentage and as an absolute spread (W). Refer to Equations (10) and (11).

$$\text{Spread of temperature} = T_{\max(X,Y)} - T_{\min(X,Y)} \text{ (K)} \quad (9)$$

$$\text{Spread of power} = \frac{P_{\max(X,Y)} - P_{\min(X,Y)}}{P_{av(X,Y)}} \text{ (%) } \quad (10)$$

$$\text{Spread of power} = P_{\max(X,Y)} - P_{\min(X,Y)} \text{ (W)} \quad (11)$$

Where for each period X and Y:

T is the temperature

P is the power in W

% is the result of the quotient (expressed as a percentage, where 1,0 = 100 %)

B.4.2 Case SS2 acceptance criteria

For the period selected for determination of P_{SS2} **steady state** power to be valid, the following criteria shall be met:

- Period X and Y shall be made up of no less than 4 whole **temperature control cycles** (where **temperature control cycles** are present) and shall have the same number of **temperature control cycles**. Where no **temperature control cycles** are present (or where fixed time slices are used), X & Y shall be the same length.
- Period X and Y shall not be less than 4 h in length.
- The ratio of the total length of Period X (in hours) to the total length of Period Y (in hours) shall be in the range 0,8 to 1,25 where **temperature control cycles** are present.
- The spread of temperature of the two selected Periods X and Y shall be less than 0,5 K for each **compartment**;
- The spread of power of the two selected Periods X and Y shall be less than 2 % or less than 1 W, whichever is the greater value.
- The initial **defrost and recovery period** which is included in period SS2 shall qualify as a valid **defrost and recovery period** in accordance with Annex C.
- The value of ΔE_{df} for the initial **defrost and recovery period** which is included in period SS2 shall be determined in accordance with Annex C.

The **temperature control setting** shall remain unchanged for all the test period used to determine the value for SS2, including the period used to determine the incremental **defrost and recovery** energy (ΔE_{df} for DF1) specified in Annex C (including all of Periods X and Y).

Where the initially selected Period X and Period Y do not comply with the acceptance criteria specified above, the minimum length of time for Period X and Y shall both be increased in steps of 1 **temperature control cycle** (in 1 h steps where there are no **temperature control cycles** or where fixed time slices are used) to see if there are any possible complying periods. Where the size of X and Y are increased, the first valid value using the sequence specified above shall be used. The length of X and Y shall not exceed 50 % of the defrost interval or 8 h, whichever is the longer.

Where there are more than two **compartments**, assessment of temperature stability as set out above is required for:

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- The largest **unfrozen compartment** and largest **frozen compartment** (where applicable), or
- The largest two **compartments** (where all **compartments** are **frozen** or **unfrozen**).

In addition, temperature stability shall be achieved as specified above for all **compartments** that are used for interpolation for **energy consumption** in accordance with Annex E.

In rare cases where there is no **steady state** operation between defrosts, it may not be possible to ever confirm the validity of the initial **defrost and recovery period** at the start of SS2 in accordance with Annex C. An alternative approach to deal with such cases is outlined in Annex K, but this should only be used if compliance with Annex C can never normally be achieved.

B.4.3 Case SS2 calculation of values

Where the acceptance criteria in B.4.2 have been met, the determination of **steady state** power and **steady state** temperature in each **compartment** are calculated from the whole test period used for SS2 (including the initial **defrost and recovery period**) as set out in Formula (12) and Formula (13) below. The calculation determines the **energy consumption** over whole **defrost control cycle** and subtracts the incremental defrost and recovery energy in accordance with Annex C in order to determine the **steady state** power consumption P_{SS2} . Similarly, each **compartment** temperature is determined over the whole **defrost control cycle** and the accumulated temperature difference during the **defrost and recovery period** in each **compartment** (in accordance with Annex C) is subtracted in order to determine the **steady state** temperature in each **compartment** T_{SS2-i} .

The average power during the **steady state** period shall be calculated from the whole test period used for SS2 as follows:

$$P_{SS2} = \frac{(E_{end-Y} - E_{end-X}) - \Delta E_{df}}{(t_{end-Y} - t_{end-X})} \quad (12)$$

Where

P_{SS2} is the **steady state** power for the selected **defrost control cycle** in W

E_{end-X} is the accumulated energy reading at the end of Period X in Wh

E_{end-Y} is the accumulated energy reading at the end of Period Y in Wh

t_{end-X} is the test time at the end of Period X in h

t_{end-Y} is the test time at the end of Period Y in h

ΔE_{df} is the incremental **defrost and recovery** energy in Wh in accordance with Annex C for the **defrost and recovery period** commencing at the end of Period X.

The length of the test period used ($t_{end-Y} - t_{end-X}$) shall be separately reported. Where applicable, it shall be noted whether Period Y was adjacent to a subsequent defrost.

The **steady state** power used for subsequent energy calculations P_{SS} is determined by modifying the value of P_{SS2} using the formula in B.5 where the measured **ambient temperature** is not equal to the nominal **ambient temperature** during the test.

The average temperature during the **steady state** period shall be calculated from the whole test period used for SS2 as follows:

$$T_{SS2-i} = (T_{av-endX-endY-i}) - \left[\frac{\Delta Th_{df-i}}{(t_{end-Y} - t_{end-X})} \right] \quad (13)$$

Where

- T_{SS2-i} is the **steady state** temperature in **compartment** i that occurs in the whole test period used for SS2 in degrees C
- $T_{av-endX-endY-i}$ is the average temperature in **compartment** i over the period from the end of Period X to the end of Period Y in degrees C
- ΔTh_{dfj-i} is the accumulated temperature difference over time in each **compartment** i in Kh as determined in accordance with C.3.3 for the **defrost and recovery period** j commencing at the end of period X
- t_{end-X} is the test time at the end of Period X in h
- t_{end-Y} is the test time at the end of Period Y in h

For products with a compressor run time defrost controller, the **steady state** compressor run time CRt_{SS} is calculated as the percentage of time that the compressor is on for the whole **defrost control cycle** less the value for Δt_{dr} determined in Annex C as set out in Equation (14).

$$CRt_{SS2} = \frac{Rt_{end-Y} - Rt_{end-X} - \Delta t_{drj}}{(t_{end-Y} - t_{end-X})} \quad (14)$$

Where

- CRt_{SS2} is the average percentage compressor run time that occurs in **steady state** in %
- Rt_{end-X} is the total accumulated compressor run time (on period) at the end of period X in h
- Rt_{end-Y} is the total accumulated compressor run time (on period) at the end of period Y in h
- Δt_{drj} is the additional compressor run time in h as determined in accordance with C.3.3 for the **defrost and recovery period** j commencing at the end of period X
- t_{end-X} is the test time at the end of the Period X in h
- t_{end-Y} is the test time at the end of the Period Y in h

Care is required not to count defrost heater on time as compressor on time in these calculations (although it is possible that some controllers include the defrost heater operation as run time – each product should be checked to see how it is configured).

B.5 Correction of steady state power

The **steady state** power used for subsequent energy calculations P_{ss} is based on the measured **steady state** power (B.3 or B.4 as applicable) after adjustment using Formula (15) below. This adjustment takes into account the difference between the measured **ambient temperature** during the test and the nominal ambient test temperature.

$$P_{SS} = P_{SSM} \times \left(1 + [T_{at} - T_{am}] \times \frac{\sum_{i=1}^n \left[\frac{V_i}{(c_l \times (18 + T_{it}) + c_2)} \right]}{\sum_{i=1}^n \left[\frac{V_i \times (T_{am} - T_{im})}{(c_l \times (18 + T_{it}) + c_2)} \right]} \right) \times \frac{1}{[1 + (T_{at} - T_{am}) \times \Delta COP]} \quad (15)$$

Where

- P_{SSM} is the measured **steady state** power for the period in W as specified in B.3 (P_{SS1}) or B.4 (P_{SS2}) as applicable
- T_{at} is the target test room **ambient temperature**
- T_{am} is the measured test room **ambient temperature** during the test period
- V_i is **rated volume** of **compartment** i (for **compartments** 1 to n)

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- T_{im} is the measured temperature in **compartment** i to n during the test period
- T_{it} is the **target temperature** for **energy consumption** in **compartment** i to n (refer Table 1)
- c_1 is a constant given as 0,011 364
- c_2 is a constant given as 1,25
- ΔCOP is the adjustment given in Table B.1 for the product type and test condition.

All temperatures are in degrees Celsius (°C).

Table B.1 – Assumed ΔCOP adjustment

Product Type	ΔCOP adjustment at 16 °C	ΔCOP adjustment at 32 °C
Two or more compartments	0,000 per K increase	–0,014 per K increase
One compartment	–0,004 per K increase	–0,019 per K increase

This formula is not valid for corrections that are outside the permitted ambient test temperature range specified in IEC 62552-1:2015 (nominally $\pm 0,5$ K). This correction is only applied to the **steady state** power. No correction is applied to measured temperatures or any **defrost and recovery** calculations in Annex C. The value(s) of **volume** that are used in the correction equation are the **rated** values in accordance with this standard as specified in the instructions or other product literature. More information on the derivation of this equation is included in Annex L.

Annex C (normative)

Defrost and recovery energy and temperature change

C.1 General

This Annex specifies the method to be used to determine the additional energy associated with **defrost and recovery periods** that occur in **refrigerating appliances** with one or more **defrost control cycles**. It also specifies the determination of the temperature change by **compartment** that is associated with those **defrost and recovery periods**. Normally, test data for these calculations is collected as part of the testing for **steady state** power consumption in Annex B. Individual **defrost and recovery periods** that occur at any time during the normal testing program can be used as long as these meet the relevant validity criteria. Where there is more than one defrost system (with its own **defrost control cycle**), the characteristics of each shall be separately determined (or in combination, where appropriate).

NOTE As **cyclic defrost** systems do not have a **defrost control cycle**, Annex C is only applicable to **compartments** or **refrigerating appliances** with **automatic defrost** systems other than **cyclic defrost**.

C.2 Setup for testing and data collection

The objective is to measure and select a number of representative **defrost and recovery periods** in order to determine a representative value for the additional (incremental) energy associated with **defrost and recovery** (over and above the **steady state power** consumption) and the change in average internal temperatures (for each relevant **compartment**) associated with **defrost and recovery** (relative to the **steady state** temperature) for each test **ambient temperature**.

The **refrigerating appliance** under test shall be set up and operated in accordance with Annex A. Where the cumulative time that the **refrigerating appliance** under test has been disconnected from power exceeds 6 h during the 24 h prior to the occurrence of a **defrost and recovery period**, then data from that **defrost and recovery period** shall be deemed invalid and shall not be used to determine representative values for incremental **defrost and recovery** energy and temperature change in accordance with Annex C.

To characterise the additional energy required, and the average temperature change, during a **defrost and recovery period** (relative to **steady state** conditions) at each test **ambient temperature**, a specified number of representative **defrost and recovery periods** need to be measured. In order to be considered representative, the **steady state power** and temperature before and after the **defrost and recovery period** shall meet the relevant stability or acceptance criteria. The number of **defrost and recovery periods** to be measured at each **ambient temperature** is specified in this Annex. A minimum of one **defrost and recovery period** is required for each test point used for energy determination for each **ambient temperature** condition. Alternatively, at least four **defrost and recovery periods** are required and at least half of all **defrost and recovery periods** have to have the coldest **compartment** at or below **target temperature** for each **ambient temperature**.

Conceptually, the additional energy associated with **defrost and recovery**, over and above the underlying **steady state** power consumption, is determined as illustrated in Figure C.1.

The main case considered is called Case DF1, where the **refrigerating appliance** can demonstrate **steady state** operation before and after the **defrost and recovery period**.

In rare cases (called DF2) it may not be possible to reliably demonstrate **steady state** operation before and after the **defrost and recovery period** for any defrost. Only in this case may the methodology set out in Annex K be used.

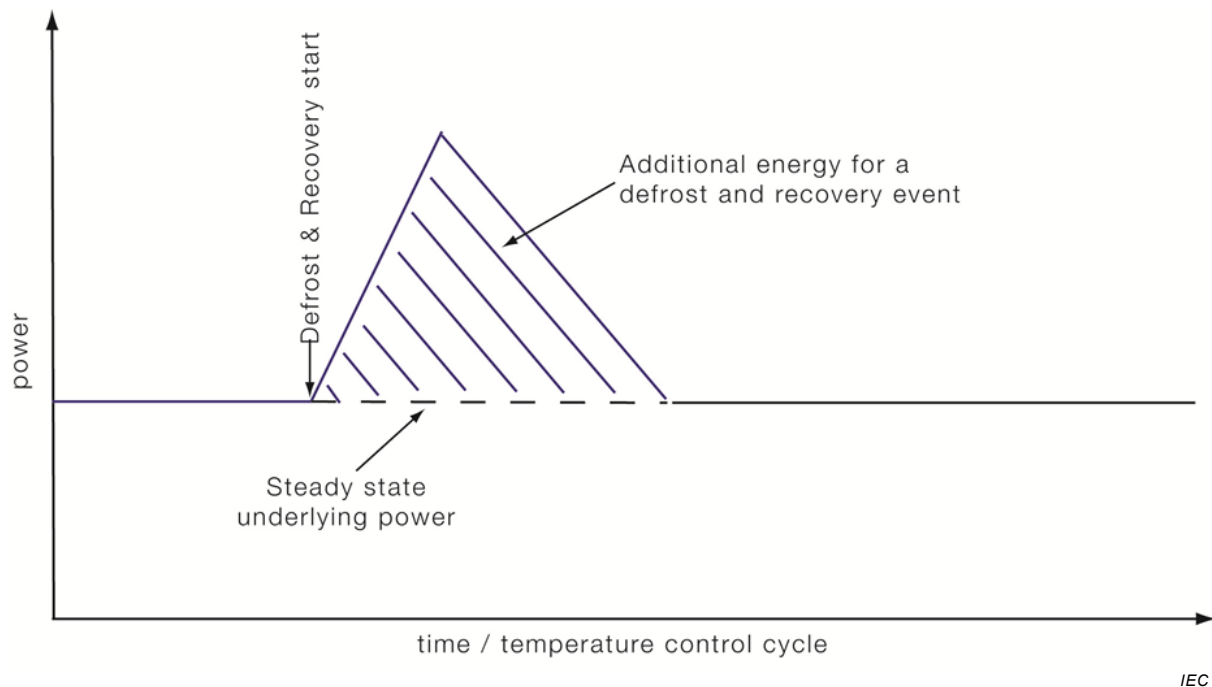


Figure C.1 – Conceptual illustration of the additional energy associated with a defrost and recovery period

C.3 Case DF1: where steady state operation can normally be established before and after defrosts

C.3.1 Case DF1 approach

Case DF1 is where the **refrigerating appliance** normally operates in a **steady state** condition prior to defrost and returns to **steady state** operation some time after the defrost. Effectively, **steady state** operation occurs on either side of a **defrost and recovery period**. Each **defrost and recovery period** is examined in isolation. This approach is used for all types of **refrigerating appliances** that have one or more **compartments** with a defrost system (with its own **defrost control cycle**).

A period of **steady state** operation (called Period D), ending well before the start of a **defrost and recovery period** is selected to be the minimum possible size that meets the criteria set out in C.3.2. A period of **steady state** operation (called Period F), starting well after the end of the same **defrost and recovery period** is selected to be the minimum possible size that meets the criteria set out in C.3.2.

For the purposes of validity assessment in C.3.2, the nominal centre of the **defrost and recovery period** is defined as 2 h after the initiation of the defrost heater or, in the case where there is no defrost heater, after the interruption of the refrigeration system related to the **automatic defrost**. This is illustrated in Figure C.2 – time interval Δt_{DI} and time interval Δt_{FI} shall be approximately the same, but will vary depending on the exact time of the selected **temperature control cycle** (where applicable) at the end of Period D and the start of Period F.

NOTE C.3.2 sets out cases where the length of Periods D and F and time for Δt_{DI} and Δt_{FI} can be adjusted in order to find complying values.

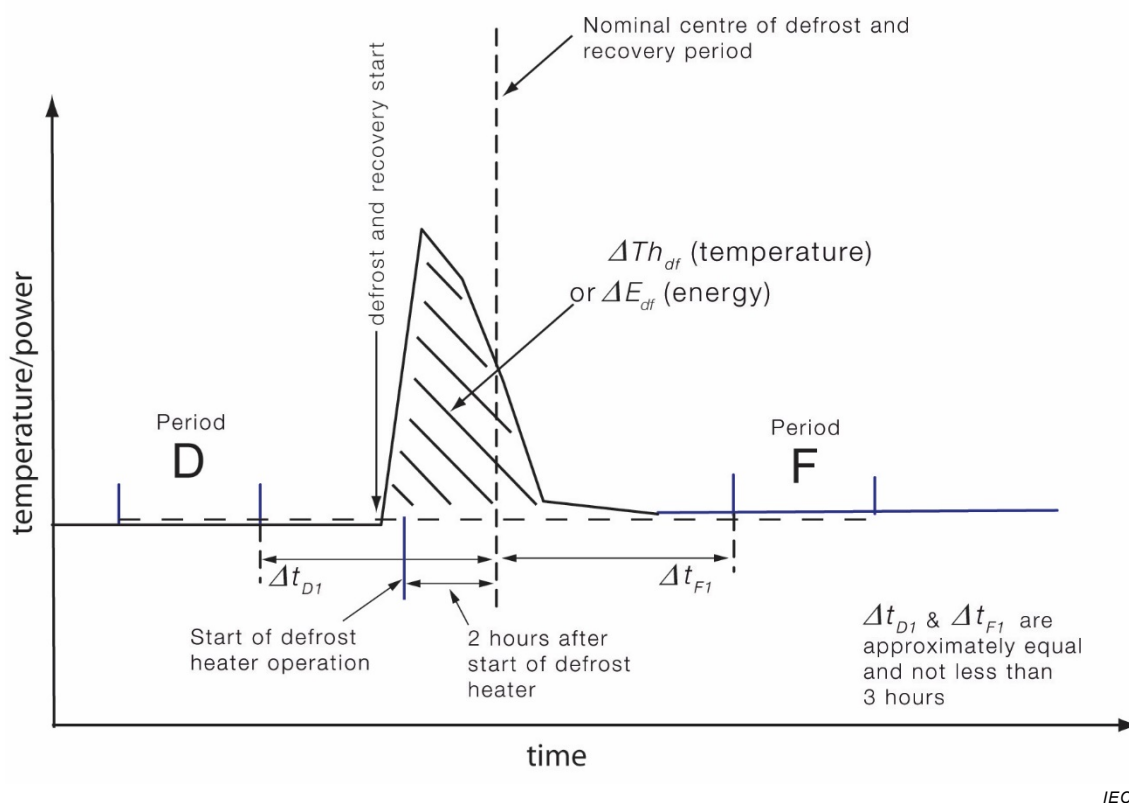


Figure C.2 – Case DF1 with steady state operation before and after a defrost

The temperature in each **compartment** and the power for Period D are then compared to the temperature in each **compartment** and power for Period F and assessed in accordance with C.3.2.

It is important to note that the average power for Period D will never be exactly equal to the average power for Period F (as illustrated above in Figure C.2). By spacing Periods D and F evenly around the nominal centre of the **defrost and recovery period**, the average power for Periods D and F provides a reasonable estimate of the underlying **steady state** power during the **defrost and recovery period**. This methodology allows individual **defrost and recovery periods** to be examined in isolation, which makes testing faster and more convenient.

Strict validity limits on the differences between Periods D and F are required to ensure that there are no significant changes in product behaviour during the assessment period (set out in C.3.2). Such differences may be due to a range of causes such as: **user-adjustable temperature control** change just before Period D or before Period F, inclusion of some residual pull down (from a warm start), some residual **processing load** in the **defrost and recovery period** (and in Period D) or automatic changes in the operation of the product (e.g. step changes in inverter speed, change in heater operation, significant temperature or power drift etc. that may give significantly different values in Period D and F). In all of these cases, the validity criteria should correctly reject the selected defrost, so it cannot be used for energy calculations. In this case testing has to continue until another **defrost and recovery period** is recorded.

Calculate the following characteristics across the Periods D and F:

- Spread of temperature for each **compartment**: calculated as the difference between the average temperature of the warmer period (D or F) minus the average temperature of the colder period (D or F). All temperature differences (spread) are in degrees K. Refer to Equation (16).

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- Spread of power: calculated as the difference between the average power of the higher power period (D or F) minus the average power of the lower power period (D or F) divided by the average power for the Periods D and F. The spread of power is expressed as both a percentage and as an absolute spread (W). Refer to Equation (17) and Equation (18).

$$\text{Spread of temperature} = T_{\max(D,F)} - T_{\min(D,F)} \text{ (K)} \quad (16)$$

$$\text{Spread of power} = \frac{P_{\max(D,F)} - P_{\min(D,F)}}{P_{av(D,F)}} \text{ (%) } \quad (17)$$

$$\text{Spread of power} = P_{\max(D,F)} - P_{\min(D,F)} \text{ (W)} \quad (18)$$

Where for periods D and F:

T is the temperature

P is the power

% is the result of the quotient (expressed as a percentage, where 1,0 = 100 %).

C.3.2 Case DF1 acceptance criteria

For the **defrost and recovery period** to be valid, the following criteria shall be met:

- Period D and F shall be made up of no less than 3 whole number of **temperature control cycles** (where **temperature control cycles** are present) and shall have the same number of **temperature control cycles**. Where no **temperature control cycles** are present or where fixed time slices are used, Periods D and F shall be the same length.
- Period D and F shall not be less than 3 h in length.
- Period D shall finish no less than 3 h before the nominal centre of the current **defrost and recovery period** ($\Delta t_{DI} \geq 3 \text{ h}$).
- Period F shall start no less than 3 h after the nominal centre of the **defrost and recovery period** ($\Delta t_{FI} \geq 3 \text{ h}$).
- The spread of temperature for Periods D and F shall be less than 0,5 K for each **compartment**.
- The spread of power for Periods D and F shall be less than 2 % or less than 1W, whichever is the greater value.
- The ratio of the total length of Period D (in hours) to the total length of Period F (in hours) shall be in the range 0.8 to 1.25 where **temperature control cycles** are present.
- The start of any selected Period D shall be no less than 5 h after the initiation of the previous defrost heater on or, in the case where there is no defrost heater, no less than 5 h after the interruption of the refrigeration system related to the **automatic defrost**.
- The end of any selected Period F shall not be after the initiation of the subsequent **defrost and recovery period**.

NOTE In this case, spread is the difference between the average values for Period D and F. Refer to B.3.1 for more information on the term spread.

Where the initially selected Period D and Period F do not comply with the acceptance criteria specified above, the minimum length for Periods D and F shall both be increased in steps of 1 **temperature control cycle** (in 1 h steps where there are no **temperature control cycles** or where fixed time slices are used) to see if there are any possible complying periods with Δt_{DI} and Δt_{FI} set to a minimum of 3 h.

Where it is not possible to find complying periods D and F (e.g. because the **defrost and recovery period** is long), the minimum size of interval Δt_{DI} and Δt_{FI} (see points c) and d) above) shall be increased in 30 min steps and validity for varying sizes of Periods D and F reassessed for each increase.

Where the size of Periods D and F are increased or the length of Δt_{DI} and Δt_{FI} increased, the first valid value using the sequence specified above shall be used.

Where no complying selections for Periods D and F can be found using the above sequence, the distance from the initiation of the defrost heater or, in the case where there is no defrost heater, after the interruption of the refrigerating system related to the **automatic defrost**, to the nominal centre of the **defrost and recovery period** may be adjusted from the default value of 2 h. The adjusted value shall not be less than 1 h and not more than 4 h and shall be a multiple of 30 min.

EXAMPLE If the distance from the start of the **defrost and recovery period** to the nominal centre of the **defrost and recovery period** was set to 3 h in order to obtain complying data (because the **defrost and recovery period** was long), the **defrost and recovery period** is considered to start at the same time as before but the nominal centre of the **defrost and recovery period** is set at 1 h later.

Where any non-standard parameters are used to select Periods D and F (i.e. they vary from the requirements specified in C.3.1), then this shall be noted in the test report.

Where there are more than two **compartments**, assessment of temperature stability as set out above is required for:

- The largest **unfrozen compartment** and largest **frozen compartment** (where applicable), or
- The largest two **compartments** (where all **compartments** are **frozen** or **unfrozen**).

In cases where there is no **steady state** operation between defrosts, it may not be possible to ever confirm the validity of the **defrost and recovery period** by examining symmetrically placed Periods D and F. An alternative approach (DF2) to deal with such cases is outlined in Annex K, but this should only be used if compliance with Clause C.3 can not normally be achieved.

C.3.3 Case DF1 calculation of values

Where the acceptance criteria in C.3.2 have been met, the determination of additional energy associated with each **defrost and recovery period** is calculated as set out below.

$$\Delta E_{dfj} = (E_{end-F} - E_{start-D}) - \frac{(P_{SS-D} + P_{SS-F})}{2} \times (t_{end-F} - t_{start-D}) \quad (19)$$

where

ΔE_{dfj}	is the additional energy consumed by the refrigerating appliance for defrost and recovery period j in Wh
$E_{start-D}$	is the accumulated energy reading at the start of Period D in Wh
E_{end-F}	is the accumulated energy reading at the end of Period F in Wh
P_{SS-D}	is the average power consumption for Period D in W
P_{SS-F}	is the average power consumption for Period F in W
$t_{start-D}$	is the test time at the start of Period D in h
t_{end-F}	is the test time at the end of Period F in h

NOTE In the above equation, the power for Period D and the power for Period F are averaged. A time-weighted average for both periods is not used.

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During a **load processing efficiency** test, it is possible that one or more defrosts occur for which a correction must be made. This correction is based on splitting the defrost and recovery energy in a fixed part and the energy used by the defrost heater:

$$\text{Fixed defrost adder: } \Delta E_{df-adderj} = \Delta E_{dfj} - E_{df-heaterj} \quad (63)$$

where:

$E_{df-heaterj}$ is the measured defrost heater energy during the **defrost and recovery period** j , expressed in Wh

NOTE This formula is applied to each valid defrost during steady state. A representative value for the fixed defrost adder ($\Delta E_{df-adder}$) is determined in accordance with Formula (64) and is subsequently used in the evaluation of a load processing test [using Formula (51) or, if multiple defrost systems are present, Formula (65)].

The determination of the temperature change in each **compartment** i associated with the **defrost and recovery period** j is calculated as follows:

$$\Delta Th_{dfj-i} = (t_{end-F} - t_{start-D}) \times \left[(T_{av-startD-endF-i}) - \frac{(T_{av-D-i} + T_{av-F-i})}{2} \right] \quad (20)$$

where

ΔTh_{dfj-i} is the accumulated temperature difference over time in **compartment** i (for 1 to n **compartments**) associated with **defrost and recovery** in Kh (note that this term may be positive or negative) for **defrost and recovery period** j

$T_{av-startD-endF-i}$ is the time weighted average temperature in **compartment** i over the period from the start of Period D to the end of Period F in degrees C (including the **defrost and recovery** temperature impacts)

T_{av-D-i} is the average temperature in **compartment** i that occurs during Period D in degrees C

T_{av-F-i} is the average temperature in **compartment** i that occurs during Period F in degrees C

$t_{start-D}$ is the test time at the start of Period D in h

t_{end-F} is the test time at the end of Period F in h.

For products with a compressor run time defrost controller, the additional compressor run-time associated with **defrost and recovery period** j (over and above the **steady state** run time) (in hours) is calculated as follows:

$$\Delta t_{drj} = (Rt_{end-F} - Rt_{start-D}) - \frac{[(Rt_{end-F} - Rt_{start-F}) + (Rt_{end-D} - Rt_{start-D})]}{(t_{end-F} - t_{start-F}) + (t_{end-D} - t_{start-D})} \times (t_{end-F} - t_{start-D}) \quad (21)$$

where

Δt_{drj} is the additional compressor run time associated with **defrost and recovery period** j in h (over and above the **steady state** compressor run time that would have occurred)

$Rt_{start-D}$ is the total accumulated compressor run time (on period) at the start of period D in h

$Rt_{start-F}$ is the total accumulated compressor run time (on period) at the start of Period F in h

Rt_{end-D} is the total accumulated compressor run time (on period) at the end of Period D in h

Rt_{end-F}	is the total accumulated compressor run time (on period) at the end of Period F in h
$t_{start-D}$	is the test time at the start of the Period D in h
$t_{start-F}$	is the test time at the start of the Period F in h
t_{end-D}	is the test time at the end of the Period D in h
t_{end-F}	is the test time at the end of the Period F in h.

Care is required not to count defrost heater on time as compressor on time in these calculations (although it is possible that some controllers include the defrost heater operation as run time – each product should be checked to see how it is configured). The value of Δt_{dr} could be zero or negative for continuously running products.

C.4 Number of valid defrost and recovery periods

For Case DF1 and Case DF2 the minimum number of valid **defrost and recovery periods** required for each ambient test temperature in order to calculate a representative value for **defrost and recovery** energy and temperature change is specified below:

Option 1: A valid value of ΔE_{df} shall be determined for each **temperature control setting** used for an energy determination on a single appliance in accordance with 6.8.2 and 6.8.3. The **defrost and recovery period** selected for each **temperature control setting** shall be adjacent to the **steady state** period used for energy determination in Annex B (this may occur before or after the **steady state** period for Case SS1; it shall be before the **steady state** period for Case SS2). The representative value for ΔE_{df} for the appliance shall be the average of all valid values for test points used for energy determination.

Option 2: Where there is more extensive data available for a particular model (either through longer tests or tests on several units of the same model), then the representative value for ΔE_{df} for the appliance shall be the average of at least 4 valid values. In this case at least 50 % of all values of ΔE_{df} shall have the coldest **compartment** at or below **target temperature**. A separate value for ΔE_{df} shall be determined for each **ambient temperature**.

Subject to regional regulations and requirements, Option 1 or 2 may be used.

NOTE The defrost heater energy $E_{df-heaterj}$ and incremental defrost and recovery energy ΔE_{dfj} for new appliances and appliances that have not been operated for some time may be initially low until the defrost heater energy stabilises.

C.5 Calculation of representative defrost energy and temperature

Calculations of a representative value for **defrost and recovery** energy and **defrost and recovery** temperature changes are given as follows:

$$\Delta E_{df} = F_{df} \frac{\sum_{j=1}^m \Delta E_{dfj}}{m} \quad (22)$$

where

ΔE_{df}	is the representative incremental energy for defrost and recovery for the test ambient temperature
m	is the number of valid defrost and recovery periods specified in C.4
ΔE_{dfj}	is the incremental energy for each defrost and recovery period j (from 1 to m)
F_{df}	is a regional scaling factor that can be used to compensate for frost load and usage factor, which impacts the defrost intervals. The default value for F_{df} is 1,0.

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To correct a **load processing efficiency** test where one or more defrosts occurs, a representative value for the fixed defrost adder is defined:

$$\Delta E_{df-adder} = \frac{\sum_{j=1}^m \Delta E_{df-adderj}}{m} \quad (64)$$

$$\Delta Th_{df-i} = \frac{\sum_{j=1}^m \Delta Th_{dfj-i}}{m} \quad (23)$$

where

ΔTh_{df-i} is the representative temperature difference for **defrost and recovery** in **compartment i** (from 1 to n) for the test **ambient temperature**

m is the number of **defrost and recovery periods** specified in C.4

ΔTh_{dfj-i} is the accumulated temperature difference over time for each **defrost and recovery period j** (from 1 to m) in **compartment i** (from 1 to n)

For products with a compressor run time defrost controller, the representative additional compressor run-time associated with a **defrost and recovery period** is calculated as follows:

$$\Delta t_{dr} = \frac{\sum_{j=1}^m \Delta t_{drj}}{m} \quad (24)$$

where

Δt_{dr} is the representative additional compressor run-time associated with a **defrost and recovery period** for the test **ambient temperature**

m is the number of valid **defrost and recovery periods** specified in C.4

Δt_{drj} is the additional compressor run-time associated with **defrost and recovery period j** (from 1 to m)

Annex D (normative)

Defrost interval

D.1 General

This Annex specifies the method to be used to determine the **defrost interval** for **refrigerating appliances** where there are one or more **defrost control cycles**.

The three main types of defrost controllers are as follows:

- Elapsed time – the **defrost interval** is largely independent of ambient conditions or the load on the refrigeration system. These types are less common and the controls for them may be mechanical or electronic.
- Compressor run time – the **defrost interval** is dependent on the hours of operation of the compressor (i.e. a proxy for the load in the refrigeration system). These are relatively common and controllers for these are usually mechanical and only operate effectively where a single speed compressor is used.
- Variable – the **defrost interval** is adjusted under **normal use** by an automatic process that uses an operating condition variable (or variables) other than, or in addition to, elapsed time or compressor run time in order to better match the frost load on the **evaporator** arising from **normal use**. These types are now common and controls for these are usually electronic.

NOTE A defrost controller that directly measures the frost load on the **evaporator** is classified as a **variable defrost** controller.

The intent of this Annex is to establish the basis for operation of the defrost control and to then determine a representative **defrost interval** for each **ambient temperature**. In the case of compressor run time controllers, the **defrost interval** will also be partly affected by the **temperature control setting** when testing at a specified **ambient temperature**. The value determined in accordance with this Annex is then used for the determination of **energy consumption** in accordance with Clause 6.

D.2 Elapsed time defrost controllers

For these controllers, the **defrost interval** remains relatively fixed (in hours) under a wide range of operating conditions. While these types of controls are fairly unusual, they are found in some markets. In most cases the **defrost interval** is less than 24 h.

If the elapsed time controller is accessible, direct measurements may be undertaken in order to determine the actual elapsed time value of the controller. Acceptable tests to directly determine the elapsed time defrost controller period include:

- Direct measurement of the operation of the controller in the product (e.g. measurement of time that voltage is present)
- Operating the run time controller on the bench when removed from the product.

The value marked on an elapsed time controller may not be relevant, for example if a controller is **rated** at 60 Hz and the product operates on 50Hz. Elapsed time controllers of the same **rated** value can vary, but as they are generally a synchronous motor that operates on mains frequency, each controller should be very consistent once the interval has been determined.

If the elapsed time controller is not accessible (or where it is not clear whether the controller is an elapsed time controller) or where the laboratory is not able to directly measure the

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controller operation, the value shall be estimated by testing as set out below. Sufficient data shall be collected during tests in accordance with Annex B and C in order to establish a representative average **defrost interval** as set out below. Initially a **defrost interval** is determined for a single test condition, which can be taken at any **ambient temperature** and any **temperature control setting**. At least two additional **defrost intervals** are then determined at other **ambient temperatures** and/or **temperature control settings**. Values for at least three **defrost intervals** shall be determined, with at least one value at an **ambient temperature** of 16 °C and one value at an **ambient temperature** of 32 °C.

Irrespective of whether the time of the elapsed time defrost controller is directly measured or determined via a whole product test, some additional testing should be undertaken at other **ambient temperatures** and/or **temperature control settings**. During these tests the **refrigerating appliance** may be subjected to some user related loads such as door openings and small **processing loads** during these tests. The observed **defrost interval** should be consistent with the measured elapsed time, otherwise it shall be classified as a **variable defrost** controller.

NOTE 1 These tests are to detect whether the elapsed time controller is over-ridden by some other control mechanism during **normal use** conditions.

To qualify as an elapsed time controller, the coefficient of variation (standard deviation divided by the mean) of all measured **defrost intervals** shall be less than 10 % for the three or more **defrost intervals** determined. Where the product does not comply with this requirement, it shall be classified as a **variable defrost** controller.

Care is required to determine whether or not the elapsed time controller advances while the defrost heater is activated – this can depend on individual product design.

NOTE 2 The same timers could be used as compressor run time controllers or as elapsed time controllers, depending on how they are configured in the **refrigerating appliance**.

D.3 Compressor run time defrost controllers

For these controllers, the **defrost interval** is defined by the compressor run time (or on time in hours) (or, in some cases, the compressor run time plus the maximum time allocated for defrost heater operation). These controllers are only applicable to single-speed compressors. The **defrost interval** is therefore approximately inversely proportional to the total heat load on the refrigeration system (**ambient temperature** and user loads plus any internal heat loads). The most common defrost run time controllers range from 6 h to 12 h of compressor run time. Typically, this would result in **defrost intervals** of the order of 12 h to 30 h (elapsed time) at elevated **ambient temperatures** and somewhat longer **defrost intervals** at lower **ambient temperatures**.

NOTE 1 The same timers could be used as compressor run time controllers or as elapsed time controllers, depending on how they are configured in the **refrigerating appliance**.

If the run time controller is not accessible (or where it is not clear whether the controller is a run time controller) or where the laboratory is not able to directly measure the controller operation and does not know its run time, the value for the proxy run time shall be measured by testing as set out below. Any routine energy tests or other tests may be used for this purpose.

Each measurement shall be undertaken over a whole **defrost control cycle** and tests shall be undertaken in at least two different **ambient temperatures** in order to verify that it is a run time controller and to estimate the value of t_{prt} . The period selected shall comply with the following requirements:

- the first defrost shall qualify as a valid defrost as specified in Clause C.3;
- the test period shall include at least part of the subsequent **defrost and recovery period** that is initiated automatically without any intervention (defrost heater on).

The estimated proxy run time of the compressor run time defrost controller for a given set of test data that complies with these requirements is given by:

$$t_{prtj} = t_{crtj} + t_{dhj} \quad (25)$$

where

t_{prtj} is the estimated proxy run time of the compressor run time defrost controller for the test period starting with **defrost and recovery period** j in h;

t_{crtj} is the measured compressor run time in h from the initiation of defrost heater operation for **defrost and recovery period** j to the initiation of defrost heater operation for the subsequent **defrost and recovery period** $j + 1$;

t_{dhj} is the time from the start of the defrost heater on until the compressor restarts, in h, during **defrost and recovery period** j where the timer advances during the heater operation; otherwise, a value of zero if the timer does not advance during the heater operation.

NOTE 2 A common configuration is that the defrost heater is allocated a fixed maximum time of operation in the timer defrost controller (say 20 min). The actual heater on time will vary depending on the frost load for the specific defrost. The time between the heater off and the compressor on can vary, but the total time from heater on to compressor on is typically constant in this configuration. Where the laboratory has any doubt about the appliance configuration, it is assumed that the defrost timer does not advance when the defrost heater is on, so that only compressor on time is counted and the value of t_{dhj} is set to zero in Formula (25).

Additional routine tests undertaken at other **ambient temperatures** and/or **temperature control settings**, including user related loads, such as door openings and small **processing loads**, should be reviewed to assess defrosting behaviour. The observed **defrost interval** should be consistent with the measured proxy run time, otherwise it shall be classified as a **variable defrost** controller.

NOTE 3 These tests can be used to detect whether the run time controller is overridden by some other control mechanism during **normal use** conditions.

To qualify as a compressor run time defrost controller, the coefficient of variation (standard deviation divided by the mean) of the measured values for either compressor proxy run time t_{prtj} or compressor run time alone t_{crtj} shall be less than 5 % for the **defrost intervals** examined. Where the product does not comply with this requirement, it shall be classified as a **variable defrost** controller. The value of t_{prt} used in subsequent calculations shall be the average of all measured values of t_{prtj} .

Once confirmed, the proxy run time can be used to calculate the actual **defrost interval** (in elapsed time) for any **temperature control setting**, **ambient temperature** and load processing condition, as a function of the compressor run time. For all **refrigerating appliances** with compressor run time defrost controllers, the percentage run time shall be reported for **steady state** conditions in Annex B and the extra compressor run time (in h) shall be calculated for **defrost and recovery periods** (Annex C, Formula (21)). The **defrost interval** for each test condition and **temperature control setting** is given by:

$$t_{df} = \frac{t_{prt} - \Delta t_{dr} - t_{dh}}{CRt_{SS}} = \frac{t_{crt} - \Delta t_{dr}}{CRt_{SS}} \quad (26)$$

where

t_{df} is the estimated **defrost interval** (elapsed time) for each **temperature control setting** and **ambient temperature** under test, in h, including the impact of **defrost and recovery**;

t_{prt} is the representative measured proxy run time of the compressor run time defrost controller (in h) in accordance with Formula (25);