The following calculations are optional and can be used to provide a common benchmark of the ice making efficiency of the appliance.

The energy to change the water added to ice for the specific quantity of ice made during the test can be calculated as follows:

$$E_{ice-enthalpy} = \frac{[M_{ice-test} \times (4{,}186 \times T_{amb} + 333{,}6 - T_{ice} \times 2{,}05)]}{3{,}6} \quad (44)$$

where

$E_{ice\text{-}enthalpy}$	is the energy removed from the water load to make the specific quantity of ice made during the test in Wh (as defined by physics)
$M_{ice\text{-}test}$	is the mass of water turned into ice during the test in kg
T_{ice}	is the average temperature of ice making bin after the ice making test is completed in °C (this shall be less than 0 °C)
T_{amb}	is the average ambient air temperature for the 6 h period before water is added to the tank (initial water temperature) in °C
4,186	is a factor for enthalpy change of water in kJ/(kg·K) (while unfrozen)
2,05	is a factor for enthalpy change of water in kJ/(kg·K) (while frozen)
333,6	is a factor for enthalpy water phase change in kJ/ kg (water to ice)
3,6	is a factor to convert kJ to Wh (s/h × 10^{-3}).

NOTE 1 The units of mass above are kg, whereas g are used in many places in this Annex, so care is required to ensure the correct units are used.

The overall efficiency of the ice making process can be determined as follows:

$$Efficiency_{ice} = \frac{E_{ice-enthalpy}}{\Delta E_{ice-test}} \quad (45)$$

where

$Efficiency_{ice}$	is the ice making efficiency for the specified **ambient temperature** and mass of ice made (unitless – Wh/Wh)
$E_{ice\text{-}enthalpy}$	is the energy removed from the water load to make to make the specific quantity of ice made during the test in Wh
$\Delta E_{ice\text{-}test}$	is the additional energy consumed by the **refrigerating appliance** to make the specific quantity of ice made during the test in Wh.

NOTE 2 The measured value of $Efficiency_{ice}$ may be greater than one.

F.3.2.8 Data to be recorded and calculations

The following values shall be included in the test report for each **ambient temperature** where the **energy consumption** for making ice for a tank type ice maker is measured and reported:

- Initial mass of the tank and residual water in kg
- Final mass of the tank and residual water in kg
- Mass of water load added to the tank in kg
- Nominal **ambient temperature** in °C
- Mass of ice made in kg
- **Ambient temperature** measured for the 6 h prior to the start of the test in °C
- Duration of the ice making test in h

– **Steady state** power at the end of the test in W
– Number of defrosts that occurred during the ice making test (z)
– Value of ΔE_{df} used in calculations (where applicable)
– Additional energy used to make ice $\Delta E_{ice\text{-}test}$ as defined in F.3.2.7
– Additional energy consumed per kg of ice made $\Delta E_{kg\text{-}ice}$ (Wh/kg) as defined in F.3.2.7.

The following parameters are recommended for inclusion in the test report:

- Energy removed from the water to make ice $E_{ice\text{-}enthalpy}$ as defined in F.3.2.7 in Wh
- $Efficiency_{ice}$ ice making efficiency for each specified ambient test temperature as defined in F.3.2.7.

F.3.2.9 Addition of automatic ice making into daily energy

This Annex provides an estimate of the incremental **energy consumption** required to make ice automatically. The user demand for ice is highly variable at a regional level as this depends on climate, season and indoor conditions, as well as user habits. Therefore, the measured incremental energy to make ice in this Annex is normally scaled so that the ice consumption more closely matches regional requirements.

Where a regional estimate of the consumed quantity of ice is given in kg/d, the impact on the daily **energy consumption** at a given **ambient temperature** can be estimated as follows:

$$\Delta E_{ice-making} = \Delta E_{kg-ice} \times M_{ice-making} \quad (46)$$

where

$\Delta E_{ice\text{-}making}$ is the additional energy consumed by the **refrigerating appliance** to make $M_{ice\text{-}making}$ kg of ice per day at the specified **ambient temperature** in Wh/day

$\Delta E_{kg\text{-}ice}$ is the estimated additional energy consumed by the **refrigerating appliance** to make 1 kg of ice in Wh as set out in F.3.2.7

$M_{ice\text{-}making}$ is the mass of water turned into ice per day in kg/day – this is a regional factor.

The value for $\Delta E_{ice\text{-}making}$ can be added to the daily **energy consumption** value to estimate a value for this user related usage element. If the values at an **ambient temperature** of 16 °C and 32 °C are both used, the annual factor could be expressed as:

$$\Delta E_{ice\text{-}making\text{-}annual} = f\{\Delta E_{ice\text{-}making16C}, \Delta E_{ice\text{-}making32C}\} \quad (47)$$

Annex G
(normative)

Determination of load processing efficiency

G.1 Purpose

This test quantifies the additional energy consumed by the **refrigerating appliance** to remove a known amount of energy which is contained in warm water, which is placed into **unfrozen** and/or **frozen compartments** in a defined way. The ratio of the energy in the water (which is removed) to the additional energy consumed by the **refrigerating appliance** is used to determine the **load processing efficiency**.

The purpose of the **load processing efficiency** test is to quantify the incremental energy impact of user-related aspects of **refrigerating appliance** use such as door openings and cooling of warm food and drinks. This data can be used in conjunction with closed door tests to produce a total **energy consumption** estimate that more closely represents actual use in different regions. To use the **load processing efficiency** value, an estimate of typical regional user related **processing load** needs to be made. This is usually best done through regional end use measurement programs. The impact of the estimated regional **processing load** on the energy for the particular **refrigerating appliance** can then be estimated from the **load processing efficiency** value determined in this Annex.

If regional energy standards and labelling requirements do not incorporate this component in their calculations (i.e. set the **processing load** to zero), then this test is not required for that region.

Where a supplier provides data or makes a claim of **load processing efficiency**, it shall be based on measurements undertaken in accordance with this Annex.

NOTE For **refrigerating appliances** with **unfrozen** and **frozen compartments**, this Annex sets out a method to measure the combined **load processing efficiency** of both **compartments**. The procedure could, in principle, be used to separately measure the **load processing efficiency** of just the **unfrozen compartment** or just the **frozen compartment**.

G.2 General description

A **refrigerating appliance** is operated in a **steady state** condition with **temperature control settings** that are close to the relevant **target temperature** for **energy consumption** as specified in Table 1 for each **compartment** (see 5.1). The **temperature control settings** shall remain unchanged for the duration of the **load processing efficiency** test.

A specified mass of water (which is a function of the **volume** of the **unfrozen compartments** and/or **frozen compartments**) is placed in the test chamber with the **refrigerating appliance** and allowed to reach the ambient test temperature.

Once specified conditions are met, the door of the largest **unfrozen compartment** is opened for a specified time and the water containers placed in their specified positions. Then the door of the largest **frozen compartment** is opened for a specified time and the water-filled **ice cube trays** placed in specified positions.

The **refrigerating appliance** is allowed to operate until it reaches a **steady state** condition in terms of temperature and power consumption. The data collected is used to determine the **load processing efficiency** at the specified **ambient temperature**. The **load processing efficiency** is determined as the ratio of the processed heat load in the water (removed) divided by the additional **energy consumption** (over and above the **steady state** power) used by the **refrigerating appliance** to cool it down.

The general approach to measurements and the subsequent analysis is similar in concept to the determination of **defrost and recovery** energy as specified in Annex C.

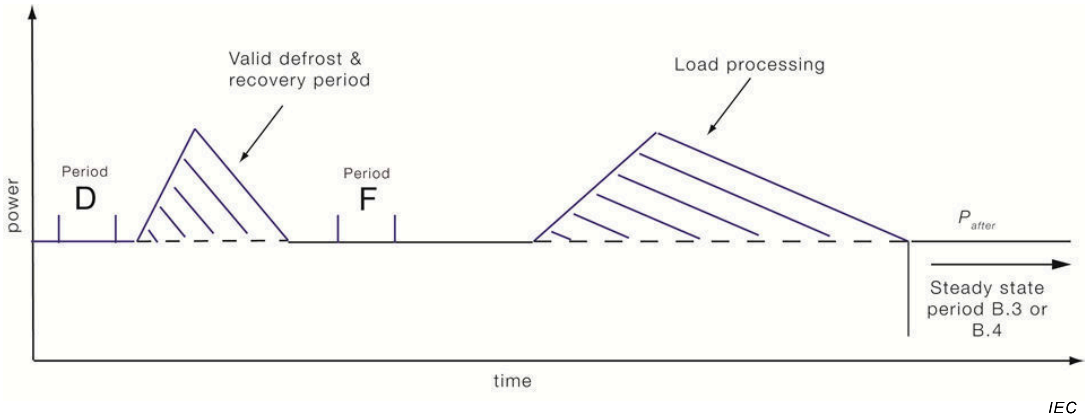


Figure G.1 – Conceptual illustration of the load processing efficiency test

NOTE An illustration of a defrost occurring prior to the completion of load processing is included in Figure G.5. Worked examples are contained in Annex I.

G.3 Setup, equipment and preparation

G.3.1 General

The test is carried out at ambient test temperatures of 16 °C and at 32 °C.

Where a **load processing efficiency** test is used as the basis for a manufacturer claim, the average temperature of all **compartments** that are used to process test load shall be at or below the relevant **target temperatures** specified in 5.1 during the **steady state** operation prior to the start of the **load processing efficiency** test.

NOTE 1 All temperatures specified in this Annex are for **steady state** conditions and do not include the temperature impact of any **defrost and recovery period** (where applicable).

For verification tests, the temperatures of all **compartments** that are used to process the test load shall be within ±1 K of the relevant **target temperature** during the **steady state** operation prior to **load processing efficiency** test. Alternatively, the results of two **load processing efficiency** tests can be interpolated to the value at the **compartment target temperature** of the coldest **compartment**, but one of the test points shall have all **compartments** that are used to process test load at or below **target temperatures**.

The principle included in this Clause is that a manufacturer is permitted to make a claim of **load processing efficiency** that is less than the optimum value possible (i.e. at a condition which may be somewhat colder than **target temperature**). This principle is set out for **energy consumption** tests in Clause 6 for a single energy test point.

Wherever possible, 3 **shelves** shall be used to hold the **processing load** in an **unfrozen compartment** (see Figure G.2) and shall be configured so that:

– Sensor TMP_3 is above **shelf** 3 (bottom) and below **shelf** 2
– Sensor TMP_2 is above **shelf** 2 and below **shelf** 1
– Sensor TMP_1 is above **shelf** 1.

NOTE 2 **Shelf** 3 may be the bottom of the appliance or it may be the top of a **convenience feature**, such as a crisper.

G.3.2 Equipment

The type of container used in **unfrozen compartments** is a thin walled plastic bottle made of PET (or equivalent material) with a nominal **volume** of 500 ml. The dimensions of the PET bottle shall be ≤220 mm in height and ≤90 mm in width/or diameter. All bottles shall be the same size and shape. Each bottle is filled with still water as specified below.

NOTE PET is polyethylene terephthalate. PET bottles can be any commercially available bottles with a nominal 500 ml capacity. They each contain a specified mass of drinking water. PET bottles that have a square cross section are preferred as they do not roll around when lying on their side.

The type of container used in **frozen compartments** is a plastic **ice cube tray** with a nominal working **volume** of about 200 ml per tray.

Ice cube trays are often supplied with a new product. For this test the **ice cube trays** used need to be able to comfortably hold 200 ml of water without risk of spillage. Nominal dimensions of approximately 120 mm × 275 mm × 40 mm are recommended. **Ice cube trays** that are smaller may be used if the recommended size does not fit.

Water used for all **processing loads** shall be potable, still water suitable for human consumption without added gas (i.e. uncarbonated), colour or additives.

Potable water from a tap is acceptable. Pure distilled water should be avoided in the **ice cube trays** as this can be difficult to freeze in some circumstances.

G.3.3 Quantity of water to be processed

G.3.3.1 Unfrozen compartments

The total **volume** of all **unfrozen compartments** and **sub-compartments** is summed. The water mass added to the largest **unfrozen compartment** shall be 12 g of water for each litre of total summed **unfrozen compartment volumes**. This equates to one PET bottle per 41,7 l or part thereof of unfrozen **volume**.

Where the total unfrozen **volume** is less than 41,7 l, all water is placed in one PET bottle. Where the total unfrozen **volume** is greater than 41,7 l but less than 83,4 l, all water is placed equally in two PET bottles. Where the unfrozen **volume** is greater than 83,4 l, 500 g ±1 g of water is placed in each PET bottle until the remaining water mass is less than 1 000 g. The remaining mass shall be divided evenly between the two remaining PET bottles.

The total mass of water placed in the largest **unfrozen compartment** and the number of 500 ml PET bottles shall be included in the test report.

G.3.3.2 Frozen compartments

The total **volume** of all **frozen compartments** and **sub-compartments** is summed. The water mass added to the largest **frozen compartment** shall be 4 g of water for each litre of **frozen compartment volume**. This equates to one **ice cube tray** per 50 l or part thereof of frozen **volume**.

Where the frozen **volume** is less than or equal to 50 l, all water is placed in one **ice cube tray**. Where the frozen **volume** is greater than 50 l but less than or equal to 100 l, all water shall be approximately divided evenly between the two **ice cube trays**. Where the frozen **volume** is greater than 100 l, approximately 200 g of water is placed in each **ice cube tray** until the remaining water mass is less than 400 g. The remaining quantity shall be approximately divided evenly between the two remaining **ice cube trays.**

The total **volume** of water placed in the largest **frozen compartment** and the number of **ice cube trays** shall be included in the test report.

G.3.4 Position of the water load in compartments

G.3.4.1 Position in unfrozen compartments

The PET bottles specified in G.3.3 shall be positioned in the largest **unfrozen compartment** as illustrated in Figure G.2.

Where there is 250 mm or more vertical clearance above the nominated **shelf**, PET bottles shall be placed standing in the following positions:

- The first bottle on each **shelf** on each side shall be placed as close as possible to the **compartment** liner while maintaining approximately 25 mm clearance from the side liner.
- Additional bottles in this position may be placed two or three deep while maintaining approximately 25 mm clearance between bottles and the front and rear of the **shelf** or **load limit**.
- Where more bottles are required in this position, additional rows of bottles (as required) are placed closer to the **compartment** centre while maintaining approximately 25 mm clearance between rows.
- All bottles shall be centred from front to back at even intervals on the **shelf** in their rows (taking account of the **shelf** edge and any **load limits** that may affect the depth).
- All bottles shall maintain at least 25 mm clearance in all directions from any **compartment** temperature sensor.

Where there is less than 250 mm vertical clearance above the nominated **shelf**, PET bottles shall be laid flat on the specified **shelf** with lids (caps) facing towards the **compartment** door (front) in the following positions:

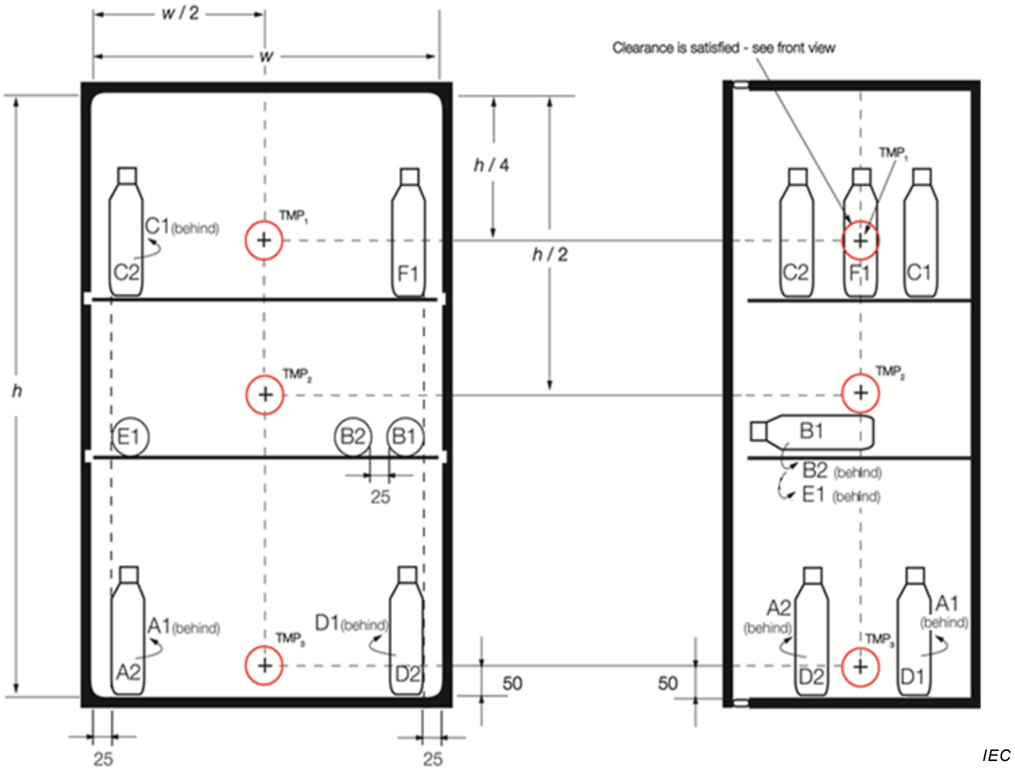
- The first bottle on each **shelf** on each side shall be placed as close as possible to the **compartment** liner while maintaining approximately 25 mm clearance from the side liner.
- Where more bottles are required in this position, additional bottles are placed closer to the **compartment** centre while maintaining approximately 25 mm clearance between bottles.
- No stacking or touching of bottles is permitted.
- All bottles shall maintain at least 25 mm clearance from any **compartment** temperature sensor.
- All bottles are aligned so that the top (cap) is at the front of the **shelf** or the **shelf load limit**. In the case of shallow **shelves**, the orientation of the bottle may be adjusted to ensure that no part protrudes past the front of the **shelf** or **load limit**, while maintaining 25 mm clearance from any temperature sensors.

All bottles should be placed in a position that minimises restriction of air flow from any ducts or vents. When it is not possible to place the PET bottles in the positions specified, equivalent positions are to be selected. Where equivalent positions are used, these shall be recorded in the test report. Where PET bottles have to be arranged differently because of space restrictions, they shall remain on the same **shelf** and shall be as close as possible to the specified position.

The PET bottles shall only be placed on **shelves** that are immediately below temperature sensor positions TMP_1, TMP_2 and TMP_3. Additional **shelves** that may be present are ignored. The PET bottles shall be placed in the following **shelf** positions in sequence until all bottles have been placed:

- One bottle in the sequence of positions ABCDEF
- Repeat the placement sequence until all bottles are placed.
- The two partially filled PET bottles (where applicable) are placed at the last two positions.
- All positions shall be noted in the test report.

NOTE The sequence above is to define the position or location of each bottle. The bottles may be loaded in any order into these specified positions when they are being placed into the **unfrozen compartment** in G.4.2. In the example illustrated in Figure G.2, 10 PET bottles would results in two bottles in positions A to D and one bottle in position E and F.



Dimensions in millimetres

NOTE Additional **shelves** may be present in the **refrigerating appliance** but are not shown in the figure.

Figure G.2 – Shelf locations and loading sequence (example showing 10 PET bottles)

G.3.4.2 Position in frozen compartments

The **ice cube trays** specified in G.3.3 shall be positioned in the largest **frozen compartment** as illustrated in Figure G.3. Where the largest **frozen compartment** has a combination of **shelves** and drawers, the **ice cube trays** shall be placed on **shelves** in preference to drawers (or baskets) as far as possible.

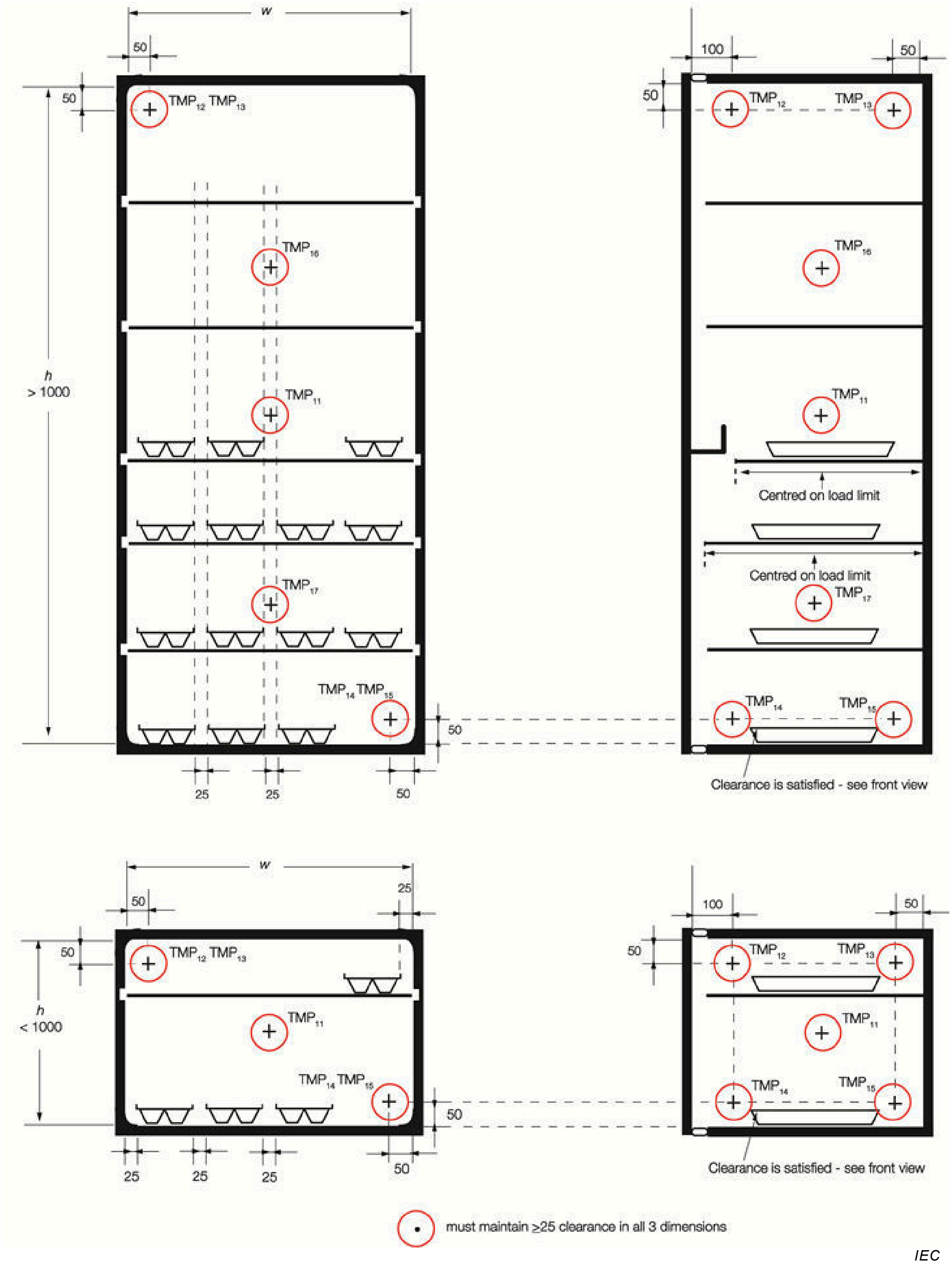
- The first **ice cube tray** on the lower level is placed on the opposite side to sensors TMP_{14} and TMP_{15} and as close as possible to the **compartment** liner while maintaining approximately 25 mm clearance. Additional **ice cube trays** are added next to the previous **ice cube tray** while maintaining approximately 25 mm clearance between **ice cube trays. Ice cube trays** may be oriented in any way that maximises the number of trays on each level while maintaining all necessary clearances.
- Where no more **ice cube trays** can be fitted onto the lower level (i.e. the number required results in the clearance to the temperature sensor positions of less than 25 mm in all directions), then **ice cube trays** are placed progressively on the next available level(s), as required.
- Where it is necessary to place **ice cube trays** on a **shelf** which sits below a central temperature sensor position (e.g. TMP_{11}, TMP_{16} or TMP_{17} as applicable), the first **ice cube tray** is placed adjacent to the left side liner, the second **ice cube tray** is placed adjacent to the right side liner. Additional **ice cube trays** on this level (if required) are placed progressively closer to the centre while maintaining approximately 25 mm clearance from each other and at least 25 mm from any temperature sensor position in all directions.

- Where it is necessary to place **ice cube trays** on a **shelf** which sits below the upper temperature sensor positions (e.g. TMP_{12} and TMP_{13}), the first **ice cube tray** is placed on the opposite side to sensors TMP_{12} and TMP_{13} and as close as possible to the **compartment** liner while maintaining approximately 25 mm clearance. Additional **ice cube trays** (if required) are added next to the previous **ice cube tray** while maintaining 25 mm clearance between **ice cube trays.**
- All **ice cube trays** are spaced approximately 25 mm from the **compartment** liner and each other on each level.
- The two partially filled **ice cube trays** (where applicable) are placed at the last two (upper most) positions required.
- No stacking or touching of **ice cube trays** is permitted.
- All **ice cube trays** shall maintain at least 25 mm clearance from any **compartment** temperature sensor position in all directions.
- All **ice cube trays** are centred from front to back of the **shelf** (taking account of the **shelf** edge and any **load limits** that may affect the depth) and shall not protrude beyond the front of the **shelf**.
- When **ice cube trays** are located inside a drawer or bin, the inside of the drawer or bin shall be treated as the inside of the liner with respect to placement.

NOTE As a practical example, a large **freezer** in a **refrigerator-freezer** with a **volume** of 180 l requires a total water mass of 720 g in 4 **ice cube trays.** The internal clearance of the **freezer** is 600 mm wide. Sensor positions TMP_{14} and TMP_{15} are 50 mm from the right hand lower wall. This leaves a space of 500 mm with clearances at each end for the placement of **ice cube trays.** Some 3 **ice cube trays** can be fitted at the lower level (120 mm + 25 mm minimum each, parallel to the sides), so one **ice cube tray** has to be placed on the upper level. If the **freezer** was deeper than say 460 mm, it would be possible to fit all 4 trays on the lower level (3 deep at right angles to the sides and one parallel to the sides) while maintaining clearances. See G.3.2 regarding the recommended size of **ice cube trays.**

All **ice cube trays** should be placed in a position that minimises restriction of air flow from any ducts or vents. When it is not possible to place the **ice cube trays** in the positions specified, equivalent positions are to be selected. Where equivalent positions are used, these shall be recorded in the test report. Where **ice cube trays** have to be arranged differently because of space restrictions, they shall remain on the same **shelf** and shall be as close as possible to the specified position. All **ice cube tray** positions shall be noted in the test report.

The sequence above is to define the position or location of each **ice cube tray**. The **ice cube trays** may be loaded in any order into these specified positions when they are being placed into the **frozen compartment** in G.4.2.



Dimensions in millimetres

NOTE Additional **shelves** may be present in the **refrigerating appliance** but are not shown in the figure. **Ice cube trays** are always placed on **shelves** in preference to drawers or baskets.

Figure G.3 – Ice cube tray locations and clearances

G.3.5 Temperature of the water to be processed

PET bottles with less than 500 g water should have the specified amount of water measured into the PET bottles prior to storage and temperature stabilization in the test room. Separate PET bottles containing sufficient water for all the **ice cube trays** (where applicable) shall be stored in the test room and (to avoid evaporation) shall only be decanted into the **ice cube trays** within 30 min of placement into the **frozen compartment**.

All PET bottles and **ice cube trays** shall be placed in the test room that is operating at the relevant **ambient temperature** in a position that is representative of the test room temperature. All PET bottles shall be placed vertically on a bench or the wooden test platform (floor) with no less than 50 mm clearance between them to allow free air circulation. This equipment shall remain in the test room for a period of no less than 15 h prior to the commencement of the **load processing efficiency** test.

NOTE The nominal ambient test temperatures for energy testing are 16 °C and 32 °C.

G.4 Load processing efficiency test method

G.4.1 Commencement of the load processing efficiency test

For **refrigerating appliances** without any **defrost control cycle,** the **load processing efficiency** test shall be preceded by a period of operation, at the **temperature control setting** used for the **load processing efficiency** test. The settings shall be such that it could qualify as a valid energy test period in accordance with B.3.

For a **refrigerating appliance** with one or more defrost systems (with its own **defrost control cycle**) the **load processing efficiency** test shall be preceded by:

- An energy test period that complies with B.3 at the **temperature control setting** used for the **load processing efficiency** test (including validity requirements); or
- An energy test period that complies with B.4 at the **temperature control setting** used for the **load processing efficiency** test (including validity requirements); or
- A **defrost and recovery period** that complies with C.3 at the **temperature control setting** used for the **load processing efficiency** test (as applicable).

NOTE Where stability is determined by DF1 (C.3), the load can only be inserted after confirmation of the defrost validity (i.e. after the end of Period F, which is at least 8 h after the operation of the defrost heater). Where stability has been established using **steady state** conditions or an earlier defrost, the load should be inserted as soon as practicable after the **defrost and recovery period** has been completed to minimise the chance of another defrost occurring prior to completion of the load processing test. As a guide, more than 5 h after the defrost heater operates (which could normally qualify as the start of Period F under C.3.1) is recommended (laboratories should use their experience of previous valid **defrost and recovery periods** to make an accurate judgment). In this case the previous **defrost and recovery period**, which is immediately prior to load insertion, is not included in the load processing test period.

For all product types, the **temperature control settings** shall remain unchanged for the duration of the **load processing efficiency** test.

For simple products with regular compressor cycles, a compressor on event can be taken as the start of the **load processing efficiency** test. For more complex products, a temperature maximum in the **compartment** that dominates the **energy consumption** can be taken as the start of the **load processing efficiency** test (see Annex B for more guidance). Where the **processing load** is inserted during the **defrost and recovery period**, the start of the test is defined as the start of that **defrost and recovery period**.

Insertion of the load during the **defrost and recovery period** (prior to establishment of **steady state** conditions) is generally not recommended.

G.4.2 Placement of the load

The load shall be prepared in accordance with Clause G.3. The load shall be placed in the **refrigerating appliance** as specified in Clause G.3 as soon as practicable after the start of a **temperature control cycle** as specified in G.4.1, but while the compressor is still operating (for simple products) or before a **compartment** temperature minimum is reached (for more complex products). The loading of each **compartment** shall be undertaken with one door opening and closing for that **compartment**. The door shall be left open at an angle of at least 90 degrees from the closed position for a duration that is as close as possible to one minute (±5 s) for each storage **compartment** being loaded, irrespective of the time taken to load the