

SASO 2664
(DRAFT)

**ENERGY PERFORMANCE AND CAPACITY OF
HOUSEHOLD REFRIGERATORS, REFRIGERATOR-
FREEZERS, AND FREEZERS**

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**ENERGY PERFORMANCE AND CAPACITY OF
HOUSEHOLD REFRIGERATORS, REFRIGERATOR-
FREEZERS, AND FREEZERS**

ICS:

**Date of SASO Board of Director's Approval :
Date of Publication in the Official Gazette :
Date of Enforcement of this Standard :**

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ENERGY PERFORMANCE AND CAPACITY OF HOUSEHOLD REFRIGERATORS, REFRIGERATOR- FREEZERS, AND FREEZERS

1. SCOPE

1.1 This Standard applies to

- (a) household refrigerators, refrigerator-freezers, and freezers; and
- (b) compact refrigerators, compact refrigerator-freezers and compact freezers that are electrically operated on a 60 Hz alternating current, with a nominal supply voltage of 230 V.

1.2 This Standard applies to

- (a) refrigerators and refrigerator-freezers with a capacity up to 1100 L (39 ft³); and
- (b) freezers with a capacity up to 850 L (30 ft³).

1.3 The requirements in this Standard are not applicable to electrically operated refrigerators employing an absorption refrigeration system and for commercial refrigerators, refrigerators-freezers and freezers.

1.4 The values given in SI (metric) units are the standard. Any values given in parentheses are for information only.

2. DEFINITIONS

The following definitions apply in this Standard:

Air duct - a passage that directs the flow of air.

Antisweat heater - a device incorporated into the design of a refrigerator or freezer to prevent the accumulation of moisture on exterior surfaces of the cabinet under conditions of high ambient humidity. This heater may be switchable from fully ON to fully OFF or to some intermediate condition of operation.

Baffle - a plate, wall, or partition designed to perform one or more of the following functions:

- (a) to prevent the contact of food with refrigerated surfaces;
- (b) to prevent the dripping of condensate on food; or
- (c) to regulate or direct circulation of refrigerated air, or both.

Cabinet breaker strip - a separate insulating element or integral extension of the cabinet interior surfaces around the periphery of the cabinet door or drawer opening(s) that functions as a thermal barrier to minimize heat flow to the interior of the cabinet.

Compartments - food storage areas for a particular type of product or purpose.

Basket - an open container, usually made from coated wire or plastic mesh, provided to hold and allow easy access to food items. The container may be suspended from or sit on appliances walls, shelving or other containers.

Butter, margarine, or cheese compartment(s) - a compartment provided for the storage of butter, margarine, or cheese.

Butter or margarine conditioner - an enclosed compartment that is provided for the storage of butter, margarine, or both and that has an auxiliary temperature control.

Crisper - An enclosed compartment or container that retards the dehydration of fruits and vegetables. It may have adjustable venting and sit on or be suspended from appliance walls or shelving.

Drip tray - a tray or drawer that is located beneath the refrigerated surfaces of a manual or semiautomatic defrosting refrigerator for the chilling of food or collecting of water during defrosting, or both. It may also serve as a baffle to regulate compartment temperature.

Ice storage bin - a container in which ice may be stored.

Meat Pan - A customer controlled variable temperature storage compartment utilized for the storage of meats and cheeses.

Compressor cycle - a period commencing from that point in time when the compressor makes the transition from the OFF mode to the ON mode, to the moment when the compressor again makes the transition from the OFF mode to the ON mode.

Cycle - the period of 24 h for which the energy use of a refrigerator or freezer is calculated, when consumer-activated compartment temperature controls are set so that desired compartment temperatures are maintained.

Defrost period - the period commencing from that point in time when the defrosting mechanism has made the transition from the OFF mode to the ON mode, to the moment when the defrosting mechanism again makes the transition from the OFF mode to the ON mode.

Defrost system - a means to remove frost, ice, or both, from the refrigerated surfaces.

Automatic defrost (no-frost) - a system in which the defrost cycle is automatically initiated and terminated, with resumption of normal refrigeration at the conclusion of the defrost operation.

Note: The system automatically prevents the permanent formation of frost on all refrigerated surfaces. Nominal refrigerated food temperatures are maintained during operation of the automatic defrost system(s) and the defrost water is disposed of automatically. Normal compressor cycling is not considered a defrost system.

Long-time automatic defrost - an automatic defrost system where successive defrost cycles are separated by 14 h or more of compressor-operating time.

Manual defrost - a system in which defrosting of the refrigerated surface is accomplished by natural or manual means with manual initiation and manual termination of the overall defrost operation.

Partial automatic (cycle) defrost (refrigerators) - a system in which the refrigerated surfaces of the freezer compartment are defrosted manually and the refrigerated surfaces of the fresh food compartment are defrosted automatically. Defrost water from the fresh food compartment is disposed of automatically or collected in a container for subsequent manual removal.

Semi-automatic defrost - a system in which the defrost cycle is manually initiated and automatically terminated with automatic resumption of normal refrigeration at the conclusion of the defrost operation. Defrost water is disposed of automatically or collected in a container for subsequent manual removal. A means of accelerating the rate of defrost may or may not be included in the product design.

Variable defrost - a long-time automatic defrost system (except the 14 h defrost qualification does not apply) where successive defrost cycles are determined by an operating condition variable or variables other than solely compressor operating time. This includes any electrical or mechanical device. Demand defrost is a type of variable defrost control.

Door -

Door dike - a projection on the door that extends into the refrigerated compartment(s) and that functions primarily as a barrier to minimize heat flow to the interior of the cabinet.

Right-hand door - a door which is hinged on the right-hand side when viewed facing the cabinet.

Left-hand door - a door which is hinged on the left-hand side when viewed facing the cabinet.

Drip (drain) trough - a device for channeling water.

Evaporator -The component of a mechanical refrigeration system in which the refrigerant is evaporated using the heat absorbed from the medium to be cooled.

Fan shroud - a protective housing surrounding the fan and which may also direct the flow of air.

Freezer - a cabinet that is designed

- (a) for the extended storage of frozen food at an average temperature of -17.8°C (0°F) or lower;
- (b) with the inherent capability for freezing of food; and
- (c) with a minimum reserve capacity of 2 kg/100 L/24 h.

Chest type - a freezer that is accessible from the top.

Upright type - a freezer that is accessible from the front.

Freezer compartment - a compartment that has the inherent capability of freezing to the level of performance required in the specific appliance.

Freezing Capability – the reserve refrigerating capability of the freezer, expressed in kg of ice per 24 h, under the operating conditions specified in Clause 5.2

Fresh food compartment - compartment(s) designed for the refrigerated storage of food in a refrigerator at an average temperature above 0°C (32°F).

Special compartments designed for the storage of fresh foods at temperatures near 0°C (32°F) are considered part of the fresh food compartment.

Special compartments of combination refrigerator-freezers operating at average temperatures between -15 and 0°C (5 and 32°F) are considered part of the fresh food compartment.

Frozen food compartment - a compartment that has the inherent capability to maintain frozen food at the temperature required in the specific appliance.

Ice Maker

Automatic - Connected to a water supply - a device which automatically produces, harvests, and stores ice in a storage bin, with a means to automatically interrupt the harvesting operation when the bin is filled to a predetermined point.

Cyclic type - an automatic ice maker with separate and sequential water fill, freezing, and harvesting phases of the ice-making operation.

Noncyclic (continuous) type - an automatic ice maker with simultaneous water supply, freezing, and/or harvesting phases in the ice-making operation.

Ice storage bin rating - the capacity of an automatic ice maker storage bin is the average weight of ice contained in the bin when the bin-fill device terminates the ice-making operation.

Ice tray - a container for freezing water into ice.

Liner - the enclosure forming the interior of the fresh food compartment, some freezer compartment(s), or both. The complete liner comprises the compartment liner in the cabinet, the exposed breaker strip surfaces, and the door liner(s).

Plaque and/or sump - the volume generated by embossed areas on the interior surfaces of the fresh food, freezer compartment(s), or both.

Product type - the category of refrigerators, refrigerator-freezers and freezers as determined from the following list according to size, type of defrost system, location and orientation of freezer compartment and type of ice service:

Type 1 - Refrigerators and refrigerator-freezers with manual defrost

Type 2 - Refrigerator-freezers with partial automatic defrost

Type 3 - Refrigerator-freezers with automatic defrost with top-mounted freezer without through-the-door ice service, and all refrigerators with automatic defrost

Type 4 - Refrigerator-freezers with automatic defrost with side-mounted freezer without through-the-door ice service

Type 5 - Refrigerator-freezers with automatic defrost with bottom-mounted freezer without through-the-door ice service

Type 6 - Refrigerator-freezers with automatic defrost with top-mounted freezer with through-the-door ice service

Type 7 - Refrigerator-freezers with automatic defrost with side-mounted freezer with through-the-door ice service

Type 8 - Upright freezers with manual defrost

Type 9 - Upright freezers with automatic defrost

Type 10 - Chest freezers and all other freezers

Type 11 - Compact refrigerators and refrigerator-freezers with manual defrost

Type 12 - Compact refrigerator freezers with partial automatic defrost

Type 13 - Compact refrigerator freezers with automatic defrost with top-mounted freezer and compact all-refrigerators with automatic defrost

Type 14 - Compact refrigerator-freezers with automatic defrost with side-mounted freezer

Type 15 - Compact refrigerator-freezers with automatic defrost with bottom-mounted freezer

Type 16 - Compact upright freezers with manual defrost

Type 17 - Compact upright freezers with automatic defrost

Type 18 - Compact Chest freezers and all other freezers

Quick-freeze - an optional feature on freezers that is initiated manually and shut off manually. It bypasses the thermostat control and places the compressor in a steady-state operating condition until it is shut off.

Refrigerator - a cabinet or any part of a cabinet that is designed for the refrigerated storage of food at temperatures above 0°C (32°F), that has a source of refrigeration. The cabinet may include a compartment for the freezing and storage of ice or for the storage of food or both at temperatures below 0°C (32°F).

All-refrigerator - a refrigerator that does not include a compartment for the storage of food at temperatures below 0°C (32°F). It may include a compartment of 14.2 L (0.5 ft³) or less for the freezing and storage of ice.

Basic refrigerator - a refrigerator that includes a low temperature compartment larger than 14.2L (0.5ft³) for the freezing and storage of ice and for short-term storage of food at temperatures below 0°C (32°F) and normally above -15°C (5°F). It is characterized by a refrigerated surface(s) that partially encloses the low temperature compartment and cools the fresh food compartment by natural convection. It frequently has a partition (called the chiller or drip tray).

Class I - a basic refrigerator with a low temperature frozen food storage compartment capable of maintaining temperatures at or below -9.4°C (15°F), with an average temperature of 5°C (41°F) in the fresh food compartment.

Class II - a basic refrigerator with a low temperature compartment capable of maintaining temperatures below 0°C (32°F) and normally above -9.4°C (15°F), with an average temperature of 5°C (41°F) in the fresh food compartment.

Compact refrigerator, refrigerator-freezer or freezer - an appliance with a total refrigerated volume of less than 219.5 L (7.75 cu ft) and an overall height of less than 91.4 cm (36 inches).

Refrigerator-Freezer - a cabinet that consists of two or more compartments, with at least one of the compartments designed for the refrigerated storage of foods at temperatures above 0°C (32°F) and with at least one of the compartments designed for the freezing and storage of frozen foods at or below average temperatures of -15°C (5°F), and typically capable of being adjusted by the user to a temperature at or below -17.8°C (0°F).

The refrigerator-freezer is also capable of maintaining simultaneously an average freezer temperature of $\leq -15^{\circ}\text{C}$ (5°F) and an average fresh food compartment temperature of $\geq 0 \leq 5^{\circ}\text{C}$ ($\geq 32 \leq 41^{\circ}\text{F}$).

Shelf - any horizontal surface within the cabinet that is provided for the storage of food.

Door shelf - any surface on the door that may be used for the storage of food.

Fractional shelf - a surface that is less than either the width or the depth, or both, of the interior cross-section of the cabinet.

Full shelf - a surface that essentially fills the interior cross-section of the cabinet.

Special features - functional components, in a refrigerated cabinet that occupy space and provide additional capabilities.

Free-standing special feature - a functional component that rests freely on a shelf or on a storage compartment bottom, such as an ice tray or a set-in pan.

Supported fixed special feature - a functional component that is supported in a fixed location, such as an automatic ice maker or a chiller tray.

Supported re-locatable special feature - a functional component that is supported in a location chosen by the user, such as a meat pan or an egg container.

Stabilization period - the total period of time during which steady-state conditions are attained or evaluated.

Standard cycle - the cycle type in which the anti sweat heater control, when provided, is set at the highest energy consuming position.

Steady-state condition - a condition established during a stabilization period under either cyclic or continuous operating conditions in which the average compartment temperature or frozen food package temperature, where applicable, does not vary more than $\pm 0.6^{\circ}\text{C}$ (1°F) in two cycles (if cycling occurs) or 2 h, whichever is longer.

Note: *If the unit does not cycle, the average temperature between any two readings will not vary more than $\pm 0.6^{\circ}\text{C}$ (1°F) for a period of 2 h immediately preceding a defrost cycle, if applicable, will not vary more than $\pm 0.6^{\circ}\text{C}$ (1°F) when compared to the average temperature during the 2 h period prior to the next defrost cycle.*

Total shelf area - for refrigerators, a calculated value based on the net areas of the main shelves, door shelves, bottoms of suspended containers or dispensers, and the bottom of the liner(s) of the fresh food and freezer compartments. For freezers, a calculated value based on the net areas of the main shelves, door shelves, bottoms of suspended containers or dispensers, and the bottom of the liner(s).

Volume -

Adjusted volume -

- (a) For refrigerators and refrigerator-freezers adjusted volume is the sum of
 - (i) the fresh food compartment volume in litres; and
 - (ii) the product of an adjustment factor and the net freezer compartment volume in litres; and
- (b) For freezers, the adjusted volume is the product of the freezer volume in litres times an adjustment factor.

Freezer compartment volume - that portion of the total refrigerated volume below 0°C (32°F) average for basic refrigerators and -15°C (5°F) average or below for refrigerator-freezers.

Fresh food compartment volume - that portion of the total refrigerated volume above -9.4°C (15°F) average for basic refrigerators and all-refrigerators, or above -15°C (5°F) average for refrigerator-freezers. Regardless of its temperature, the volume of the refrigerated chiller tray and other special compartment(s) for storage of fresh food near 0°C (32°F) shall be included in the fresh food compartment volume.

Net freezer volume - that part of the total refrigerated volume of the freezer maintained below -15°C (5°F) when the average interior temperature is maintained at -17.8°C (0°F).

Total refrigerated volume -

- (a) For a refrigerator, total refrigerated volume is the sum of the fresh food compartment volume and the freezer compartment volume; and
- (b) For a freezer, total refrigerated volume is the freezer compartment volume.

Water cooler - a section of a refrigerator or refrigerator-freezer designed to provide the cooling of water directly plumbed into the appliance.

Check test : a full or part test To verify the performance or energy consumption or both of an individual brand and model registered for energy labeling

Star rating – the no. of stars displayed on the energy label (dimensionless).

Family of models – a range of models of the one brand , registered under one application , where each of the models on the application has same relevant physical characteristics, comparative energy consumption . energy efficiency rating and performance characteristics ,throughout this standards ,the word "model" shall be read as "model or family of models"

3. GENERAL REQUIREMENTS

3.1 Test Room

3.1.1 Ambient Temperature

The upright ambient temperature gradient in any 305 mm (1 ft) of upright distance from 51 mm (2 in) above the floor or supporting platform to a height 305 mm (1 ft) above the top of the cabinet shall not exceed 1°C/m (0.5°F/ft).

If the test room floor temperature is not within 1.7°C (3°F) of the specified ambient temperature, a platform shall be used to support the cabinet. This platform shall have a solid top with all sides open for air circulation underneath, and its top shall extend at least 305 mm (1 ft) beyond each side and front of the cabinet and to the wall in the rear. (see clause 5.1.2 – 5.2.2)

3.1.2 Ambient Relative Humidity

Wet bulb and dry bulb readings or the equivalent shall be taken to determine ambient relative humidity when required. The ambient relative humidity need not be controlled, except when specified under Clauses 5.1.2 and 5.2.2.

3.1.3 Air Circulation

The cabinet under test shall be shielded from forced air currents having a velocity of more than 0.25 m/s (50 ft/min).

3.1.4 Radiation

Shields shall be provided to prevent direct radiation from or to any heated or cooled surfaces whose temperature differs from the air temperature by more than 5°C (10°F).

3.2 Instruments

3.2.1 Temperature

Temperature measurements shall be made with one or more of the following instruments or their equivalents:

- (a) electrical resistance thermometers
- (b) thermistors; and
- (c) thermocouples;

Temperature readings shall be accurate to within $\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$).

For digital measuring instruments, the resolution shall be 0.1°C (0.2°F) or better.

3.2.2 Increasing the Heat Capacity of a Thermocouple Junction

When a mass is called for to increase the heat capacity of a thermocouple junction, the total heat capacity of the mass shall not exceed the heat capacity of 20 g of water (200 g brass). Weighting of the temperature sensors shall be accomplished with a cylindrical brass mass, 30 ± 5 mm ($1\text{-}1/8 \pm 1/4$ in) in diameter and height, in good thermal contact with each temperature sensor. All temperature measuring sensor masses shall be supported by low-thermally conductive material in such a manner that the air gaps required in Clauses 3.2.3 and 5.2.5 are maintained.

The reported temperature at any given point shall be the average temperature at that point at a particular time, with temperatures read at regular intervals not exceeding 4 min.

3.2.3 Temperature Measurements in a Freezer

When the freezer compartment is required to be test loaded with packages, temperatures shall be measured by unweighted thermocouples, located in the geometrical centre of packages measuring approximately 130 x 100 x 40 mm (5 x 4 x 1.5 in).

The packages shall

- (a) be sealed; and
- (b) be filled to a density of 560 ± 80 kg/m³ (35 ± 5 lb/ft³) with hardwood sawdust that has been water-soaked, or, an equivalent package of frozen food, such as chopped spinach, shall provide a valid alternative.

The frozen food compartment shall be loaded with 75% of the maximum number of filled packages that can be fitted into the compartment. The 75% load shall be fitted into the compartment(s) so as to permit air circulation around and above the load.

The air gap around the freezer compartment load shall be 15 to 40 mm (1/2 to 1-1/2 in), with the packages placed in a pyramid or tiered form if necessary to properly locate the thermocouples. To facilitate loading of the freezer compartment, a portion of the load may be made up of cartons filled with

individual packages, as long as these cartons do not interfere with the placement of thermocouples in the required locations or with the required air circulation.

Note: In order to keep packages from shifting and destroying the air gap, a wire grid that has small nonthermally conductive spacers for contact with the freezer liner may be used.

3.2.4 Electrical

Electrical measurements shall be made with one or more of the following instruments or their equivalents:

- (a) **Watt-hour meters** - The watt-hour meter shall have a resolution no larger than 1 Wh and a maximum error no greater than 2% of the measured value for any demand greater than 50 Wh.
- (b) **Voltmeters** - The voltmeter for measuring the electrical input shall be accurate to within $\pm 0.5\%$ of the quantity measured.

3.2.5 Time

Time measurements shall be accurate to within ± 0.5 s/h.

3.2.6 Length

All linear dimensions shall be measured to the nearest millimetre (1/16 in).

3.3 General Test Requirements

For each test, the cabinet shall be operated at the specified test conditions for a sufficient length of time to establish steady-state conditions.

3.3.1 Steady-State Conditions

For each test, the cabinet shall be operated at the specified test conditions for a sufficient length of time to establish steady-state conditions.

3.3.2 Power Supply

Unless otherwise specified, the electrical power supply shall be 230 V, 60 Hz at the product service connection. The actual voltage shall be reported as measured at the product service connection, with the compressor motor operating.

3.3.3 Preparation of the Test Sample

3.3.3.1 Assembly and Set-up

The cabinet with its refrigerating mechanism shall be assembled and set-up in accordance with the manufacturer's printed instructions supplied with the appliance. All packing materials and skid boards shall be removed.

3.3.3.2 Installation

Unless otherwise specified, the cabinet shall be installed with all sides, except the back, more than 250 mm (10 in) from walls or ceiling to ensure free air circulation. The space between the back and the test room wall or simulated

wall shall be in accordance with the manufacturer's instructions, or if not otherwise specified by the mechanical stops on the back of the cabinet.

Unless otherwise specified, cabinet doors shall be kept closed during all tests. Outer door gasket seals shall be checked for adequacy of seal to the cabinet and adjusted, if necessary.

All leads from measuring devices shall be brought to the outside of the cabinet in such a manner as to prevent air leakage. Where sealing is not complete because of the use of thermocouple wires, taping of the door gasket on either side of the wires using adhesive tape is permitted, as long as the tape does not exert extra pressure on the gasket.

3.3.3.3 Adjustments Prior to Testing

- (a) In preparing a refrigerator, refrigerator-freezer or a freezer for test, the unit shall be set-up as specified in Clauses 3.3.3.1 to 3.3.3.6 and particular attention shall be paid to the instructions pertaining to the placement and position of the chiller or drip tray during all tests. The proper placement may be designated by detents, depressions, bumpers or by other means;

Note: Since the location of chiller or drip trays can influence the convective air flow around the freezing compartment (and also the performance of the appliance), it is essential that the proper placement be established.

- (b) baffles shall be open;
- (c) automatic ice makers shall be inoperative during the test;
- (d) butter conditioners shall be set at the lowest energy usage position when adjustment is provided;
- (e) convenience lights, radios, clocks, hygienic lamps, etc, shall be set at the lowest energy usage positions, when adjustment is provided;
- (f) features that are electrically powered, manually initiated, and automatically (or manually) terminated (such as customer operated dispensers, fast chill compartments, etc) shall be operated at the lowest energy use position;
- (g) compartments that are convertible from refrigerator to freezer shall be operated at the highest energy usage position;
- (h) other temperature controllable compartments (such as crispers, convertible to meat keepers) shall be considered special compartments and shall be tested with the compartment controls set to provide the coldest temperature; and
- (i) containers and covers shall not be removed, unless otherwise specified in the printed instructions supplied with the appliance.

3.3.3.4 Preconditioning

Before the cabinet is tested, it shall be given a run-in period sufficient to assure a thorough working-in of mechanical parts, including operating controls. A run-in period shall be no less than 24 h of compressor run time. The run-in may be made at any convenient room temperature.

3.3.3.5 Defrosting Between Tests

The evaporator in manual defrost models need not be defrosted prior to each test unless frost accumulation exceeds 6 mm (1/4 in) in average thickness. Chiller and drip trays and the interior of the cabinet shall be dried after the evaporator has been manually defrosted and prior to the start of the test.

3.3.3.6 Freezer Loading

When the test procedure requires the use of frozen food packages, ice trays and ice buckets related to nonautomatic ice-making shall be removed from the freezer section and the space vacated shall be loaded to 75% of capacity with frozen food packages; and

Storage baskets in chest freezers shall be removed if they are removable without the use of tools.

3.3.4 Ambient Temperature Measurement

The ambient temperature shall be recorded at points located 1 m (3 ft) above the floor line and 250 mm (10 in) from the centre of the two sides of the cabinet. The temperature at each point shall be maintained within $\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$) of the specified value and shall be so maintained during stabilization periods as well as during the actual test runs.

Temperature measuring devices shall be located or shielded so that the indicated temperature will not be affected by the operation of the condensing units. A weighted thermocouple may be used in accordance with Clause 3.2.2.

Ambient air temperature shall be recorded at each of the specified positions at intervals not greater than 30 min during the test period.

3.4 Temperature Measurement

3.4.1 General

Temperature Measurements shall be recorded at the locations shown on Figures 1-4. No freezer temperature measurements shall be necessary for all-refrigerator models.

3.4.2 Measured Temperatures

3.4.2.1

The compartment temperature for each test period shall be an average of the temperatures measured in a compartment during a complete cycle or several complete cycles of the compressor motor (a compressor cycle shall be one complete motor ON period and one complete motor OFF period), over a time period exceeding 1 h.

For long-time automatic defrost models, compartment temperatures shall be those measured in the first part of the test period specified in Clause 5.1.8.4 for refrigerators or refrigerator-freezers or Clause 5.2.8.4 for freezers.

For models equipped with variable defrost controls, compartment temperatures shall be those measured in the first part of the test period specified in Clause 5.1.8.5 for refrigerators or refrigerator-freezers or Clause 5.2.8.5 for freezers.

- 3.4.2.2** One of the cycles shall be counted as the last complete compressor motor cycle during the test period.
- 3.4.2.3** On models with automatic defrost, all cycles should occur during the steady-state condition between two defrost periods or one of the cycles should be the last complete compressor motor cycle prior to defrost.
- 3.4.2.4** If no compressor motor cycling occurs, the compartment temperature shall be the average of the temperatures taken during the last 60 min of the test period, or the last 60 min of compressor motor ON time prior to defrost for models with automatic defrost.
- 3.4.2.5** If incomplete cycling occurs (less than one cycle), the compartment temperatures shall be the average of the temperatures taken during the last 3 h of the last complete ON period, or the last 3 h of complete compressor ON period prior to defrost for models with automatic defrost.

4. METHODS OF COMPUTATION

4.1 Total Refrigerated Volume of Refrigerators and Refrigerator-Freezers

4.1.1 Total Refrigerated Volumes - Areas Included

The total refrigerated volume shall include the volume occupied by

- (a) special features, such as baskets, crispers, meat pans, chiller trays, ice makers (including storage bins for automatic ice makers), and water coolers;
- (b) cabinet shelves, door shelf fronts and bottoms, and doors of special feature compartments located within the door; and
- (c) features, such as light shields, trims, and aesthetic items, that are removable without the use of tools.

4.1.2 Total Refrigerated Volumes - Areas Not Included

The total refrigerated volume shall not include the volume occupied by

- (a) the following cabinet volumes:
 - (i) parts necessary for the proper functioning of the unit, such as evaporator doors, cooling coils, evaporators, air ducts, drip troughs, condensers, baffles, and fan shrouds;
 - (ii) fixed projections such as control knobs, shelf hangers, shelf and pan rails, and thermostat escutcheons that collectively exceed a volume of more than 1.4 L (0.05 ft³) per compartment and
- (b) the following door refrigerated volumes:
 - (i) door dikes that do not serve as shelves;
 - (ii) partitions and projections within the door(s) enclosing a compartment that do not serve as shelves, and that collectively exceed a volume of more than 1.4 L (0.05 ft³);

- (iii) the space between the deductible door dikes (see item (b)(i)) and cabinet breaker strips or adjacent liner wall.

4.1.3 Fresh Food and Freezer Compartment Volume Measurement

4.1.3.1 The fresh food compartment volume and the freezer compartment volume shall be divided into the appropriate sections having similar width and depth dimensions (see Figures 5 – 10).

4.1.3.2 The volume of each section and the volume of all shaded spaces shown in Figures 5 - 10 shall be calculated. The volume of the fresh food compartment sections shall be totalled to determine the total unadjusted fresh food compartment volume. The volume of the freezer compartment sections shall be totalled to determine the total unadjusted freezer compartment volume.

4.1.3.3 The volumes of those items listed in Clause 4.1.2 and illustrated by cross-hatching in Figures 5 - 16 shall be deducted from the

- (a) total unadjusted fresh food compartment volume in order to determine the fresh food compartment volume; and
- (b) total unadjusted freezer compartment volume, in order to determine the freezer compartment volume.

4.1.3.4 The total refrigerated volume of a refrigerator or a refrigerator-freezer shall be determined by adding the fresh food compartment volume and the freezer compartment volume.

4.1.4 Total Refrigerated Volume Data to be Reported

The total refrigerated volume shall be reported to the nearest whole number of litres, or to the nearest one-tenth of a cubic foot.

The fresh food compartment volume and the freezer compartment volume shall be reported to the nearest tenth of a litre or nearest one hundredth of a cubic foot.

4.2 The Volume of Special Features of Refrigerators and Refrigerator-Freezers

4.2.1 Special Features Volume – Areas Included

Special features to be included in the volume calculation for refrigerators and refrigerator-freezers shall be

- (a) compartments or accessories such as baskets, crispers, meat pans, chiller trays, water coolers, can or package racks, movable compartments such as drawers or trays, and ice makers (including storage bins); and
- (b) compartments or accessories located in the door, such as crispers, liquid or ice dispensers, or compartment doors.

4.2.2 Special Features Volume – Areas Not Included

Door features of refrigerators and refrigerator-freezers such as shelves, racks, rails, retainers, or any component that is attached or formed into the door liner and intended to improve its utility for storing jars, cans, and packages, shall not be included in the volume calculation.

4.2.3 Volume Occupied by Special Features

4.2.3.1 The volume occupied by free-standing special features (see Figures 17 and 18) shall be calculated on an individual basis as the product of the values of width, length, and height of an encompassing right angle envelope for each feature. When special features are adjacent to each other, the volume between them shall be included.

4.2.3.2 The volume occupied by supported-fixed special features (see Figure 19) shall be calculated on an individual basis as the product of adjusted values of width, length, and height of each feature. These adjusted values shall be the actual average exterior dimensions of the feature, increased by the distances to adjacent surfaces or shelves where the volume defined by the distances is not readily accessible for normal use. A volume not readily accessible for normal use shall be defined as volume that is accessible only by removal of parts from the cabinet.

A volume adjacent to a special feature that has a dimension of less than 102 mm (4 in) in the case of a fresh food compartment, or less than 51 mm (2 in) in the case of a freezing compartment, shall be considered as not readily accessible for normal use unless specific means are provided for supporting stored articles and preventing their interference in the operation of the special feature.

In the case of ice makers or other features, where the volume occupied by the feature is defined in part by the movement of parts associated with the mechanical operation of the feature, the adjusted value of width and length shall include the maximum dimension(s) required by the path of the moving part(s), increased by the distances to adjacent surfaces or shelves where the volume defined by these distances is not readily accessible for normal use. This shall include the dimensions of any volume that is not readily accessible for normal use.

4.2.3.3 The volume occupied by supported-relocatable special features (see Figures 17 and 18) shall be calculated on an individual basis as the product of adjusted values of width, length, and height of each feature, with the feature located in the position occupying the least volume.

4.2.4 Volume Occupied by Special Features - Data to be Reported

The sum of all storage volumes occupied by the special features shall be reported to the nearest 0.1 L or nearest 0.01 ft³, with separate data for freezer compartments and fresh food compartments.

4.2.5 Volume Provided by Special Features

The storage volume provided by free-standing, supported-fixed or supported-relocatable special features shall be the product of the average interior width, length, and height from the interior bottom to the cover of the container when installed in its normal position in use. For ice trays, ice storage bins, and liquid containers, the storage volume shall be the interior volume when filled to the maximum operating level. See Figures 17-19.

4.2.6 Volume Provided by Special Features - Data to be Reported

The sum of the volumes provided by special features shall be reported to the nearest 0.1 L or nearest 0.01 ft³, with separate data for fresh food compartments and freezer compartments.

4.3 Total Shelf Area of Refrigerators and Refrigerator-Freezers

4.3.1 General

The total shelf area shall be determined from the areas of the main shelves, door shelves, bottoms of suspended containers or dispensers, and the bottom of the liner(s) of the fresh food and freezer compartments.

4.3.2 Clearances

The area of any part of a shelf in the fresh food compartment that has less than 102 mm (4 in) clearance above the shelf shall not be included in the total shelf area, except if on the door or as otherwise provided in Clauses 4.3.3 and 4.3.4.

4.3.3 Shelf Area

4.3.3.1 The area of the full shelves and of the bottom of the liner of the fresh food and freezer compartments shall be the product of the mean depth and mean width as shown in Figures 20 and 21.

If the bottom of the liner(s) of the fresh food and freezer compartments cannot qualify as a full shelf, the area shall be computed as the area of a cutout shelf or a fractional shelf.

The depth dimension used for computing the shelf area shall be measured from the front of the shelf. See Figures 20 and 21.

The depth of the shelf shall be the distance from the front edge of the shelf to the rear liner or to a point 38 mm (1-1/2 in) beyond the rear edge of the shelf, whichever is less. See Figures 20 and 21.

The width of a shelf shall be measured to the liner side(s) or to a point 38 mm (1-1/2 in) beyond the shelf edge, whichever is less. See Figures 20 and 21.

4.3.3.2 The area of fractional shelves shall be the product of the width and depth, including the allowable overhang, and shall be determined in accordance with Clause 4.3.3.1 and Figure 21.

4.3.3.3 When any part of a full shelf or a fractional shelf is cut out, the area of the cutout that exceeds the allowable overhang as determined in accordance with Clause 4.3.3.1, shall be deducted from the calculated shelf area. See Figure 21.

4.3.3.4 The area of shelves in the freezer compartment shall be included in the total shelf area provided there is a minimum clearance of 51 mm (2 in) above such shelves. See Figures 20 and 21.

4.3.3.5 The area of door shelves shall be the product of the mean depth and mean width of the shelf. The area of any part of a door shelf having an access clearance of less than 51 mm (2 in) shall not be included in the total shelf area. See Figures

21 and 22.

4.3.4 Area of Suspended Containers

The area of the bottom of suspended containers shall be included in the total shelf area provided there is a minimum clearance of 51 mm (2 in) above the bottom of the container. See Figure 23.

4.3.5 Shelf Suspended Container Area - Data to be Reported

The total shelf area shall be reported to the nearest 100 cm² (nearest 0.1 ft²).

4.4 Total Refrigerated Volume of Freezers

4.4.1 Total Refrigerated Volumes - Areas Included

The total refrigerated volume shall include the volume occupied by

- (a) special features, such as can or package racks, dividers or dispensers (provided such features are not projections (see Clauses 4.4.2(a)(ii) and 4.4.2(b)(ii)), baskets, compartment fronts, ice makers, and non refrigerated shelves;
- (b) door-shelf fronts and bottoms and doors of special feature compartments located within the door; and
- (c) features, such as light shields, trims and shelf, pan and basket rails, aesthetic items that are removable without the use of tools.

Note: The door volumes indicated in item (b) are included, as they normally add to the facility of the unit.

4.4.2 Total Refrigerated Volumes - Areas Not Included

The total refrigerated volume shall not include volume

- (a) occupied by parts necessary for the proper functioning of the unit, such as cooling coils, evaporators, air ducts, drip troughs, baffles, and fan shrouds;
- (b) occupied by door dikes that do not serve as shelves;
- (c) occupied by partitions and projections within the door(s) enclosing a compartment, that do not serve as shelves, and that collectively exceed a volume of more than 1.4 L (0.05 ft³);
- (d) between the deductible door dikes (see Item (b)) and cabinet breaker strips or adjacent liner walls; and
- (e) occupied by fixed projections, such as control knobs, shelf hangers, shelf and basket rails, and thermostat escutcheons, that collectively exceed a volume of more than 1.4 L (0.05 ft³) per compartment.

4.4.3 Total Refrigerated Volume Measurement

4.4.3.1 The total refrigerated volume shall be divided into the appropriate sections having similar width and depth dimensions (see Figures 24 - 28).

4.4.3.2 The volume of each section and the volume of all shaded spaces shown in

Figures 24 - 29 shall be calculated. The volumes of these sections shall be totalled to determine the total unadjusted refrigerated volume.

4.4.3.3 Those items listed in Clause 4.4.2 and illustrated by cross-hatching in Figures 24 - 32 shall be deducted from the total unadjusted refrigerated volume in order to determine the total refrigerated volume.

4.4.4 Total Freezer Volume - Data to be Reported

The total refrigerated volume of the freezer shall be reported to the nearest 1 L (0.1 ft³).

4.5. The Volume of Special Features of Freezers

4.5.1 Special Features Volume - Areas Included

Special features to be included in the volume calculation for freezers shall be

- (a) compartments or accessories such as baskets, can or package racks, movable compartments such as drawers or trays, and ice makers (including storage bins); and
- (b) compartments or accessories in the door, such as liquid or ice dispensers, or compartment doors.

4.5.2 Special Features Volume – Areas Not Included

Door features of freezers such as shelves, racks, rails, retainers, or any component that is attached or formed into the door liner and intended to improve its utility for storing jars, cans, and packages, shall not be included in the calculation.

4.5.3 Volume Occupied by Special Features

4.5.3.1 Free-Standing Special Features

The volume occupied by free-standing special features shall be calculated on an individual basis as the product of the values of width, length, and height of an encompassing right angle envelope for each feature. When special features are adjacent to each other, the volume between them shall not be included. See Figures 17 and 18.

4.5.3.2 Supported-Fixed Special Features

The volume occupied by supported-fixed special features (see Figure 19) shall be calculated on an individual basis as the product of adjusted values of width, length, and height of each feature. These adjusted values shall be the actual average exterior dimensions of the feature, increased by the distances to adjacent surfaces or shelves where the volume defined by the distances is not readily accessible for normal use. A volume not readily accessible for normal use shall be defined as volume that is accessible only by removal of parts from the cabinet.

A volume adjacent to a special feature that has a dimension of less than 51 mm (2 in) in the case of a freezer compartment, shall be considered as not readily accessible for normal use unless specific means are provided for supporting stored articles and preventing their interference in the operation of the special

feature.

In the case of ice makers or other features, where the volume occupied by the feature is defined in part by the movements of parts associated with the mechanical operation of the feature, the adjusted value of width and length shall include the maximum dimension(s) required by the path of the moving part(s), increased by the distances to adjacent surfaces or shelves where the volume defined by these distances is not readily accessible for normal use. This shall include the dimensions of any volume that is not readily accessible for normal use.

4.5.3.3 Supported-Relocatable Special Features

The volume occupied by supported-relocatable special features shall be calculated on an individual basis as the product of adjusted values of width, length, and height of each feature, with the feature located in the position occupying the least volume.

4.5.4 Volume Occupied by Special Features - Data to be Reported

The sum of all volumes occupied by the special features shall be reported to the nearest 0.1 L or nearest 0.01 ft³.

4.5.5 Volume Provided by Special Features

The storage volume provided by free-standing, supported re-locatable and supported-fixed special features shall be the product of the average interior width, length, and height from the interior bottom to the cover of the container when installed in its normal position in use. For ice trays, ice storage bins, and liquid containers, the storage volume shall be the interior volume when filled to the maximum operating level.

4.5.6 Volume Provided by Special Features - Data to be Reported

The sum of the volumes provided by special features shall be reported to the nearest 0.1 L or nearest 0.01 ft³.

4.6 Total Shelf Area of Freezers

4.6.1 General

The total shelf area shall be determined from the areas of the main shelves, door shelves, bottoms of suspended containers or dispensers, and the bottom of the liner(s).

4.6.2 Clearances

The area of any part of a shelf that has less than 51 mm (2 in) clearance above the shelf shall not be included in the total shelf area, except if on the door or as otherwise provided in Clauses 4.6.3.

4.6.3 Shelf Areas

4.6.3.1

The area of the full shelves and of the bottom of the liner of the freezer compartment shall be the product of the mean depth and mean width as shown in Figures 33 and 34.

If the bottom of the liner of the freezer compartment cannot qualify as a full shelf, its area shall be computed as the area of a cutout shelf or a fractional shelf.

The depth dimension used for computing the shelf area shall be measured from the front of the shelf. See Figures 33 and 34.

The depth of the shelf shall be the distance from the front edge of the shelf to the rear liner or to a point 38 mm (1-1/2 in) beyond the shelf, whichever is less. See Figures 33 and 34.

The width of a shelf shall be measured to the liner side(s) or to a point 38 mm (1-1/2 in) beyond the shelf edge, whichever is less. See Figure 34.

4.6.3.2 The area of fractional shelves shall be the product of the width and depth, including the allowable overhang, and shall be determined in accordance with Clause 4.6.3.1 and Figure 34.

4.6.3.3 When any part of a full shelf or a fractional shelf is cut out, the area of the cutout that exceeds the allowable overhang as determined in accordance with Clause 4.6.3.1, shall be deducted from the calculated shelf area. See Figure 34.

4.6.3.4 The area of door shelves shall be the product of the mean depth and mean width of the shelf. The area of any part of a door shelf having an access clearance of less than 51 mm (2 in) shall not be included in the net shelf area. See Figures 33 and 35.

4.6.3.5 The area of the bottom of suspended containers shall be included in the net shelf area provided there is a minimum clearance of 51 mm (2 in) above the bottom of the containers. See Figure 36.

4.6.4 Shelf Area and Suspended Containers – Data to be Reported

The net shelf area shall be reported to the nearest 100 cm² (0.1 ft²).

5. PROCEDURE FOR TESTING REFRIGERATORS, REFRIGERATOR-FREEZERS AND FREEZERS

5.1 Refrigerators and Refrigerator-Freezers

5.1.1 Test Conditions

The general test conditions shall be in accordance with Clause 3, with additions or exceptions described in clauses 5.1.2 - 5.1.8.

5.1.2 Ambient Temperature and Relative Humidity

- i. The ambient temperature in the locations specified in clause 3.3.4 shall be (32±1)°C and the relative humidity shall be (60±15)% during the stabilization period and during the test period.
- ii. Representative ambient temperature for tropical climate test shall be (43±1)°C as a base for carrying out the test.

When the unit is tested in accordance with Clause 5.1.7.4 the ambient

temperature shall be $26.6 \pm 1.1^{\circ}\text{C}$ ($80 \pm 2^{\circ}\text{F}$) dry bulb and $19.4 \pm 0.6^{\circ}\text{C}$ ($67 \pm 1^{\circ}\text{F}$) wet bulb ($52 \pm 9\%$ relative humidity) during the test period.

Note: *Temperatures may be measured using weighted temperature sensors as described in Clause 3.2.2.*

Please refer GCC Specifications No. GCCS200001E/20001 - Classification of Service Conditions for supply of Equipment / Materials.

5.1.3 Defrost and Antisweat Heater Controls

The defrost controls shall be operative for all tests conducted under this method.

Tests shall be run with the antisweat heater switch in both the ON and OFF positions for each temperature control setting. The average consumption shall be the calculated average of the consumption measured during each of the tests, with antisweat heaters in the ON position and in the OFF positions.

5.1.4 Load Conditions

Automatic defrost refrigerator-freezers, and all-refrigerators, shall be tested with no-load in the freezer compartment.

Manual defrost, semiautomatic defrost, and partial automatic defrost refrigerators, refrigerator-freezers with freezer compartment volumes exceeding 14.2 L (0.5 ft^3), shall be tested in a package-loaded condition as described in Clause 5.1.5.3

5.1.5 Temperature Measurements

5.1.5.1 General

For those compartments tested without load, temperatures shall be measured using weighted temperature sensors as described in Clause 3.2.2

5.1.5.2 Fresh Food Compartment Temperature (Refrigerators and Refrigerator-Freezers)

Temperatures shall be recorded at three locations, as illustrated in Figure 1. All temperature measuring devices shall be supported in such a manner that at least 25 mm (1 in) of air space shall separate the thermal mass from contact with any surface. In case of interference with hardware at these locations, the temperature measurements shall be taken at the nearest adjacent location such that at least 25 mm (1 in) of air space shall separate the thermal mass from the hardware.

If the interior arrangements of the cabinet do not conform with those illustrated in Figure 1, measurements shall be taken at selected locations chosen to approximately represent the entire fresh food compartment. The locations selected shall be reported.

The reported temperatures of the fresh food compartment shall be the average of the temperatures recorded at the three locations illustrated in Figure 1.

5.1.5.3 Freezer Compartment Temperature - Manual Defrost Refrigerators,

Semiautomatic Defrost Refrigerators, and Partial Automatic Defrost Refrigerators and Refrigerator-Freezers

For manual defrost refrigerators, semiautomatic defrost refrigerators, and partial automatic defrost refrigerators and refrigerator-freezers (where the freezer volume is greater than 14.2 L (0.5 ft³), freezer compartment temperatures shall be measured at the geometric centre of the filled packages described in Clause 3.2.3, with packages located so that temperature measurement stations approximate the locations shown in Figures 2 and 3.

Where required, freezer compartment door shelves shall be loaded with the maximum number of filled packages that can be retained on each shelf without added restraints.

If the interior arrangements of the freezer compartment shelves do not conform with those shown in Figure 3, measurements shall be taken at locations selected to represent the intent of this Standard. The locations selected shall be reported.

The reported temperature of the freezer compartment shall be the average of the temperatures recorded at the locations shown in Figures 2 and 3.

5.1.5.4 Freezer Compartment Temperature Automatic Defrost Refrigerator-Freezers

Unless otherwise required, temperature measurements in the freezer compartment(s) of automatic defrost refrigerator-freezers shall be made in a no-load condition, i.e. loading of the compartment(s) with test packages as described in Clause 3.2.3 shall not be required in these instances.

Temperatures shall be recorded at the locations illustrated in Figure 2. All temperature measuring devices shall be supported in such a manner that at least 25 mm (1 in) of air space shall separate the thermal mass from contact with any surface. In case of interference with hardware at these locations, the temperature measurements shall be taken at the nearest adjacent location such that 25 mm (1 in) of air space shall separate the thermal mass from the hardware.

If the interior arrangements of the cabinet do not conform with those shown in Figure 2, measurements shall be taken at selected locations chosen to approximately represent the entire freezer compartment. The locations selected shall be reported.

The reported temperature of the freezer compartment shall be the average of the temperatures recorded at the locations shown in Figure 2.

5.1.6 Temperature Control Settings

5.1.6.1 Control Settings for Models with No User Operable Temperature Control

Compartment temperatures and energy consumption shall be measured with

- (a) the temperature control operating; and
- (b) the temperature control electrically short-circuited to cause the compressor to run continuously.

5.1.6.2 Control Settings for Models with User Operable Temperature Control

Testing shall be performed in accordance with one of the following conditions, using the appropriate standardized reference temperatures:

- (a) all refrigerator, fresh food compartment temperature, 3.3°C (38°F);
- (b) basic refrigerator, freezer compartment temperature, -9.4°C (15°F), or 7.2°C (45°F) in the fresh food compartment, whichever yields the higher energy consumption;
- (c) refrigerator, freezer compartment temperature, -15.0°C (5°F), or 7.2°C (45°F) in the fresh food compartment, whichever yields the higher energy consumption;

and

- (d) variable defrost control models, -15°C (5°F) freezer compartment temperature and $3.3 \pm 1^\circ\text{C}$ ($38 \pm 2^\circ\text{F}$) fresh food compartment temperature during steady-state conditions with no door openings. If both settings cannot be obtained, then test with the fresh food compartment temperature at $3.3 \pm 1^\circ\text{C}$ ($38 \pm 2^\circ\text{F}$) and the freezer compartment as close to -15°C (5°F) as possible.

5.1.7 Testing Sequence

5.1.7.1 Standard Testing Sequence

The following two tests shall be performed in sequence: the first test shall be performed at the mid-position setting of the temperature control. The second test shall be performed at either the maximum or minimum temperature mark indicated on the control dial, whichever is appropriate to attempt to achieve compartment temperatures measured during the two tests that frame (ie, one falls above and one falls below) the standardized reference temperature for the type of product under test.

- (a) For the first test, all compartment temperature controls shall be set at the median position, midway between the warmest and coldest settings. Knob detents shall be mechanically defeated if necessary to attain a median setting.
- (b) For the second test, all compartment temperature controls shall be set at their warmest or coldest settings (not electrically or mechanically bypassed), whichever is appropriate to attempt to achieve compartment temperatures measured during the two tests that frame the standardized reference temperature for the type of product under test.

If the compartment temperatures measured during these two tests frame the appropriate standardized reference temperature, then these test results shall be used to determine energy consumption for a given setting of the antisweat heater switch.

If the compartment temperatures, measured with all controls set at their warmest setting, fall below the standardized reference temperature (and if the

fresh food compartment temperature falls below 7.2°C (45°F) in the case of a basic refrigerator or refrigerator-freezer, excluding an all-refrigerator), then the result of this test alone shall be used to determine energy consumption for a given setting of the antisweat heater switch.

5.1.7.2 Alternative Testing Sequence

As an alternative to tests in Clause 5.1.7.1, the first test may be performed as follows:

- i. all temperature controls shall be set at their warmest setting;
- ii. if either compartment temperature is above the reference temperature, testing shall proceed as specified in Clause 5.1.7.1.(a); and
- iii. for basic refrigerators or refrigerator-freezers (but not all-refrigerators), if compartment temperatures fall below the appropriate standardized reference temperature, and if the fresh food compartment falls below 7.2°C (45°F), then the results of this test alone shall be used to determine energy consumption for a given setting of the antisweat heater switch.

5.1.7.3 Non-Compliance and Product Description

In the standard and alternative testing sequences, the conditions of noncompliance with prescribed thermal performance shall be as follows:

- (a) if, with all compartment controls at their coldest settings, the fresh food compartment temperature is still above 5°C, the product has not met the thermal performance definition of a refrigerator or refrigerator-freezer, cannot be so described, and cannot be tested for energy consumption; and
- (b) if, with all compartment controls set at their coldest settings, frozen food compartment temperature is still above the standard operating temperature specified in Clause 5.1.6.2, the product description shall be changed to agree with that description appropriate to the measured temperature. Energy consumption shall then be declared in accordance with the revised product description.

5.1.7.4 Variable Defrost Control - Optional Test

After a steady-state condition is achieved, the optional test requires door openings of the fresh food compartment door for 12 ± 2 s every 60 min and a simultaneous 12 ± 2 s freezer compartment door opening occurring every fourth time to obtain 24 fresh food and six freezer compartment door openings per 24 h period. The first freezer door opening shall be simultaneous with the fourth fresh food door opening. The doors are to be opened 60° to 90° with an average velocity for the leading edge of the door of approximately 0.6 m/s (2 ft/s). Prior to the initiation of the door opening sequences, the refrigerator defrost control mechanism may be reinitiated in order to minimize the test duration.

5.1.8 Test Period**5.1.8.1 General**

Tests shall be performed by establishing the conditions specified in Clause 5.1.2 and by using the control settings as specified in Clauses 5.1.6 to 5.1.7.

5.1.8.2 Manual, Semiautomatic, and Partial Automatic Defrost Refrigerators and Refrigerator-Freezers

The test time period shall begin after steady-state conditions have been achieved and shall continue for at least three hours.

During the test period, the compressor motor shall complete two or more complete compressor cycles. If no OFF period occurs, as determined during the stabilization period, the test period shall be 3 h.

If incomplete cycling (less than two compressor cycles) occurs during a 24 h period, the results from the 24 h period shall be used.

5.1.8.3 Automatic Defrost

If the model tested has an automatic defrost system, the test period shall begin after steady-state conditions have been achieved and shall run from one point during a defrost period to the same point during the next defrost period.

If the model being tested has a long-time automatic defrost system, the provisions of 5.1.8.4 may be used. If the model being tested has a variable defrost control, the provisions of Clause 5.1.8.5 or 5.1.8.6 shall apply.

5.1.8.4 Long-time Automatic Defrost

If the model being tested has a long-time automatic defrost system, the test time period may consist of two parts. The first part would be the same as the test for a unit having no defrost provision (see Clause 5.1.8.2). The second part would start when a defrost period is initiated during a compressor ON cycle and terminate at the second turn ON of the compressor motor or after 4 h, whichever comes first.

5.1.8.5 Variable Defrost Control

If the model being tested has a variable defrost control system, the test shall consist of three parts. The first two parts shall be the same as the test for long-time automatic defrost specified in Clause 5.1.8.4. The third part shall be the optional test to determine the mean time between defrosts (see Clause 5.1.8.6). The third part shall be used by manufacturers who choose not to accept the default value of F of 0.20 to calculate T_D (See Clause 6.1.1.4).

5.1.8.6 Mean Time Between Defrost

After steady-state condition with no door openings is achieved, the test shall be continued using the above daily door-opening sequence (in accordance with Clause 5.1.7.4) until stabilized operation is achieved. Stabilization is defined as a minimum of three consecutive defrost cycles with times between defrosts that will allow the calculation of a Mean Time Between Defrost ($MTBD_1$), that satisfies the statistical relationship of 90% confidence. The test shall be repeated on at least one more unit of the model and until the Mean Time Between Defrost for the multiple unit tests ($MTBD_2$) satisfies the statistical relationship. If the time between defrosts is greater than 96 h (compressor ON time) and this defrost period can be repeated on a second unit, the test may be terminated at 96 h (T_D) and the absolute time value used for MTBD for each unit.

5.1.9. Tropical Climate Test

All refrigerators, refrigerator-freezers and freezers shall be subjected to the following elevated ambient temperature test.

The ambient temperature in the locations specified in Clause 3.3.4 shall be reset to $43 \pm 1^\circ\text{C}$ ($109.4 \pm 2^\circ\text{F}$) during the stabilization period and during the test period. The relative humidity need not be controlled for this test.

At the conclusion of operation under the Standard Testing Sequence or the Alternative Testing Sequence according to Clause 5.2.7, the appliance under test shall be subjected to the elevated temperature test, without re-setting the appliance's temperature setting. The test shall continue until the cabinet temperature and the freezer temperatures stabilize. The average temperature of the freezer and cabinet shall not vary from the readings taken at the 32°C (90°F) ambient by more than $\pm 2.0^\circ\text{C}$ (3.6°F).

5.2 Freezers

5.2.1 Test Conditions

The general test conditions shall be in accordance with Clause 3, with additions or exceptions described in this clause.

5.2.2 Ambient Temperature and Relative Humidity

- i. The ambient temperature in the locations specified in clause 3.3.4 shall be $(32 \pm 1)^\circ\text{C}$ and the relative humidity shall be $(60 \pm 15)\%$ during the stabilization period and during the test period.
- ii. Representative ambient temperature for tropical climate shall be $(43 \pm 1)^\circ\text{C}$ as a base for carrying out the test.

When the unit is tested in accordance with Clause 5.2.7.4 the ambient temperature shall be $26.6 \pm 1.1^\circ\text{C}$ ($80 \pm 2^\circ\text{F}$) dry bulb and $19.4 \pm 0.6^\circ\text{C}$ ($67 \pm 1^\circ\text{F}$) wet bulb ($52 \pm 9\%$ relative humidity) during the test period.

Please refer GCC Specifications No. GCCS200001E/20001 - Classification of Service Conditions for supply of Equipment / Materials.

5.2.3 Defrost and Antisweat Heater Controls

The defrost controls shall be operative for all tests conducted under this method.

Tests shall be run with the antisweat heater switch in both the ON and OFF positions for each temperature control setting. The average consumption shall be the average of the energy consumptions measured with the anti-sweat heaters ON and OFF.

The quick-freeze option shall be switched off unless otherwise specified.

5.2.4 Load Conditions

Freezers with freezer compartment volumes exceeding 14.2 L (0.5 ft³), shall be tested in a package-loaded condition as described in Clause 5.2.5.2.

5.2.5 Temperature Measurements

5.2.5.1 General

For those compartments tested without load, temperatures shall be measured using weighted temperature sensors in accordance with Clause 3.2.2

5.2.5.2 Freezer Compartment Temperature

For freezers (where the freezer volume is greater than 14.2 L (0.5 ft³), freezer compartment temperatures shall be measured at the geometric centre of the filled packages described in Clause 3.2.3, with packages located so that temperature measurement stations approximate the locations shown in Figures 2 and 3.

Alternatively, chest and upright freezers may be tested in the unloaded condition as specified in Clause 5.2.5.3.

Temperatures shall be measured by unweighted thermocouples, located in the geometrical centre of packages in accordance with Clause 3.2.3.

Where required, freezer compartment door shelves shall be loaded with the maximum number of filled packages that can be retained on each shelf without added restraints.

If the interior arrangements of the freezer compartment shelves do not conform with those shown in Figure 3, measurements shall be taken at locations selected to represent the intent of this Standard. The locations selected shall be reported.

The reported temperature of the freezer compartment shall be the average of the temperatures recorded at the locations shown in Figures 2 and 3.

5.2.5.3 Alternative to Using a Freezer Load

Chest and upright freezers may be tested without a load provided the thermocouples are weighted according to Clause 3.2.2 and satisfactory proof of the correlation factor used to calculate the final test results as a loaded freezer is provided. Satisfactory proof shall be deemed to have been accomplished upon the presentation of data consisting of:

- (a) the average of the differences measured in testing five units without load and the same five units loaded in accordance with Clause 5.2.5.2; and
- (b) where the five unit comparative test has a maximum useable life, as "significant proof", of five years. That is to say that manufacturers would have to do the five unit correlation test on each size (refrigerated volume based) of product, once every five years, whether the retesting was warranted or not.

5.2.6 Temperature Control Settings

5.2.6.1 Models With No User Operable Temperature Control

Compartment temperatures and energy consumption shall be measured with

- (a) the temperature control operating; and
- (b) the temperature control electrically short-circuited to cause the compressor to run continuously. If the model has a quick freeze option, it shall be used to bypass the temperature control.

5.2.6.2 Models with User Operable Temperature Control

Testing shall be performed in accordance with the standardized reference temperature for a freezer temperature, of -17.8°C (0°F).

5.2.7 Testing Sequence

5.2.7.1 Standard Testing Sequence

The following two tests shall be performed in sequence: the first test shall be performed at the mid-position setting of the temperature control. The second test shall be performed at either the maximum or minimum temperature mark indicated on the control dial, whichever is appropriate to attempt to achieve compartment temperatures measured during the two tests that frame (ie, one falls above and one falls below) the standardized reference temperature for the type of product under test.

- (a) All compartment temperature controls shall be set at the median position, midway between the warmest and coldest settings. Knob detents shall be mechanically defeated if necessary to attain a median setting.

All compartment temperature controls shall be set at their warmest or coldest settings (not electrically or mechanically bypassed), whichever is appropriate to attempt to achieve compartment temperatures measured during the two tests that frame (ie, one falls above and one falls below) the standardized reference temperature for the type of product under test.

If the compartment temperatures measured during these two tests frame the appropriate standardized reference temperature, then these test results shall be used to determine energy consumption for a given setting of the antisweat heater switch.

If the compartment temperatures, measured with all controls set at their warmest setting, fall below the standardized reference temperature then the result of this test alone shall be used to determine energy consumption for a given setting of the antisweat heater switch.

5.2.7.2 Alternative Testing Sequence

As an alternative to tests in Clause 5.2.7.1, the first test may be performed as follows:

- (i) all temperature controls shall be set at their warmest setting;
- (ii) if either compartment temperature is above the reference temperature, testing shall proceed as specified in Clause 5.2.7.1.(a); and
- (iii) if compartment temperatures fall below the appropriate standardized reference temperature, the results of this test alone shall be used to determine energy consumption and
- (iv) the results of this test alone shall then be used to determine energy consumption for a given setting of the antisweat heater switch.

5.2.7.3 Non-Compliance and Product Description

In the standard and alternative testing sequences, the conditions of noncompliance with prescribed thermal performance shall be as follows:

- (a) if, with all compartment controls set at their coldest settings, the ambient temperature is 32°C, and the freezer temperature is still above the standard operating temperature specified in Clause 5.2.6.2, the product description shall be changed to agree with that description appropriate to the measured temperature; and
- (b) energy consumption shall then be declared in accordance with the revised product description.
- (c) if, with all compartment temperature control settings at the same or lower temperature setting than during either the Standard Testing Sequence or Alternative Testing Sequence and the ambient temperature at 43°C and the freezer temperatures rises more than 2°C above the standard operating temperature, energy consumption shall then be declared in accordance with the revised product description.

5.2.7.4 Variable Defrost Control - Optional Test

After a steady-state condition is achieved, the optional test requires door openings for 12 ± 2 s every six freezer compartment door openings per 24 h period. The first freezer door opening shall four hours after the initiation of the test. The doors are to be opened 60° to 90° with an average velocity for the leading edge of the door of approximately 0.6 m/s (2 ft/s). Prior to the initiation of the door opening sequences, the defrost control mechanism may be reinitiated in order to minimize the test duration.

5.2.8 Test Period**5.2.8.1 General**

Tests shall be performed by establishing the conditions specified in Clause 5.2 and by using the control settings as specified in Clauses 5.2.6 and 5.2.7.

5.2.8.2 Manual, Semiautomatic, and Partial Automatic Defrost

The test time period shall begin after steady-state conditions have been achieved and shall continue for at least three hours.

During the test period, the compressor motor shall complete two or more whole compressor cycles (a compressor cycle shall be a complete ON and a complete OFF period of the motor). If no OFF period occurs, as determined during the stabilization period, the test period shall be 3 h.

If incomplete cycling (less than two compressor cycles) occurs during a 24 h period, the results from the 24 h period shall still be used.

5.2.8.3 Automatic Defrost

If the model tested has an automatic defrost system, the test period shall begin after steady-state conditions have been achieved and shall run from one point during a defrost period to the same point during the next defrost period.

If the model being tested has a long-time automatic defrost system, the alternative provisions of Clause 5.2.8.4 may be used. If the model being tested has a variable defrost control, the provisions of Clauses 5.2.8.5 or 5.2.8.6 shall apply.

5.2.8.4 Long-time Automatic Defrost

If the model being tested has a long-time automatic defrost system, the test time period may consist of two parts. The first part would be the same as the test for a unit having no defrost provision (see Clause 5.2.8.2). The second part would start when a defrost period is initiated during a compressor ON cycle and terminate at the second turn ON of the compressor motor or after 4 h, whichever comes first.

5.2.8.5 Variable Defrost Control

If the model being tested has a variable defrost control system, the test shall consist of three parts. The first two parts shall be the same as the test for long-time automatic defrost specified in Clause 5.2.8.4. The third part shall be the optional test to determine the mean time between defrosts (see Clause 5.2.8.6). The third part shall be used by manufacturers who choose not to accept the default value of F of 0.20 to calculate T_D (See Clause 6.2.1.4).

5.2.8.6 Mean Time Between Defrost (MTBD)

After steady-state condition with no door openings is achieved, the test shall be continued using the above daily door-opening sequence in accordance with Clause 5.2.7.4 until stabilized operation is achieved. Stabilization is defined as

a minimum of three consecutive defrost cycles with times between defrosts that will allow the calculation of a Mean Time Between Defrost (MTBD₁), that satisfies the statistical relationship of 90% confidence. The test shall be repeated on at least one more unit of the model and until the Mean Time Between Defrost for the multiple unit tests (MTBD₂) satisfies the statistical relationship. If the time between defrosts is greater than 96 h (compressor ON time) and this defrost period can be repeated on a second unit, the test may be terminated at 96 h (T_D) and the absolute time value used for MTBD for each unit.

5.2.9 Tropical Climate Test

All refrigerators, refrigerator freezers and freezers shall be subjected to the following elevated ambient temperature test.

The ambient temperature in the locations specified in Clause 3.3.4 shall be reset to 43.0±1°C, (109.4±2) °F during the stabilization period and during the test period. The relative humidity need not be controlled for this test.

At the conclusion of operation under the Standard Testing Sequence or the Alternative Testing Sequence according to Clause 5.2.7, the appliance under test shall be subjected to the elevated temperature test, without re-setting the appliance's temperature setting. The test shall continue until the cabinet temperature and the freezer temperatures stabilize. The average temperature of the freezer and cabinet shall not vary from the readings taken at the 32°C (90°F) ambient by more than ± 2.0°C (3.6°F).

6. CALCULATING THE ENERGY CONSUMPTION OF REFRIGERATORS, REFRIGERATOR-FREEZERS AND FREEZERS

6.1 Refrigerators and Refrigerator-Freezers

6.1.1 Per Day Energy Consumption

6.1.1.1 General

The energy consumption for each test period shall be the energy expended during the test period, as specified in Clause 5.1.8, adjusted to a 24 h period. This adjustment shall be determined as specified in Clause 6.1.1.2. If the model has a user-operable anti-sweat heater control, the energy consumption shall be the average of the consumptions measured with the anti-sweat heaters ON and OFF.

6.1.1.2 Manual, Semiautomatic, and Automatic Defrost Models

The energy consumption in kW·h/d shall be calculated according to the formula

$$E_T = \frac{E_p \times 1440 \times k}{T}$$

where

E_T = test cycle energy expended, kW·h/d

E_P = energy expended during the test period as specified in Clause 5.1.8, kW·h

1440 = conversion factor to adjust to a 24 h period, min/d

k = 1.0, a correction factor for refrigerators and refrigerator-freezers, dimensionless

T = length of time of the test period, min

6.1.1.3 Long-time Automatic Defrost

If the two-part test method is used, the energy consumption shall be calculated as

$$E_T = \frac{1440 \times k \times E_{P1}}{T_1} + \left(E_{P2} - \left(E_{P1} \times \frac{T_2}{T_1} \right) \right) \times \frac{k \times 12}{T_D}$$

where

E_T = test cycle energy expended, kW·h/d

1440 = conversion factor to adjust to a 24 h period, min/d

k = 1.0, a correction factor for refrigerators and refrigerator-freezers, dimensionless

E_{P1} = energy expended during the first part of the test as specified in Clause 5.1.8.4, kW·h

E_{P2} = energy expended during the second part of the test as specified in Clause 5.1.8.4, kW·h

T_1 = length of time of the first part of the test, min

T_2 = length of time of the second part of the test, min

12 = conversion factor to adjust to a 50% run time of the compressor, h/day

T_D = defrost timer run time required to go through a complete cycle to the nearest tenth hour per cycle, h

6.1.1.4 Variable Defrost Control

The energy consumption shall be calculated as

$$E_T = \frac{1440 \times k \times E_{P1}}{T_1} + \left(E_{P2} - \left(E_{P1} \times \frac{T_2}{T_1} \right) \right) \times \frac{k \times 12}{T_D}$$

where

E_T = test cycle energy expended, kW·h/d as specified in clause 5.1.8.5.

1440 = conversion factor to adjust to a 24 h period, min/d

k = 1.0 a correction factor for refrigerators and refrigerator-freezers, dimensionless

E_{P1} = energy expended during the first part of the test, as specified in

Clauses 5.1.8.5, kW·h

- E_{P2} = energy expended during the second part of the test as specified in Clause 5.1.8.5, kW·h
- T_1 = length of time of the first part of the test, min
- T_2 = length of time of the second part of the test, min
- 12 = conversion factor to adjust to a 50% run time of the compressor, h/day
- T_D = defrost timer run time required to go through a complete cycle to the nearest one-tenth hour per cycle, h

and

$$T_D = \frac{T_{D_{\min}} \times T_{D_{\max}}}{F \times (T_{D_{\max}} - T_{D_{\min}}) + T_{D_{\min}}}$$

where

- $T_{D_{\min}}$ = least of shortest time between defrosts in one-tenth of an hour (greater than or equal to six but less than or equal to 12 h), h
- $T_{D_{\max}}$ = maximum time between defrost cycles in one-tenth of an hour (greater than $T_{D_{\min}}$ but not more than 96 h), h
- F = ratio of per day energy consumption in excess of the least energy and the maximum differences in per day energy consumption

and

$$F = \frac{\left(\frac{1}{T_D} - \frac{1}{T_{D_{\max}}} \right)}{\left(\frac{1}{T_{D_{\min}}} - \frac{1}{T_{D_{\max}}} \right)}$$

where

- T_{DT} = defrost time required to go through a complete cycle to the nearest one-tenth of an hour per cycle, h

A value of 0.20 may be used for F in lieu of testing for T_D

For demand defrost models with no values for $T_{D_{\min}}$ and $T_{D_{\max}}$ in the algorithm, the default values of 12 and 84 shall be used, respectively.

6.1.1.5 Optional Test Method for Variable Defrost Controls

For refrigerators and refrigerator-freezers with variable defrost controls, the defrost timer run time required to go through a complete cycle shall be determined according to the following formula:

$$T_D = MTBD \times 0.5$$

where

T_D = defrost timer run time required to go through a complete cycle to the nearest tenth hour per cycle, h

MTBD = mean time between defrosts

$$MTBD = \frac{\sum_{i=1}^n T_i}{n}$$

where

T_i = time between defrost cycles, number (i-1) and i, h

n = number of complete defrost cycles

6.1.2 Average Per-Cycle Energy Consumption

6.1.2.1 All-Refrigerator Models

The average per-cycle energy consumption shall be expressed in kW·h per cycle to the nearest one-hundredth (0.01) kW·h, and shall depend upon the temperature attainable in the fresh food compartment, as shown below.

6.1.2.2 Case 1

If for each control setting, the fresh food compartment temperature remains below 3.3°C (38°F), the average per-cycle energy consumption shall be reported as:

$$E = E_{T1}$$

where

E = the total per-cycle energy consumption, kW·h/d

E_{T1} = test cycle energy expended during the first test cycle during which the highest fresh food compartment temperature is measured, kW·h/d

6.1.2.3 Case 2

If one of the fresh food compartment temperatures measured for a test period is greater than 3.3°C (38°F), the average per-cycle energy consumption shall be calculated as

$$E = E_{T1} + (E_{T2} - E_{T1}) \times \left[\frac{3.3 - T_{R1}}{T_{R2} - T_{R1}} \right]$$

where

E = the total per-cycle energy consumption, kW·h/d

E_{T1} = test cycle energy expended during the first test cycle during which the highest fresh food compartment temperature is measured, kW·h/d

E_{T2} = test cycle energy expended during the second test cycle during which the highest fresh food compartment temperature is measured, kW·h/d

3.3 = the standardized reference temperature for an all-refrigerator fresh food compartment, °C

T_{R1} = the fresh food compartment temperature determined according to Clause 5.1.5 during the first test, °C

T_{R2} = the fresh food compartment temperature determined according to Clause 5.1.5 during the second test, °C

6.1.3 Basic Refrigerators and Refrigerator-Freezers

6.1.3.1 General

The average per-cycle energy consumption shall be expressed in kW·h per cycle to the nearest (0.01) kW·h, and shall be defined, as applicable, according to clause 6.1.3.2-6.1.3.5.

6.1.3.2 Case 1

6.1.3.2.1 If, for each control setting, the fresh food compartment temperature remains below + 7.2°C (45°F) and the freezer compartment temperature below - 9.4°C (15°F) in the case of a basic refrigerator or - 15°C (5°F) in the case of a refrigerator-freezer, the per-cycle energy consumption shall be

$$E = E_{T1}$$

where

E = the total per-cycle energy consumption, kW·h/d

E_{T1} = test cycle energy expended during the first test cycle during which the highest freezer compartment temperature is measured, kW·h/d

For a graphical representation of this Clause, see Subclause 6.1.4.

6.1.3.2.2 If the first test produces average compartment temperatures that fall into quadrants B, C, or D, then the second test shall be performed with all controls at their coldest setting(s).

If the first test produces average compartment temperatures that fall into quadrant A, then the second test shall be performed with all controls at their warmest setting(s).

6.1.3.2.3 If in following the requirements of Clause 6.1.3.2.2, the second test at the coldest setting(s) produces average compartment temperatures that still fall into quadrants B or C, the product has not met the thermal performance definition.

If in following the requirements of Clause 6.1.3.2.2, the second test at the coldest setting(s) produces average compartment temperatures that fall into quadrant D, then the product description shall be changed, ie, a -15°C freezer may become a -9°C frozen food compartment, or a -9°C frozen food compartment may become an ice-making compartment only.

6.1.3.2.4 If in following the requirements of Clause 6.1.3.2.3, the second test at the warmest setting(s) produces average compartment temperatures that still fall into quadrant A, then the energy consumption limit shall be declared at this warmest point.

6.1.3.3 Case 2

If the conditions of Clause 6.1.3.1 do not exist, the per-cycle energy consumption shall be taken as the higher of the two values calculated according to following equations,

$$E = E_{T1} + (E_{T2} - E_{T1}) \times \left[\frac{7.2 - T_{R1}}{T_{R2} - T_{R1}} \right]$$

where

E = the total per-cycle energy consumption, kW·h/d

E_{T1} = test cycle energy expended during the first test cycle during which the highest fresh food compartment temperature is measured, kW·h/d

E_{T2} = test cycle energy expended during the second test cycle during which the highest fresh food compartment temperature is measured, kW·h/d

7.2 = the standardized reference temperature for the specified fresh food compartment, °C

T_{R1} = the fresh food compartment temperature determined according to Clause 5.1.5 during the first test, °C

T_{R2} = the fresh food compartment temperature determined according to Clause 5.1.5 during the second test, °C

and

$$E = E_{T1} + (E_{T2} - E_{T1}) \times \left[\frac{J - T_{F1}}{T_{F2} - T_{F1}} \right]$$

where

E = the total per-cycle energy consumption, kW·h/d

E_{T1} = test cycle energy expended during the first test cycle during which the highest fresh food compartment temperature is measured, kW·h/d

E_{T2} = test cycle energy expended during the second test cycle during which the highest fresh food compartment temperature is measured, kW·h/d

J = a constant of -9.4 for basic refrigerators or -15 for refrigerator-freezers, these being the standardized reference freezer compartment temperatures, °C

T_{F1} = the freezer compartment temperature determined according to Clause 5.1.5 during the first test, °C

T_{F2} = the freezer compartment temperature determined according to Clause 5.1.5 during the second test, °C

6.1.4 Graphical Interpretation of Clause 6.1.3.2

Note: This Appendix is not a mandatory part of this Standard but is written in mandatory language to accommodate its adoption by anyone wishing to do so.

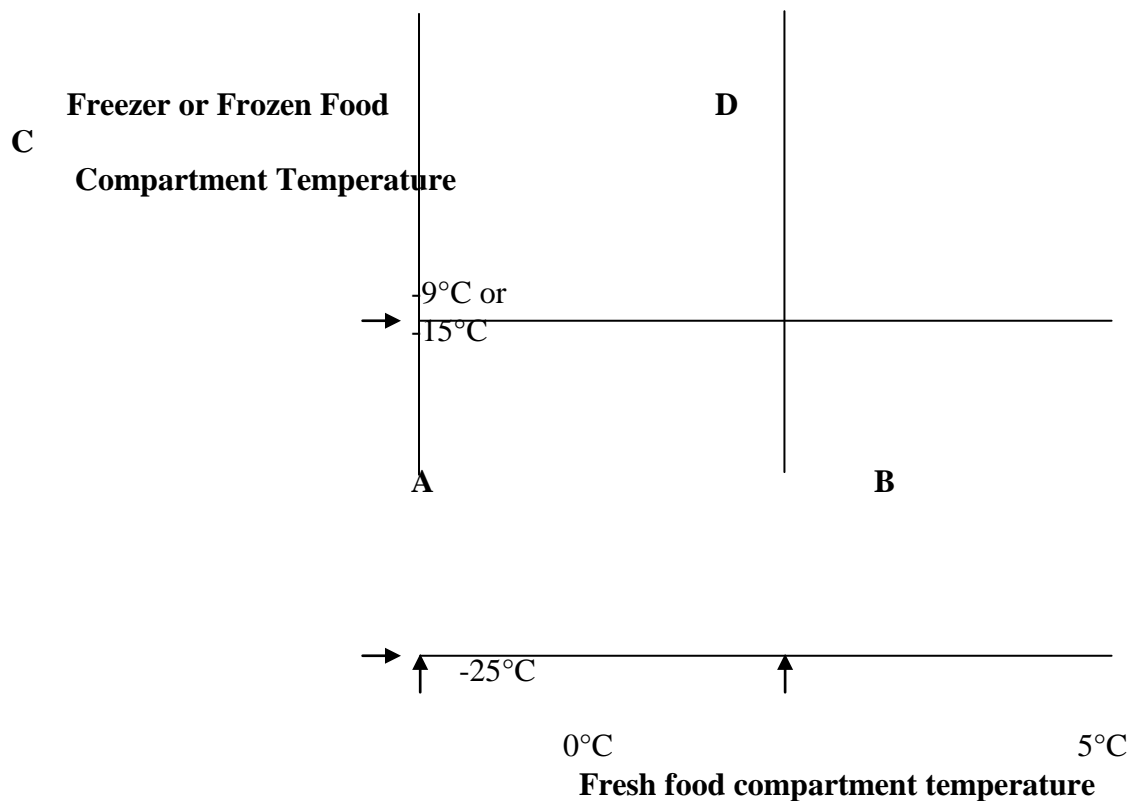


Figure 6.1.4.1

6.1.4.1 Depending on the result of the first test, one of the following procedures shall be performed:

- (a) If the first test produces average compartment temperatures that fall into quadrants B, C, or D in the graph shown in Figure 6.1.4.1, the second test shall be performed with all controls at their coldest setting(s).
- (b) If the first test produces average compartment temperatures that fall into quadrant A, the second test shall be performed with all controls at their warmest setting(s).

6.1.4.2 If, following Clause 6.1.4.1 (a), the second test at the coldest setting(s) produces average compartment temperatures that still fall into quadrants B or C, the product has not met the thermal performance definition.

If, following Clause 6.1.4.1 (a), the second test at the coldest setting(s) produces average compartment temperatures that fall into quadrant D, the product description shall be changed (i.e., a -15°C freezer may become a -9°C frozen food compartment, or a -9°C frozen food compartment may become an ice-making compartment only).

6.1.4.3 If, following Clause 6.1.4.1 (b), the second test at the warmest setting(s) produces average compartment temperatures that still fall into quadrant A, the energy consumption limit shall be declared at this warmest point.

6.2 Freezers

6.2.1 Per Day Energy Consumption

6.2.1.1 General

The energy consumption in kW·h/d for each test period shall be the energy expended during the test period, as specified in Clause 5.2.8, adjusted to a 24 h period. This adjustment shall be determined as specified in Clause 6.2.1.2.

6.2.1.2 Manual, Semiautomatic, and Automatic Defrost Models

The energy consumption in kWh/d shall be calculated according to the formula

$$E_T = \frac{E_P \times 1440 \times k}{T}$$

where

E_T = test cycle energy expended, kWh/d

E_P = energy expended during the test period, kWh as specified in Clause 5.2.8.2.

1440 = conversion factor to adjust to a 24 h period, min/d

k = a correction factor, to adjust for average usage of 0.7 for chest freezers and 0.85 for upright freezers, dimensionless

T = length of time of the test period, min

6.2.1.3 Long-time Automatic Defrost

If the two-part test method is used, the energy consumption shall be calculated according to the following formula,

$$E_T = \frac{1440 \times K \times E_{P1}}{T_1} + \left(E_{P2} - \left(E_{P1} \times \frac{T_2}{T_1} \right) \right) \times \frac{k \times 12}{T_D}$$

where

E_T = test cycle energy expended, kW·h/d

1440 = conversion factor to adjust to a 24 h period, min/d

k = a correction factor to adjust for average usage of 0.7 for chest freezers and 0.85 for upright freezers, dimensionless

E_{P1} = energy expended during the first part of the test, kWh

E_{P2} = energy expended during the second part of the test, kWh

T_1 = length of time of the first part of the test, min

T_2 = length of time of the second part of the test, min

12 = conversion factor to adjust to a 50% run time of the compressor, h/day

T_D = defrost timer run time required to go through a complete cycle to the nearest one-tenth of an hour per cycle, h

6.2.1.4 Variable Defrost Control

The energy consumption shall be calculated according to the following formula,

$$E_T = \frac{1440 \times K \times E_{P1}}{T_1} + \left(E_{P2} - \left(E_{P1} \times \frac{T_2}{T_1} \right) \right) \times \frac{k \times 12}{T_D}$$

where

E_T = test cycle energy expended, kWh/d as specified in Clause 5.2.8.5.

1440 = conversion factor to adjust to a 24 h period, min/d

k = a correction factor to adjust for average usage of 0.7 for chest freezers and 0.85 for upright freezers, dimensionless

E_{P1} = energy expended during the first part of the test, kWh as specified in Clause 5.2.8.5.

E_{P2} = energy expended during the second part of the test, kWh as specified in Clause 5.2.8.5

T_1 = length of time of the first part of the test, min

T_2 = length of time of the second part of the test, min

12 = conversion factor to adjust to a 50% run time of the compressor, h/day

T_D = defrost timer run time required to go through a complete cycle to the nearest one-tenth of an hour per cycle, h

and

$$T_D = \frac{T_{D_{\min}} \times T_{D_{\max}}}{F \times (T_{D_{\max}} - T_{D_{\min}}) + T_{D_{\min}}}$$

where

$T_{D_{\min}}$ = the shortest time between defrosts in one-tenth of an hour (greater than or equal to six but less than or equal to 12 h), h

$T_{D_{\max}}$ = maximum time between defrost cycles in one-tenth of an hour (greater than $T_{D_{\min}}$ but not more than 96 h), h

F = ratio of per day energy consumption in excess of the least energy and the maximum differences in per day energy consumption

$$F = \frac{\left(\frac{1}{T_{DT}} - \frac{1}{T_{D_{\max}}} \right)}{\left(\frac{1}{T_{D_{\min}}} - \frac{1}{T_{D_{\max}}} \right)}$$

where

T_{DT} = defrost timer run time required to go through a complete cycle to the nearest one-tenth of an hour per cycle, h

A value of .20 may be used for F in lieu of testing to find T_{DT}

For demand defrost models with no values for $T_{D_{\min}}$ and $T_{D_{\max}}$ in the algorithm, the default values of 12 and 84 shall be used, respectively.

6.2.1.5 Optional Test Method for Variable Defrost Controls

For freezers with variable defrost controls, the defrost timer run time required to go through a complete cycle shall be determined according to the following formula,

$$T_D = MTBD \times 0.5$$

where

T_D = defrost timer run time required to go through a complete cycle to the nearest tenth hour per cycle, h

MTBD = mean time between defrosts

and

$$MTBD = \frac{\sum_{i=1}^n T_i}{n}$$

where

T_i = time between defrost cycles number (i-1) and i, h

n = number of complete defrost cycles

6.2.2 Average Per-Cycle Energy Consumption

6.2.2.1 General

The average per-cycle energy consumption of upright and chest freezers shall be expressed in kWh per cycle to the nearest 0.01 kWh, and shall depend upon the compartment temperature attainable, as shown in Clauses 6.2.2.2 and 6.2.2.3.

6.2.2.2 Case 1

If, for each control setting, the compartment temperature remains below -17.8°C (0°F), the average per-cycle energy consumption shall be taken as

$$E = E_{T1}$$

where

E = the total per-cycle energy consumption, kWh/d

E_{T1} = test cycle energy expended during the first test cycle during which the highest freezer compartment temperature is measured, kWh/d

6.2.2.3 Case 2

If one of the compartment temperatures measured for a test period is greater than -17.8°C (0°F), the average per-cycle energy consumption shall be taken as:

$$E = E_{T1} + (E_{T2} - E_{T1}) \times \left[\frac{-17.8 - T_{F1}}{T_{F2} - T_{F1}} \right]$$

where

E = the total per-cycle energy consumption, kWh/d

E_{T1} = test cycle energy expended during the first test cycle during which the highest freezer compartment temperature is measured, kWh/d

E_{T2} = test cycle energy expended during the second test cycle during which the highest freezer compartment temperature is measured, kWh/d

-17.8 = the standardized reference compartment temperature for freezers, °C

T_{F1} = the freezer compartment temperature determined according to Clause 5.2.5 during the first test, °C

T_{F2} = the freezer compartment temperature determined according to Clause 5.2.5 during the second test, °C

6.2.3 Compressor Running Time Percent

6.2.3.1 General

The compressor running time is calculated as

$$R = \frac{T_{on}}{T_{Total}}$$

where

R = The ratio of the compressor running time, dimensionless

T_{on} = the duration of the compressor operation during a whole number of cycles, min

T_{Total} = the total duration of the whole number of compressor operating cycles, min

6.2.3.2 Manual Defrost Freezers

For manual defrost freezers, the compressor running time shall be reported for the largest whole number of compressor operating cycles during the test period defined in Clause 5.1.8.

6.2.3.3 Automatic Defrost Freezers

For automatic defrost freezers, the compressor running time shall be reported for the largest whole number of compressor operating cycles during the test period defined in Clause 5.1.8.

6.2.3.4 Long-time Automatic Defrost

For long-time automatic defrost freezers, the compressor running time shall be reported as calculated in clause 5.1.8.4.

6.2.3.5 Variable Defrost

For variable defrost freezers, the compressor running time shall be reported as calculated in Clause 5.1.8.5.

6.2.4 Calculation of Freezing Capability

6.2.4.1 Applicability

Freezing capability shall be calculated for upright and chest freezers only.

The freezing capability of a food freezer shall be the reserve refrigerating capability of the freezer, expressed in kg of ice per 24 h, under the operating conditions specified in Clause 5.2.

6.2.4.2 Freezing Capability

The freezing capability shall be calculated from the cyclical running time of the refrigerant compressor and the compressor manufacturer's verified published thermal performance data as

$$F_c = 24 \times \frac{C}{Q} \times (1 - R)$$

where

F_c = the freezing capability interpolated to the reference temperature of -17.8°C, kg/24 h

C = the compressor thermal rating in watts, at

- (a) -23.3°C evaporating temperature;
- (b) 54.4°C condensing temperature;
- (c) 32.2°C ambient temperature;
- (d) 32.2°C liquid temperature; and
- (e) 32.2°C suction gas temperature.

Q = 140.7 W·h, the energy required to convert 1 kg of water at 32.2°C to ice at -17.8°C, W·h

R = the ratio of the running time of the compressor as determined in Clause 6.2.3, dimensionless

7. MAXIMUM ENERGY CONSUMPTION LIMITS FOR REFRIGERATORS, REFRIGERATOR-FREEZERS AND FREEZERS

7.1 Adjusted Volume of Refrigerators and Refrigerator-Freezers

7.1.1 General

As specified in Clause 4.1, the adjusted volume of a refrigerator shall be determined according to the following formula:

$$AV = V_{\text{fresh food}} + (V_{\text{freezer}} \times AF)$$

where

AV = the adjusted volume, L

$V_{\text{fresh food}}$ = the volume of the fresh food compartment of a refrigerator as determined in Clause 4.1, L

V_{freezer} = the volume of the freezer compartment of a refrigerator as determined in Clause 4.1, L

AF = an adjustment factor as determined in Clause 7.1.2

7.1.2 Adjustment Factor

7.1.2.1 The adjustment factor shall be calculated according to the following formula:

$$AF = \frac{(t_A - t_{FSR})}{(t_A - t_{FF})}$$

where

AF = the adjustment factor, dimensionless

t_A = the ambient temperature in the test room, 32°C

t_{FSR} = the standardized reference freezer compartment temperature, °C

t_{FF} = the average fresh food compartment operating temperature, 3.3°C

7.1.2.2 Basic Refrigerators

For basic refrigerators, the adjustment factor AF shall be calculated as follows:

$$AF = \frac{32 - (-9.4)}{32 - 3.3} = 1.442$$

7.1.2.3 All-Refrigerators

For all-refrigerators, the adjustment factor shall be 1.00.

7.1.2.4 Refrigerator-Freezers

For refrigerator-freezers, the adjustment factor AF shall be calculated as follows:

$$AF = \frac{32 - (-15)}{32 - 3.3} = 1.637$$

7.2 Adjusted Volume of Freezers

7.2.1 As specified in Clause 4.4, the adjusted volume of chest and upright freezers shall be determined according to the following formula:

$$AV = V_{\text{freezer}} \times AF$$

7.2.2 For chest and upright freezers, the adjustment factor AF shall be calculated as follows:

$$AF = \frac{32 - (-17.8)}{32 - 3.3} = 1.735$$

7.3 Energy Consumption Limits for Refrigerators, Refrigerator-Freezers and Freezers

Maximum energy consumption limits for refrigerators, Refrigerator-Freezers and Freezers are given in Tables 1 and 2, expressed in kW·h per year.

8. SAMPLING PLAN**8.1 Size of Sample**

For each basic model of refrigerator, refrigerator-freezer or freezer, a sample of sufficient size shall be tested to ensure that any represented value of estimated energy consumption (or other measure of energy consumption of a basic model) shall be no less than the higher of the

- (a) mean of the sample; or
- (b) upper 95% confidence limit of the true mean divided by 1.10.

Note: See the Subclause 8.2 for further details.

8.2 Explanation of Sampling Plan**8.2.1 General**

The following is an example of a statement involving an upper confidence limit (UCL) intended to clarify the use of the one-sided confidence limit concept.

The basic equation used is

$$\text{Upper Confidence Limit} = X + \frac{t \times S}{n}$$

where

X = mean of sample

t = value in the table below

S = sample standard deviation

n = number of samples tested

No. of samples, n	n	t for 95% confidence
2	1.4142	6.314
3	1.7321	2.920
4	2.0000	2.353
5	2.2361	2.132
6	2.4495	2.015

8.2.2 Example

95% confidence

$X = 150$ kWh, $S = 10$, $n = 2$

t (from table) = 6.314

$$UCL = 150 + 6.314 \times \frac{10}{\sqrt{2}} = 195$$

Clause 8 of this Standard requires that the represented value of energy consumption shall be no less than the higher of the

- (a) mean of the sample (ie, 150); or
- (b) upper 95% confidence limit divided by 1.10

$$\text{ie } \frac{195}{1.10} = 177$$

In this example, the label figure would be not less than 177.

8.2.3 Advantage of taking a larger sample:

Say $n = 3$; then $t = 2.920$

$$UCL = 150 + 2.920 \times \frac{10}{\sqrt{3}} = 167$$

therefore:

$$\text{the label value} = \frac{167}{1.10} = 152$$

By taking three samples instead of two, the label figure has been reduced from 167 to 152.

However,

If four samples are taken, $t = 2.353$, and

$$UCL = 150 + 2.353 \times \frac{10}{\sqrt{4}} = 162$$

And for Case B (see example in Subclause 8.2.2(b))

$$\frac{162}{1.10} = 147$$

Because the mean (150) is higher than in Case B, the label figure shall be no lower than 150. Consequently, there is no advantage to a sample of more than four units.

9. DATA TO BE REPORTED**9.1 Refrigerators and Refrigerator-Freezers**

The following data shall be reported

- (a) type, model, class, serial number, if any, and manufacturer or brand name of unit;
- (b) maximum energy consumption limit as specified in Tables 1 and 2;
- (c) refrigerator volume and freezer volume; and
- (d) total energy consumption in kWh per year according to Clause 7.3.

9.2 Freezers

The following data shall be recorded:

- (a) type, model, date, serial number, if any, and manufacturer or brand name of unit;
- (b) maximum energy consumption limit as specified in tables 1 and 2;
- (c) freezer volume;
- (d) total energy consumption in kWh per year as specified in Clause 7.3;
- (e) the freezing capability as expressed in kg/24h for chest and upright freezers, at a standardized compartment temperature of -17.8°C.

Table 1 - Maximum Annual Energy Consumption Limits for Refrigerators, Refrigerator-Freezers and Freezers in SI Units (See Clauses 7.3, 9.1, and 9.2)

Product Type	Energy Consumption Limits
(1) Refrigerators and refrigerator-freezers with manual defrost	0.31 AV + 248.4
(2) Refrigerator-freezers with partial automatic defrost	0.31 AV + 248.4
(3) Refrigerator-freezers with automatic defrost with top-mounted freezer without through-the-door ice service, and all refrigerators with automatic defrost	0.35 AV + 276
(4) Refrigerator-freezers with automatic defrost with side-mounted freezer without through-the-door ice service	0.17 AV + 507.5
(5) Refrigerator-freezers with automatic defrost with bottom-mounted freezer without through-the-door ice service	0.16 AV + 459.0
(6) Refrigerator-freezers with automatic defrost with top-mounted freezer with through-the-door ice service	0.36 AV + 356.0
(7) Refrigerator-freezers with automatic defrost with side-mounted freezer with through-the-door ice service	0.36 AV + 406.0
(8) Upright freezers with manual defrost	0.27 AV + 258.3
(9) Upright freezers with automatic defrost	0.44 AV + 326.1
(10) Chest freezers and all other freezers	0.35 AV + 143.7
(11) Compact Refrigerators and Refrigerator-freezers with manual defrost	0.38 AV + 299.0
(12) Compact Refrigerator freezers with partial automatic defrost	0.25 AV + 398.0
(13) Compact Refrigerator freezers with automatic defrost with top-mounted freezer and compact all-refrigerators with automatic defrost	0.45 AV + 355.0
(14) Compact Refrigerator-freezers with automatic defrost with side-mounted freezer	0.27 AV + 501.0
(15) Compact Refrigerator-freezers with automatic defrost with bottom-mounted freezer	0.46 AV + 367.0
(16) Compact Upright freezers with manual defrost	0.35 AV + 250.8
(17) Compact Upright freezers with automatic defrost	0.40 AV + 391.0
(18) Compact Chest freezers and all other freezers	0.37 AV + 152.0

*AV = Adjusted Volume in litres as defined in Clause 7.1 for refrigerators and refrigerator-freezers and in Clause 7.2 for freezers.

Note: The energy consumption limits are in effect at the time of publication. These values are continuously updated (approximately every three years) in line with global standards .

Table 2 - Maximum Annual Energy Consumption Limits for Refrigerators, Refrigerator- Freezers and Freezers in Imperial Units

Product Type	Energy Consumption Limits
(1) Refrigerators and refrigerator-freezers with manual defrost	8.82 AV + 248.4
(2) Refrigerator-freezers with partial automatic defrost	8.82 AV + 248.4
(3) Refrigerator-freezers with automatic defrost with top-mounted freezer without through-the-door ice service, and all refrigerators with automatic defrost	9.80 AV + 276
(4) Refrigerator-freezers with automatic defrost with side-mounted freezer without through-the-door ice service	4.91 AV + 507.5
(5) Refrigerator-freezers with automatic defrost with bottom-mounted freezer without through-the-door ice service	4.60 AV + 459.0
(6) Refrigerator-freezers with automatic defrost with top-mounted freezer with through-the-door ice service	10.20 AV + 356.0
(7) Refrigerator-freezers with automatic defrost with side-mounted freezer with through-the-door ice service	10.10 AV + 406.0
(8) Upright freezers with manual defrost	7.55 AV + 258.3
(9) Upright freezers with automatic defrost	12.43 AV + 326.1
(10) Chest freezers and all other freezers	9.88 AV + 143.7
(11) Compact Refrigerators and Refrigerator-freezers with manual defrost	10.70 AV + 299.0
(12) Compact Refrigerator freezers with partial automatic defrost	7.00 AV + 398.0
(13) Compact Refrigerator freezers with automatic defrost with top-mounted freezer and compact all-refrigerators with automatic defrost	12.70 AV + 355.0
(14) Compact Refrigerator-freezers with automatic defrost with side-mounted freezer	7.60 AV + 501.0
(15) Compact Refrigerator-freezers with automatic defrost with bottom-mounted freezer	13.10 AV + 367.0
(16) Compact Upright freezers with manual defrost	9.78 AV + 250.8
(17) Compact Upright freezers with automatic defrost	11.40 AV + 391.0
(18) Compact Chest freezers and all other freezers	10.45 AV + 152.0

* AV =Adjusted Volume in cubic feet as defined in Clause 7.1 for refrigerators and refrigerator-freezers and in Clause 7.2 for freezers.

Note: The energy consumption limits are in effect at the time of publication. These values are continuously updated (approximately every three years) in line with global standards .

10 ENERGY LABEL**10.1 ENERGY EFFICIENCY STAR RATING**

- From table 1 the maximum annual energy consumption limits can be obtained for product type (1-18) .
- These product type are subjected to accredited laboratories tests for maximum annual energy consumption limits .
- According to the results of these tests the number of stars can be assigned as shown in table 3.

Table 3 – Star Rating

Annual energy consumption rating	star rating
For annual energy consumption for tested product less than by 5% or equal for the maximum annual energy consumption limits for Refrigerators, Refrigerator-Freezers and Freezers	1
For annual energy consumption for tested product less than by 10% of the maximum annual energy consumption limits for Refrigerators, Refrigerator-Freezers and Freezers	2
For annual energy consumption for tested product less than by 15% of the maximum annual energy consumption limits for Refrigerators, Refrigerator-Freezers and Freezers	3
For annual energy consumption for tested product less than by 20% of the maximum annual energy consumption limits for Refrigerators, Refrigerator-Freezers and Freezers	4
For annual energy consumption for tested product less than by 25% of the maximum annual energy consumption limits for Refrigerators, Refrigerator-Freezers and Freezers	5
For annual energy consumption for tested product less than by 30% of the maximum annual energy consumption limits for Refrigerators, Refrigerator-Freezers and Freezers	6

Note: Increasing the increments between the star ratings from 5% currently to 10% will be considered in future issues of this standard.

11. PRINTING AND PLACEMENT OF ENERGY LABELS

11.1 Placement The energy label shall be attached to the upper portion of each appliance on the outside of the door of an upright appliance and on the lid of an appliance of chest configuration

In the case of a chest configured appliance where the lid is the lift-off type (i.e. not attached by the hinge or similar) or , if the lid surface is unstable for attachment of label, then the label shall be attached in the conspicuous location on the front of the appliance .

11.2 Material and shape the label is to be self-adhesive and cut to one of the outlines shown in figure11.1

11.3 COLOURS The label is to be printed in three colours on a white background as illustrated in figure11.1 .

Note : for general information regarding printing of the label ,refer to appendix A .

(Under design , will be added in the next stage.)

FIGURE 11.1 DETAILS OF LABEL

Legend

a = this band is cut off according to the appliance's energy stars rating . Note that whole stars appear only when the continuous band of colour reaches the next number.

*b*₁, *b*₂ = the panels contain the annual energy consumption for tested unit (kwh/y) . The figures that apply to the particular appliance shall be of the font and size indicated and centred in the panel. The spacing between the figures of a three-figure number shall be the same as that for a four-figure number.

c = the panel contains the wording "Energy Efficiency Label".

the fonts to be used on the label shall be all capitals for lettering

11.4 Sample Label

An example of a printed label for refrigerating appliance is shown in figure 11.2 .

Note : The brand and model names, appliance designation and annual energy consumption for tested unit (kWh/y) to be provided .



Figure 11.2 Example Of Label

- 11.5 Label requirements and queries all of the information required to produce an energy label using modern printing techniques is contained either in this section or in appendix A , however additional materials to assist in printing may be available . any queries regarding the printing of labels should be directed to SASO .

Appendix A
ENERGY LABEL DIMENSIONS
(INFORMATIVE)

Most of the dimensional information required to create a valid energy label is given in figure A1

(Under design , will be added in the next stage.)

DIMENSIONS IN MILLIMETERS

FIGURE A1 – LABEL

**APPENDIX B
FORMAT OF APPLICATION FOR REGISTRATION
(NORMATIVE)**

This appendix sets out the required format for submitting an application for registration

**APPLICATION FOR REGISTRATION OR RENEWAL OF REGISTRATION OF
ELECTRICAL APPLIANCE FOR ENERGY EFFICIENCY**
(please type or print)

SECTION 1 APPLICATION DETAILS

I hereby apply for registration of an electrical appliance for the purpose of energy labelling.

In the Country of
(specify the country in which this application is made)

SECTION 2 APPLICANT DETAILS

Name of applicant
.....

Name of company
.....

Business address
.....
.....
.....

P.O Box
.....postcode.....

Contact person : (A name ,address and place of business in each country of sale)
Position / title :

.....
Tel ()facsimile ()
.....

SECTION 3 DESCRIPTION OF APPLIANCE

Designation
:.....
(indicate which) refrigerator , refrigerator/freezer , freezer

Type :
(refer to table 1)

Country of manufacturer

Brand name Year model (s) first manufactured / imported.....

(if registering a family of models , all with the same star rating . list all names and numbers)

Model Number(s)

.....

Model Number (s) to appear on label :

.....

Does this model or family replace or supplement another with the same star rating ?
Yes / No

.....

If yes , which model (s) ?

SECTION 4 TESTING AND TEST REPORT

Where tests conducted at applicant's own facilities?.....yes / No

Who conducted the tests

Write test results recording sheets, as required for this appliance type , attached ?.....yes/
No

If not , why not ?.....

SECTION 5 SPECIFIC APPLIANCE DETAILS

Rated Voltage (Volt):

Rated Frequency (Hz):.....

ADJUSTED VOLUME (refer to clause 7.1 and 7.2)

Record in the table below , the Adjusted Volume values

ADJUSTED VOLUME	Adjusted volume, liters
Adjusted Volume of refrigerator or refrigerator - freezer	
Adjusted Volume of freezer	

ENERGY CONSUMPTION

Product type (refer to table 1)	
Energy consumption for tested unit (kwh/d)	
Annual Energy consumption for tested unit (kwh/y)	
Star rating for tested unit (use table 3 clause 10 to obtain star rating)	

SECTION 6 DECLARATION

I declare that the details stated above are correct

Signature of applicant : date

.....

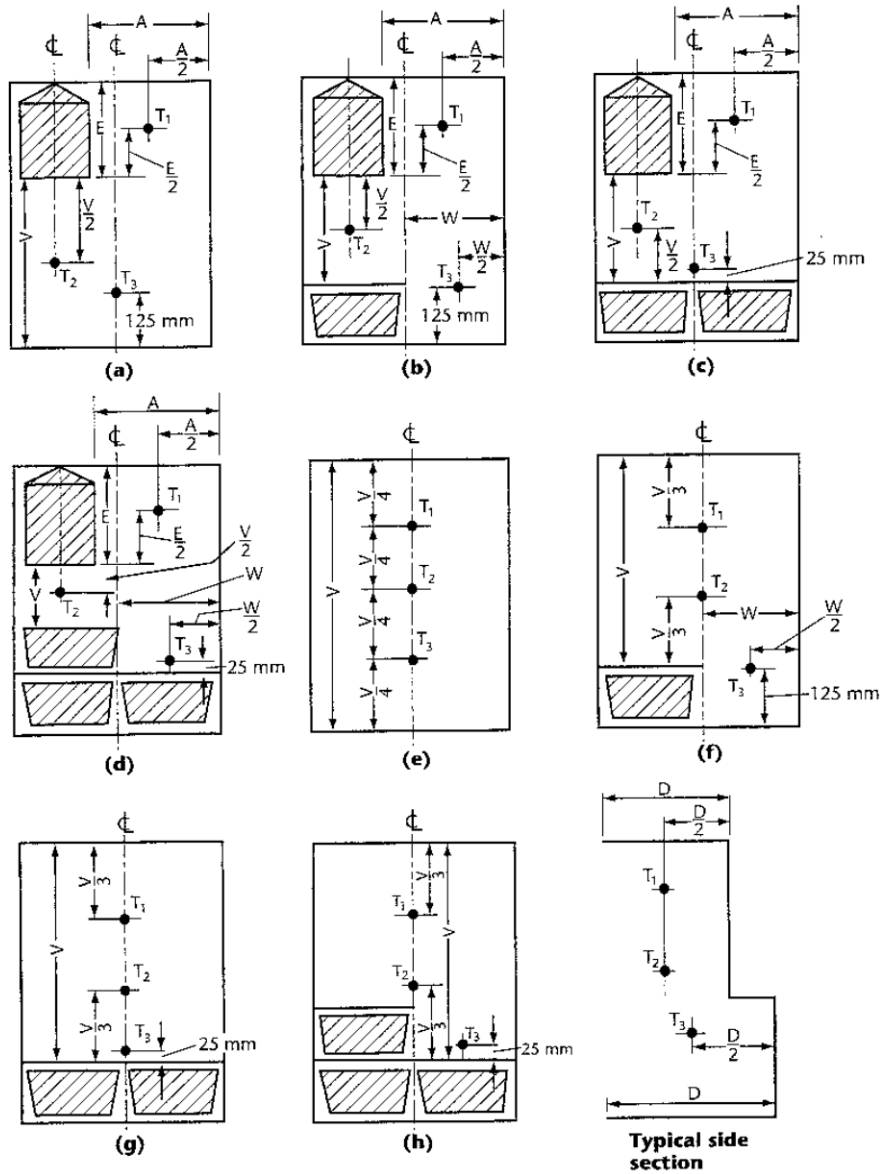
Office use only

Date received:..... Registration number

.....

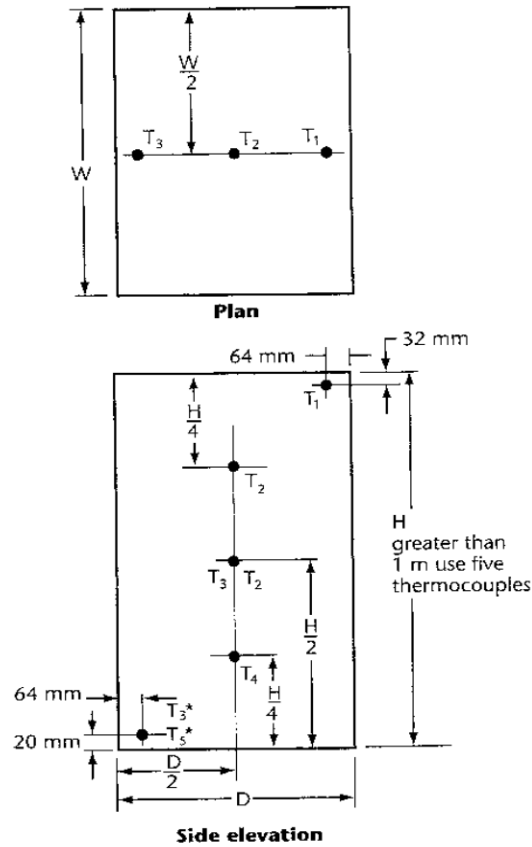
APPENDIX C- References

- 1) AS/NJS 4474.2 : 1997
- 2) ANSI/AHAM HRF-1 :1988
- 3) EN 153 (EUROPEAN STANDARDS)
- 4) CANADIAN STANDARDS : C300
- 5) ISO 8187
- 6) ISO 8561
- 7) ISO 7371
- 8) ISO 5155
- 9) ISO 15502



Note: "A", "D", "E", "W", and "V" are arbitrary designations for determining locations at which temperatures shall be measured. The depth dimension shall be measured from the back of the liner to a plane defining the gasket sealing surface. T_1 , T_2 , and T_3 indicate thermocouple locations.

Figure 1
Thermocouple Locations for Determination of Fresh Food Compartment Temperatures
 (See Clauses 3.4.1 and 5.1.5.2.)



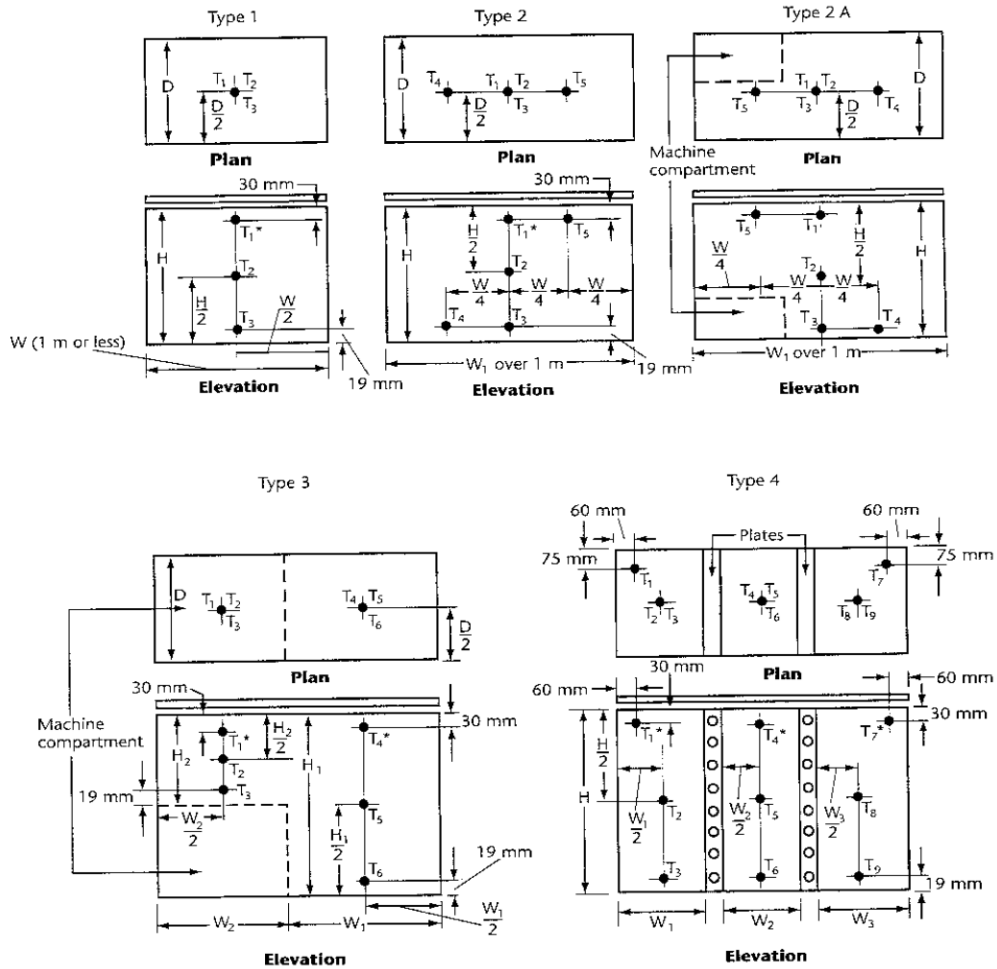
Legend:
 H = height
 W = width
 D = depth
 T = thermocouple locations

**If a projection on the inner door interferes with these thermocouple locations, the thermocouples shall be moved rearward to clear the projection.*

Notes:

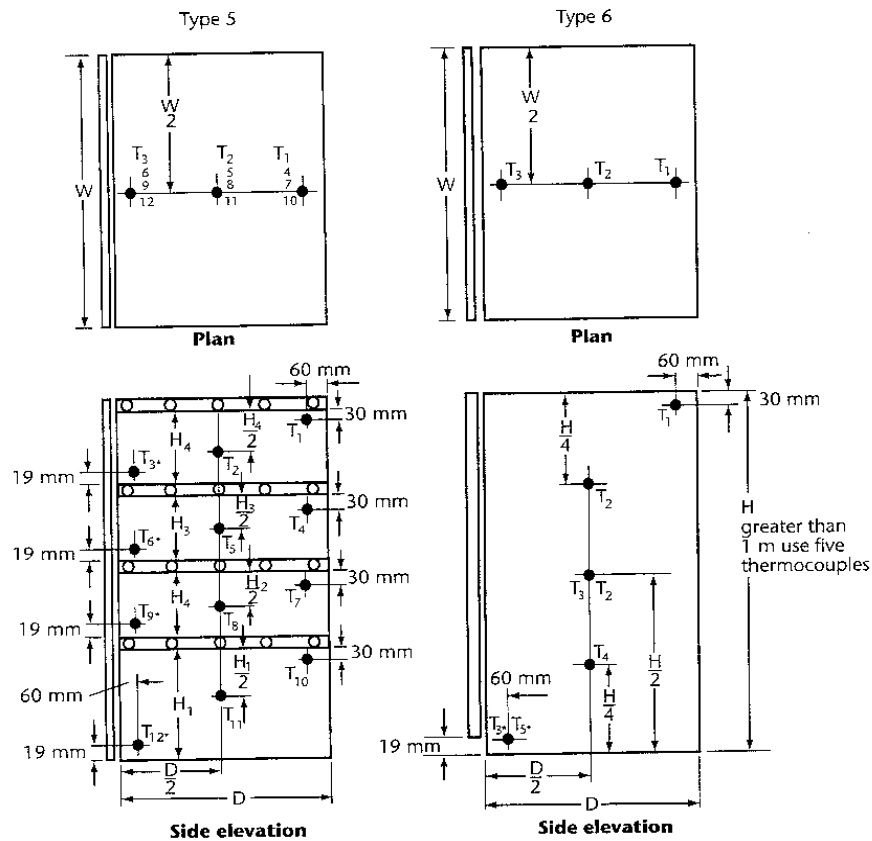
- (1) *The height dimension shall be measured from the bottom of the liner (or from the top of a trivet, if furnished).*
- (2) *The depth dimension shall be measured from the back of the liner to a plane defining the gasket sealing surface.*

Figure 2
Thermocouple Locations for Determination of Freezer Compartment Temperatures of Refrigerators and Refrigerator-Freezers
 (See Clauses 3.4.1, 5.1.5.3, 5.1.5.4, and 5.2.5.2.)



Types 1, 2, 2A, and 3 Chest freezer (lift cover) with refrigerated walls
 Type 4 Chest freezer (lift cover) with refrigerated plates

Figure 3
Thermocouple Locations for Determination of Temperatures of Freezers
 (See Clauses 3.4.1, 5.1.5.3, and 5.2.5.2.)



Legend:
 H = height
 W = width
 D = depth
 T = thermocouple locations

- Type 5 Upright freezer (front door) with refrigerated shelves (door located at left)
- Type 6 Evaporator or freezer compartment of upright freezers (front door) with refrigerated walls or with concealed evaporator (door located at left)

**If a projection on the inner door interferes with these thermocouple locations, the thermocouples shall be moved rearward to clear the projection.*

For Types 1, 2, 2A, 3, and 4 — the height dimension shall be measured from the bottom of the liner (or from the top of a trivet, if furnished) to a plane defining the gasket sealing surface.

For Types 5 and 6 — the height dimension shall be measured from the bottom of the liner (or from the top of a trivet, if furnished).

For Types 5 and 6 — the depth dimension shall be measured from the back of the liner to a plane defining the gasket sealing surface.

Note: For load tests, the thermocouple location shall designate the approximate geometric centre of a 125 x 100 x 40 mm (5 x 4 x 1-1/2 in) frozen food package.

Figure 3 (Concluded)

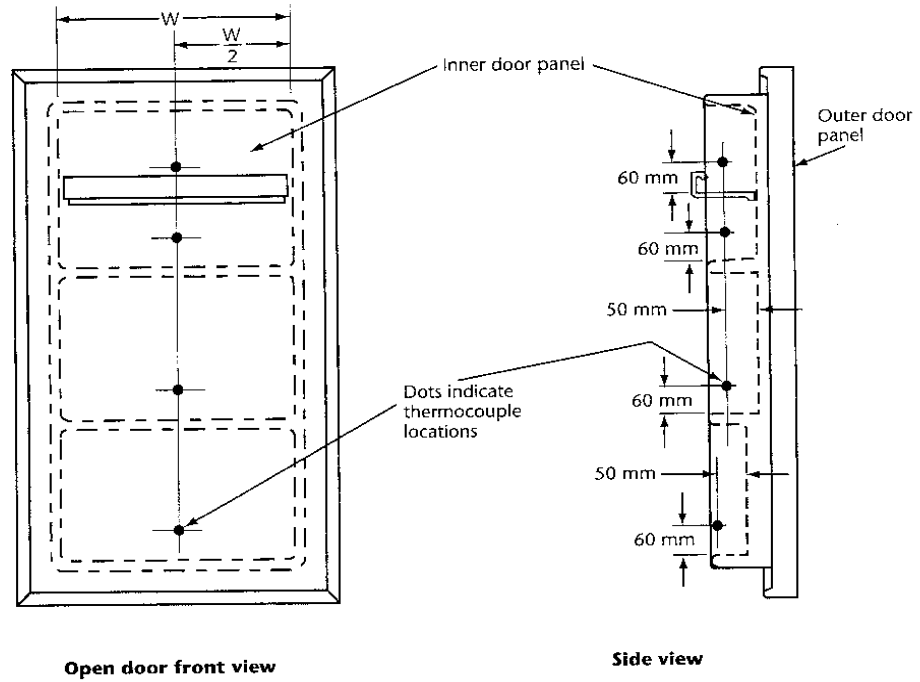
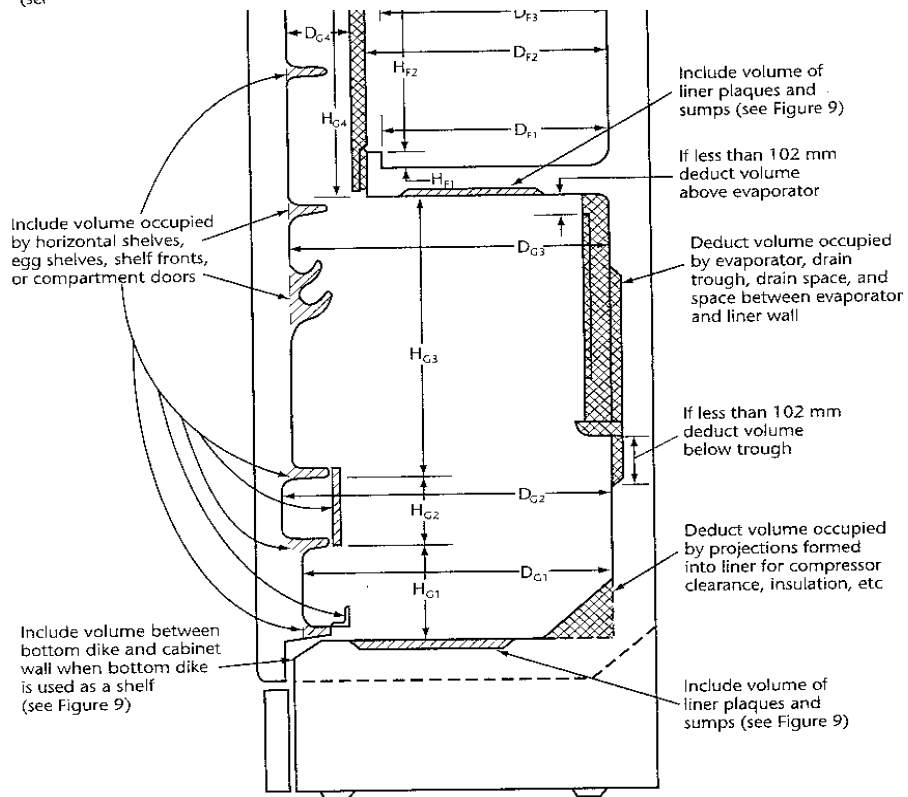


Figure 4
Thermocouple Locations for Door Shelves of Vertical Freezers and Door Shelves of Freezer Compartments in Combination Refrigerator-Freezers
 (See Clause 3.4.1.)

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(see

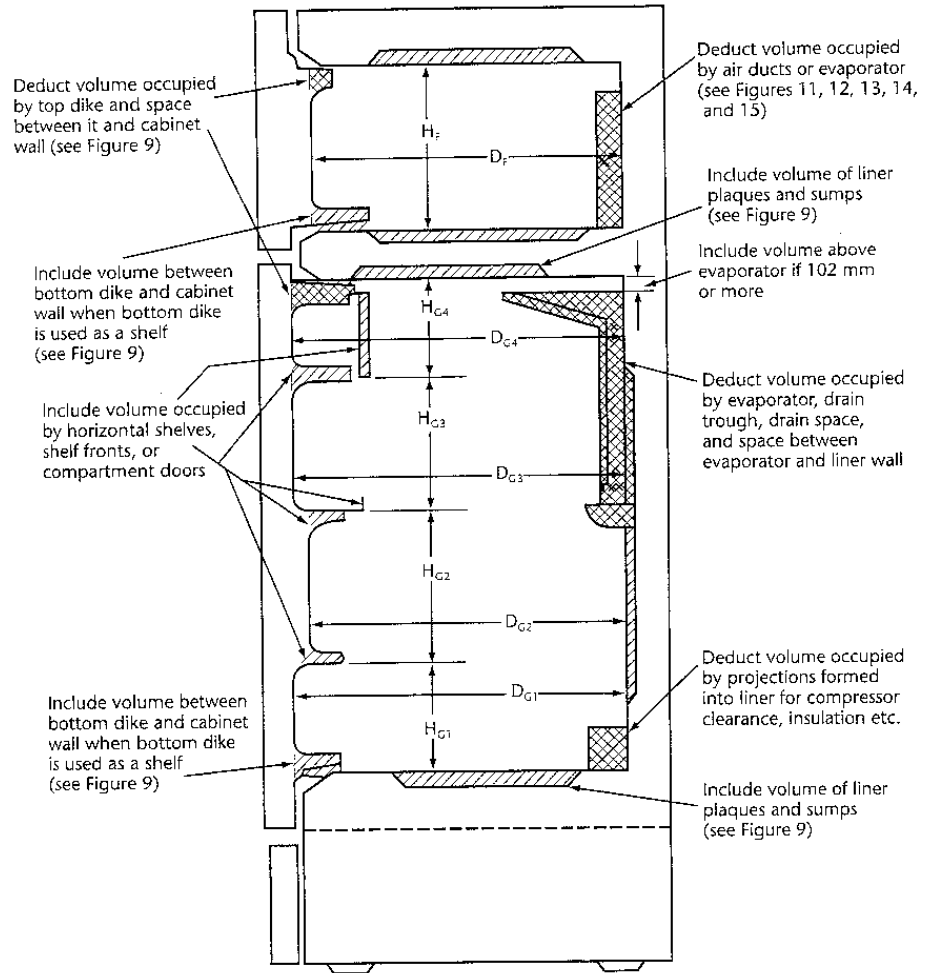


Legend:


- = volume to be included
- = volume to be deducted
- = volume to be deducted
- H_F = height of freezer compartment
- H_G = height of fresh food compartment
- D_F = depth of freezer compartment
- D_G = depth of fresh food compartment


Figure 6
Single-Door Refrigerator-Freezer (Dynamic Evaporator)
(Total Refrigerated Volume)

(See Clauses 4.1.3.1, 4.1.3.2, and 4.1.3.3.)



Legend:

 = volume to be included

 = volume to be deducted

H_F = height of freezer compartment

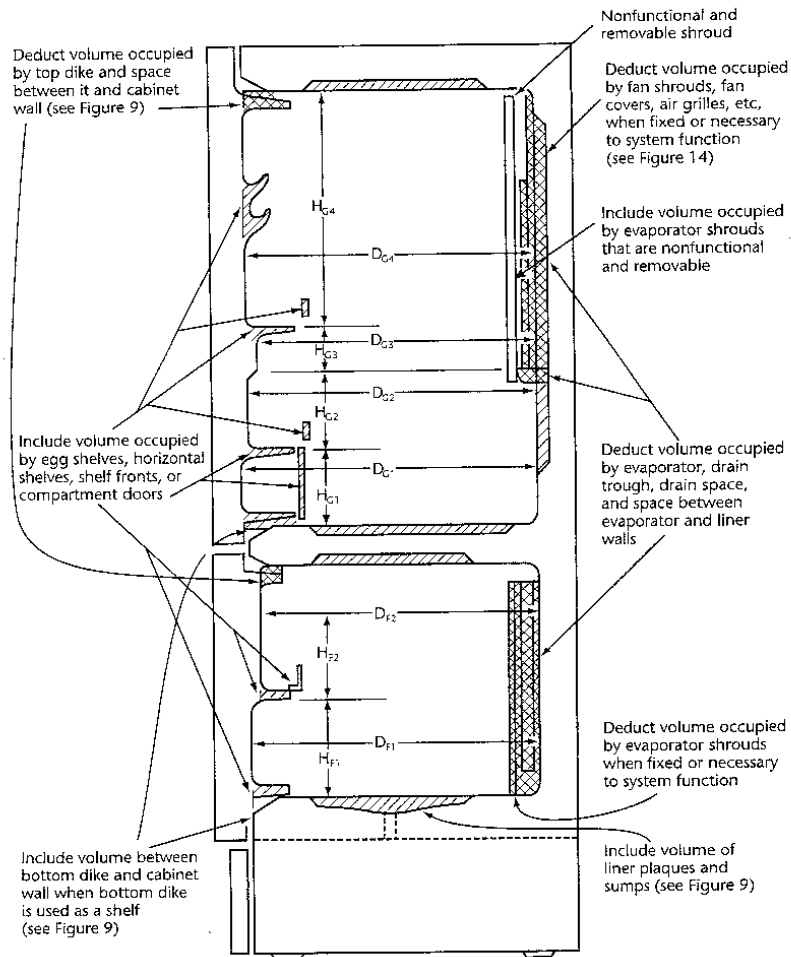
D_F = depth of freezer compartment

H_C = height of fresh food compartment

D_C = depth of fresh food compartment

Figure 7
Two-Door Combination Refrigerator-Freezer
with Top-Mounted Freezer
(Total Refrigerator Volume)

(See Clauses 4.1.3.1, 4.1.3.2, and 4.1.3.3.)





Legend:
 = volume to be included
 = volume to be deducted
 H_G = height of fresh food compartment
 D_G = depth of fresh food compartment
 H_F = height of freezer compartment
 D_F = depth of freezer compartment

Figure 8
Two-Door Combination Refrigerator-Freezer
with Bottom-Mounted Freezer
(Total Refrigerated Volume)
 (See Clauses 4.1.3.1, 4.1.3.2, and 4.1.3.3.)

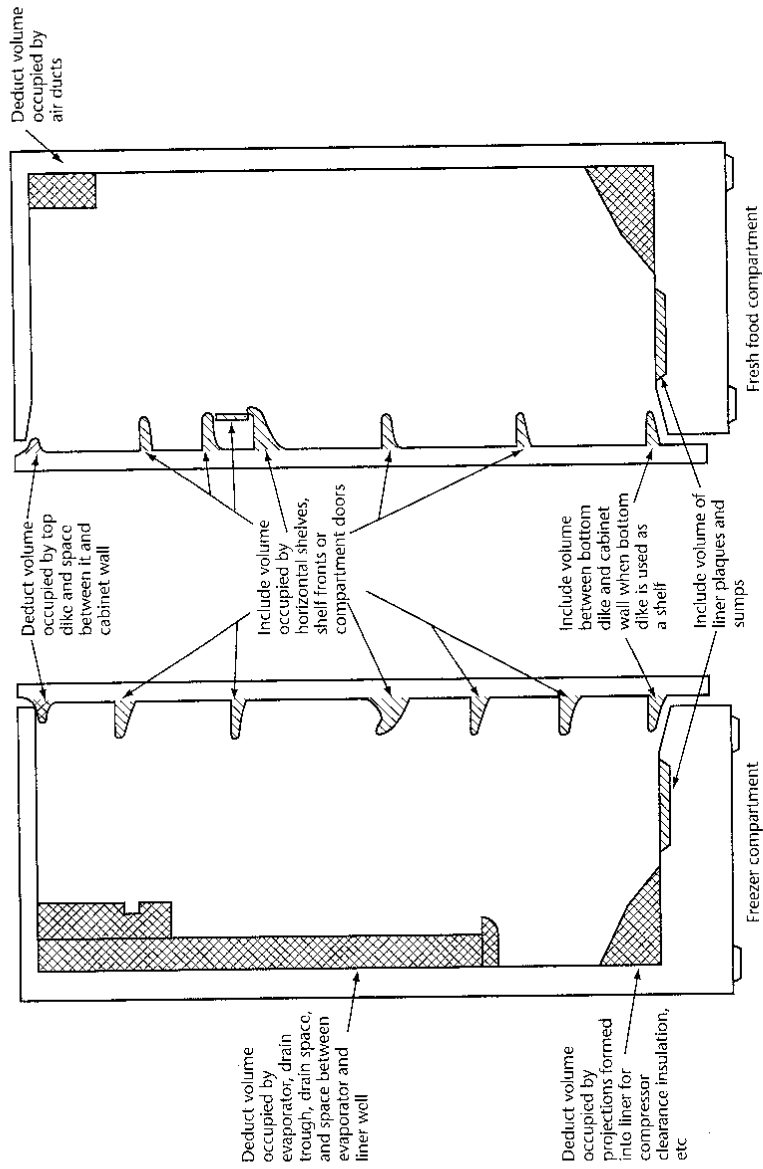


Figure 9
Fresh Food Compartment and Freezer Compartment Volumes
 (See Clauses 4.1.3.1, 4.1.3.2, and 4.1.3.3, and Figures 5, 6, 7, and 8.)

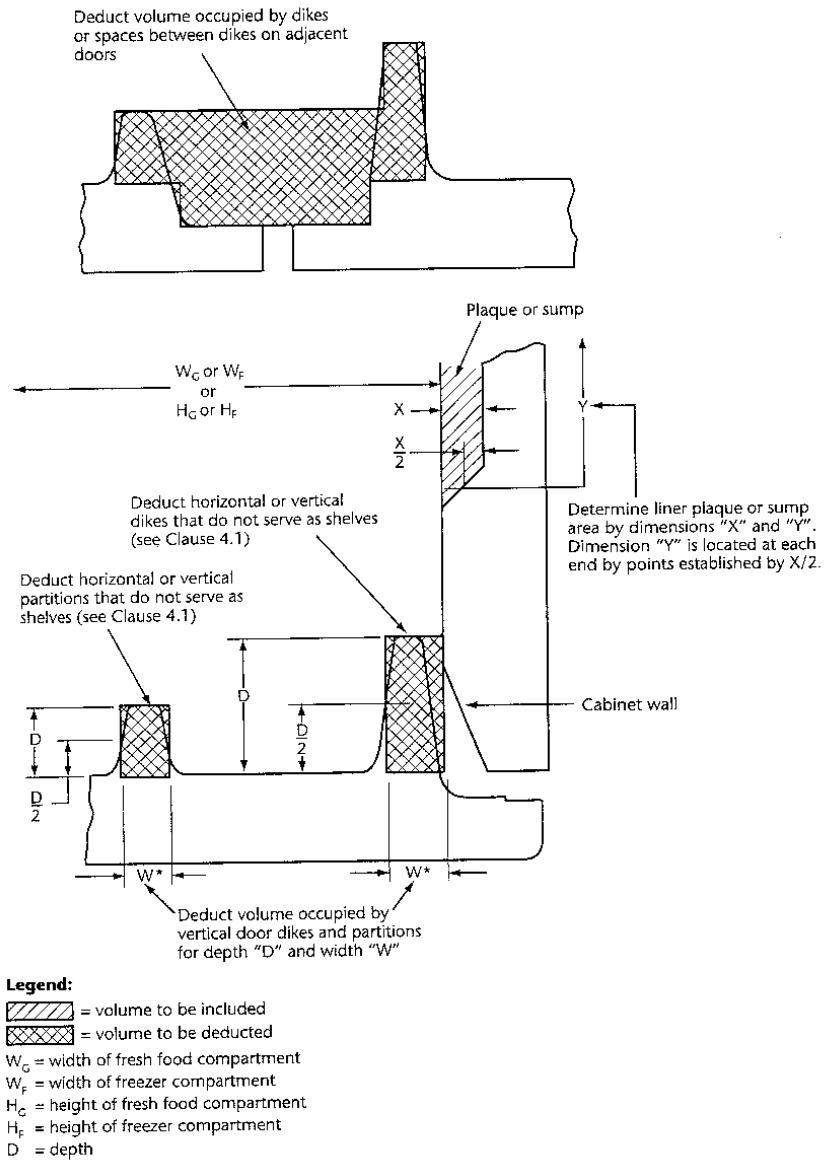


Figure 10
Door Dike and Liner Plaque Dimensions
(Total Refrigerated Volume)
 (See Clauses 4.1.3.1, 4.1.3.2, and 4.1.3.3 and Figure 5.)

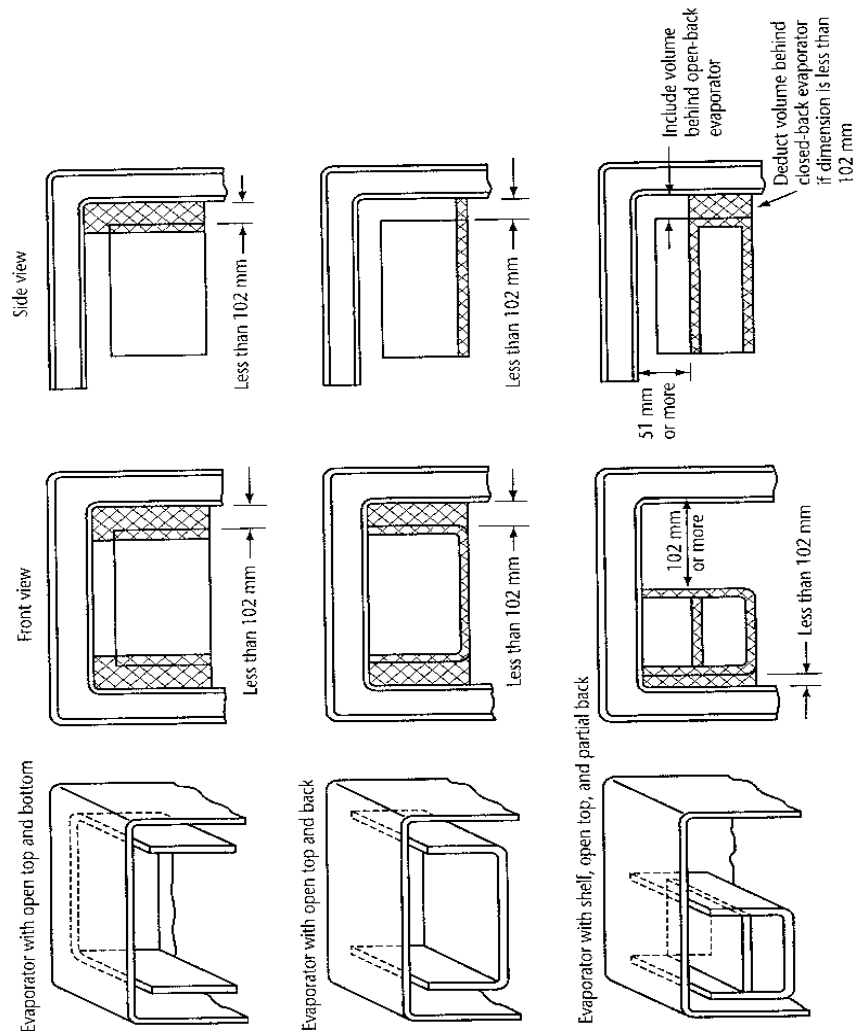


Figure 11
Evaporator Applications
(Total Refrigerated Volume)
 (See Clause 4.1.3.3 and Figures 5 and 7.)

(Continued)

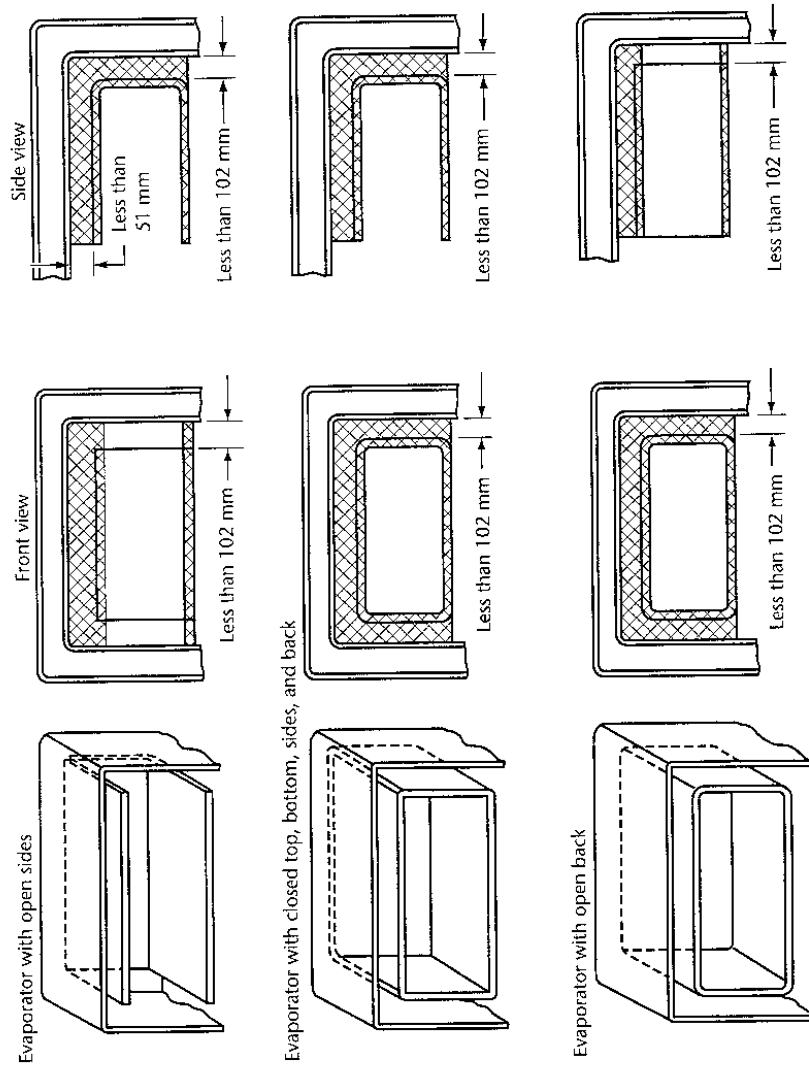


Figure 11 (Continued)

(C)

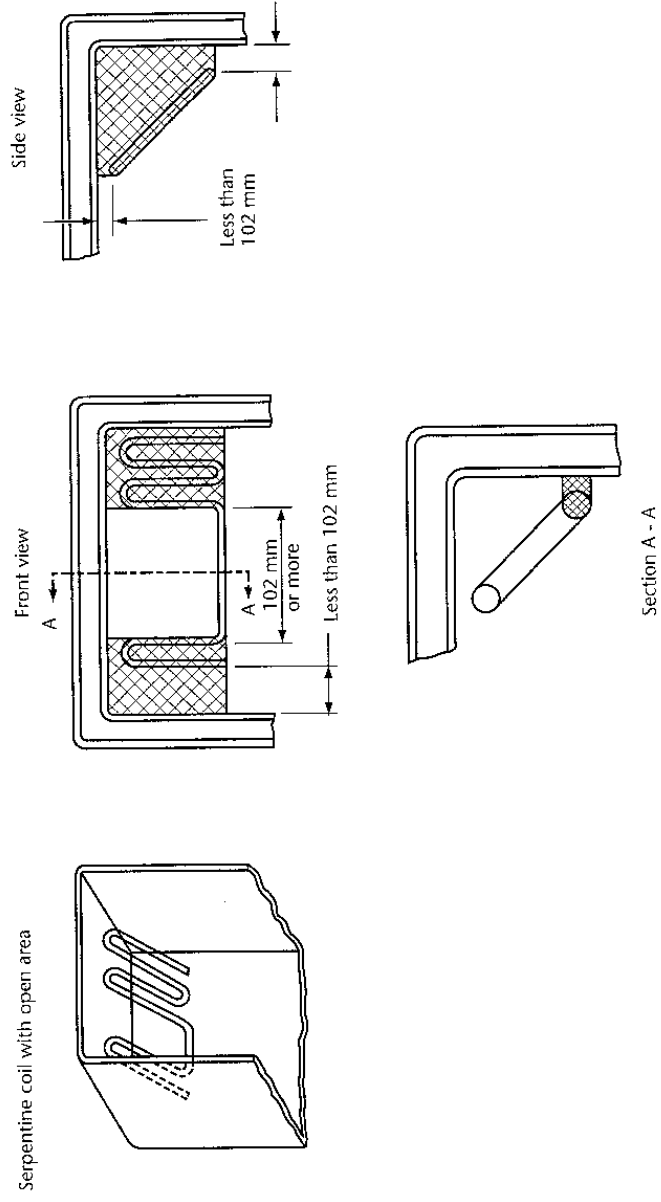


Figure 11 (Concluded)

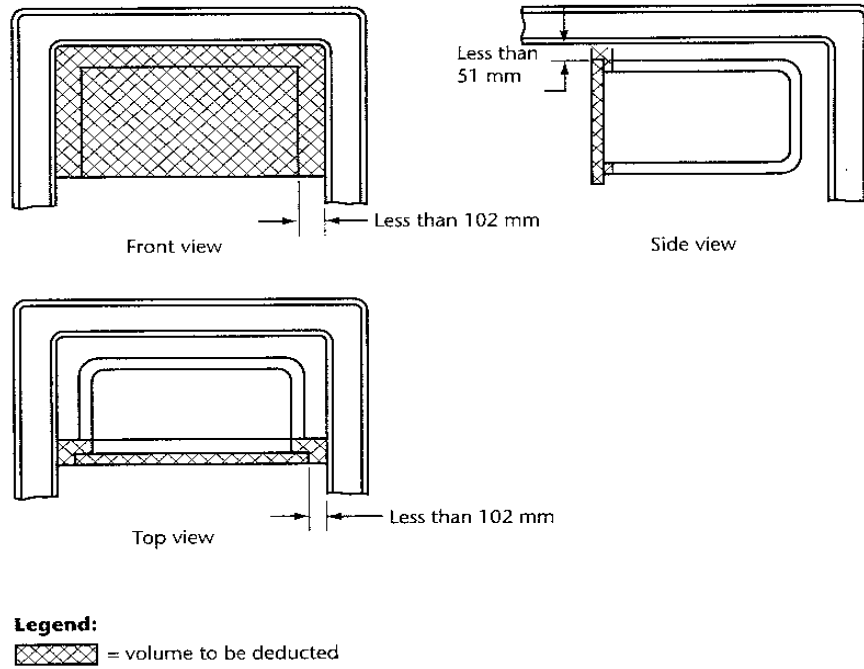


Figure 12
Evaporator Door Deductions
(Total Refrigerated Volume)
 (See Clause 4.1.3.3 and Figures 5 and 7.)

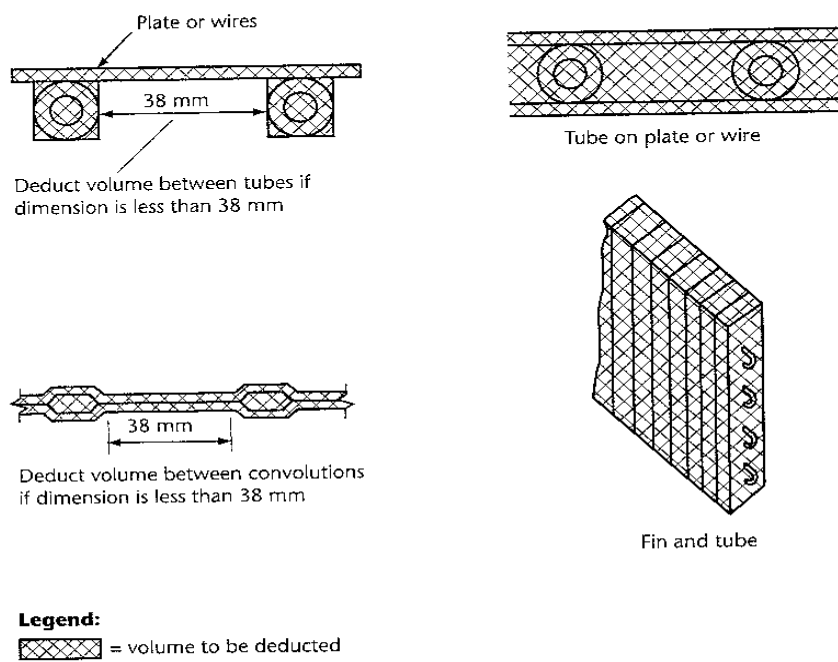
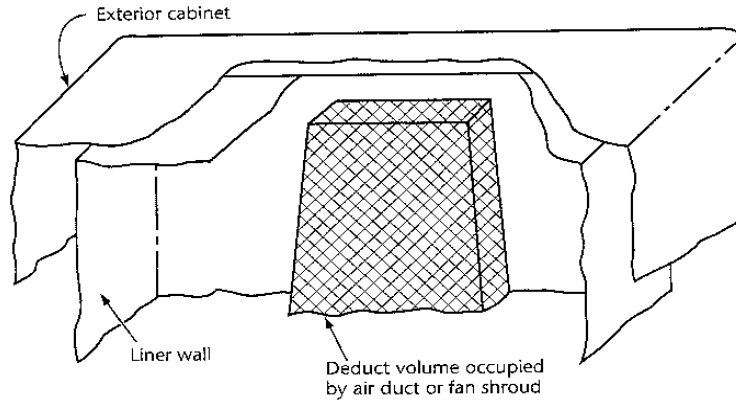


Figure 13
Types of Evaporators (Total Refrigerated Volume)
 (See Clause 4.1.3.3 and Figure 7.)




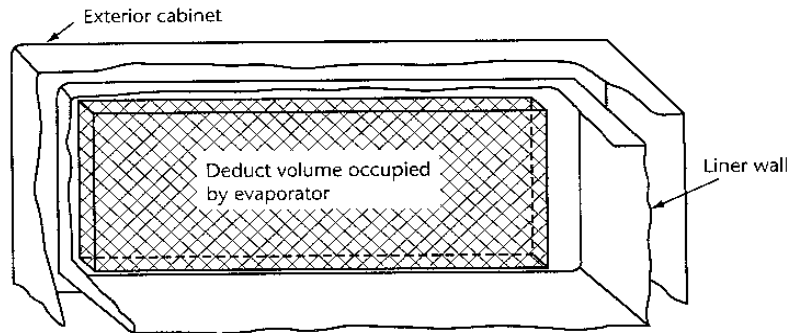
Legend:
 = volume to be deducted

Figure 14
Volume in Freezer Compartment Occupied by Air Duct (Total Refrigerated Volume)
 (See Clause 4.1.3.3 and Figure 8.)




Legend:
 = volume to be deducted

Figure 15
Volume in Freezer Compartment Occupied by Evaporator in Forced-Air Systems (Total Refrigerated Volume)
 (See Clause 4.1.3.3 and Figure 7.)

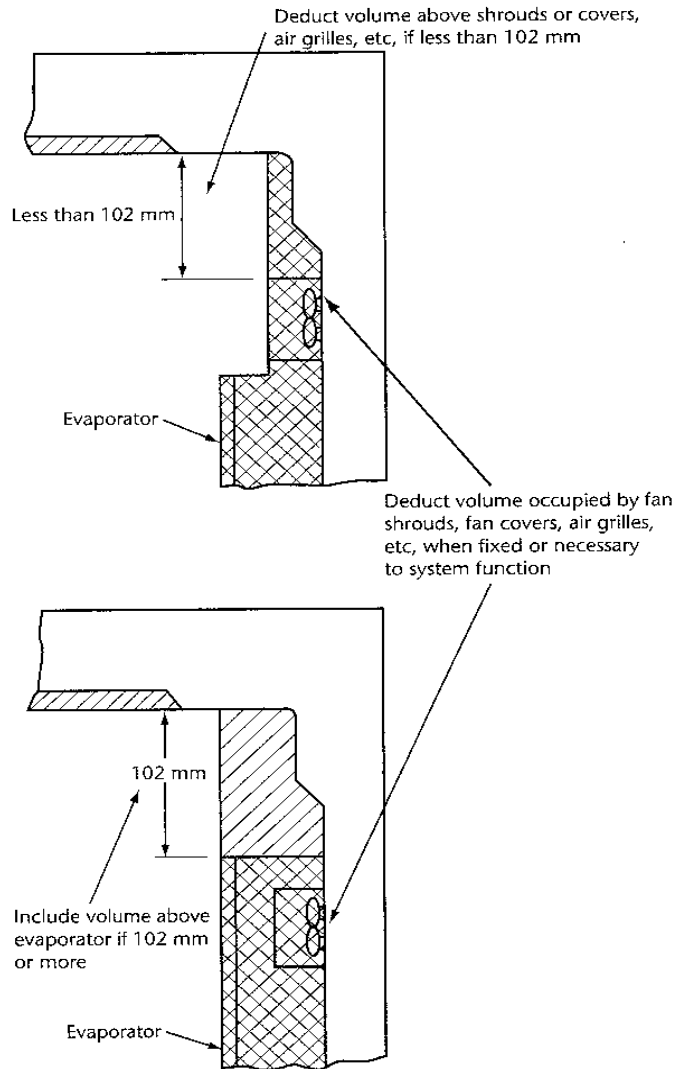


Figure 16
Volume in Fresh Food Compartment Occupied by Fan Shrouds, Etc
(Total Refrigerated Volume)
(See Clause 4.1.3.3.)

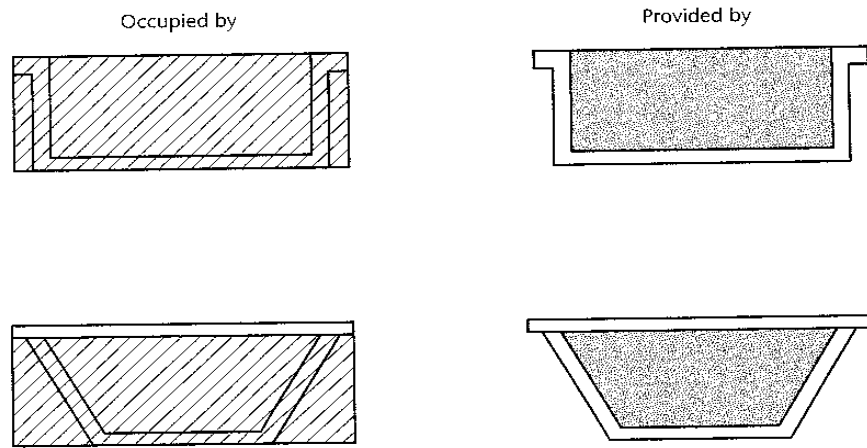


Figure 17
Volumes Occupied by and Provided by Typical Free-Standing
and Supported Relocatable Special Features
(See Clauses 4.2.3.1, 4.2.3.3, 4.2.5, and 4.5.3.1.)

(Continued)

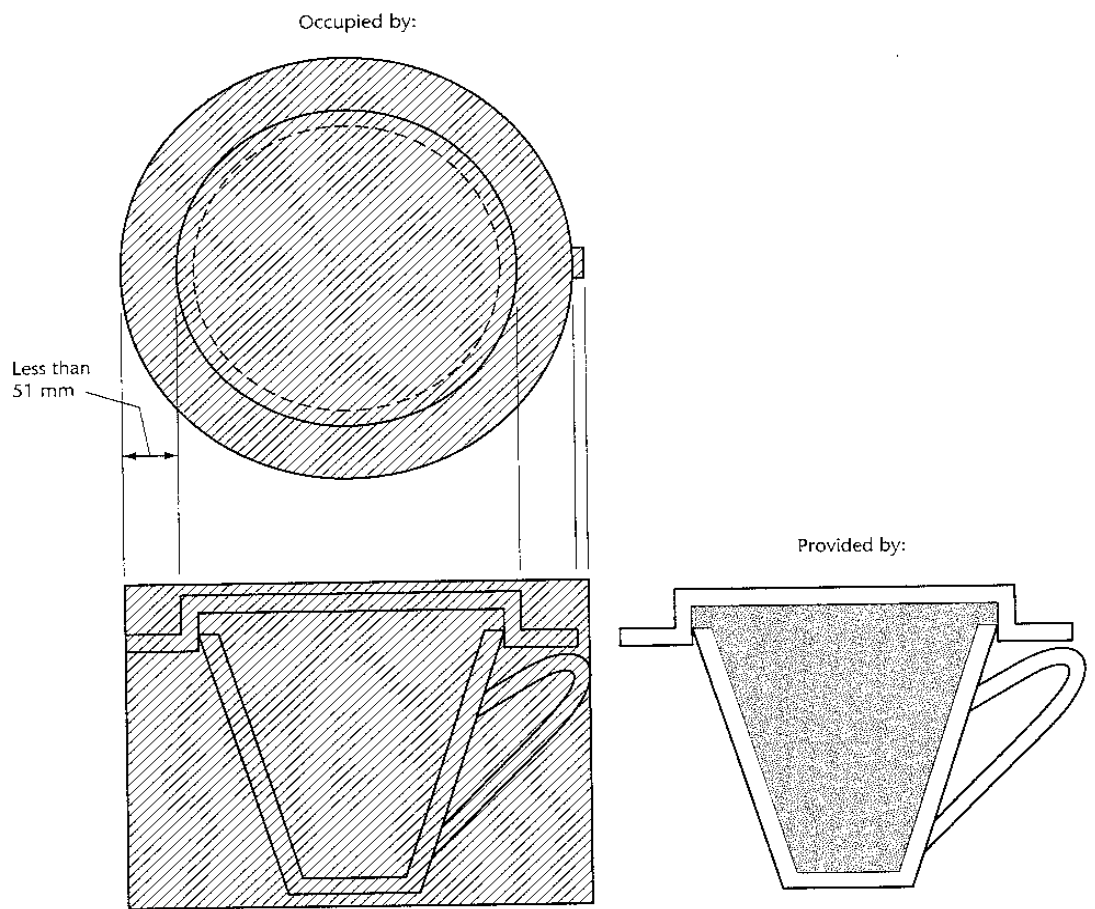
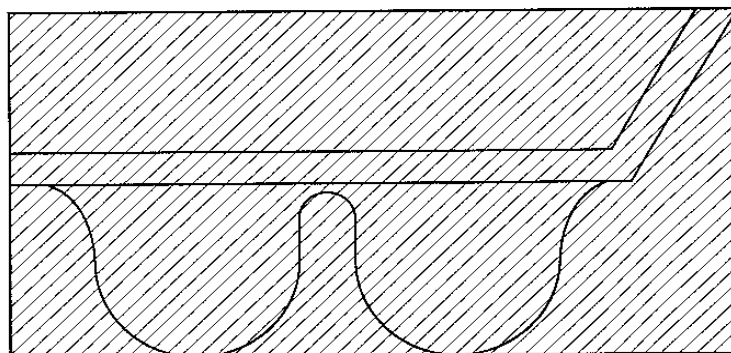


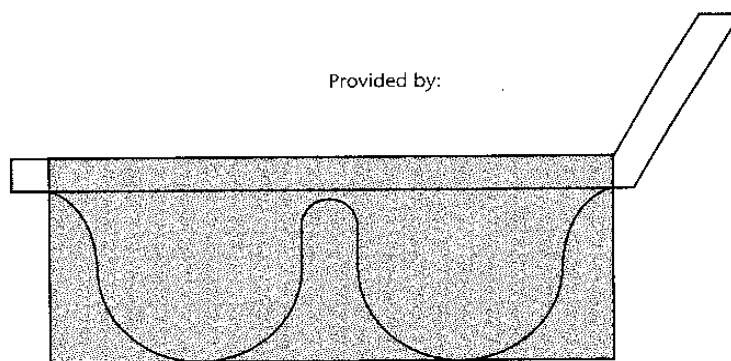
Figure 17 (Continued)

(Continued)

(c)

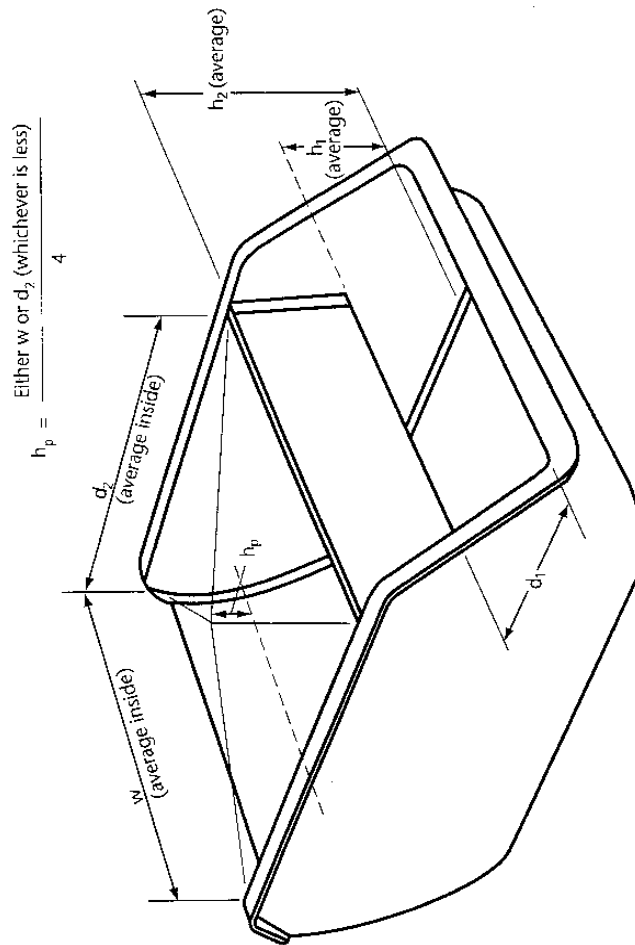


Provided by:



Egg trays

Figure 17 (Concluded)



$$h_p = \frac{\text{Either } w \text{ or } d_2 \text{ (whichever is less)}}{4}$$

Legend:
 w = width
 d = depth
 h = height

$$\text{Volume provided, ft}^3 = \frac{(h_1 \cdot w \cdot d_1) + (h_2 \cdot w \cdot d_2) + \left(\frac{h_p \cdot w \cdot d_2}{3} \right)}{1.728}$$

$$\text{Volume provided, L} = \frac{(h_1 \cdot w \cdot d_1) + (h_2 \cdot w \cdot d_2) + \left(\frac{h_p \cdot w \cdot d_2}{3} \right)}{10^6}$$

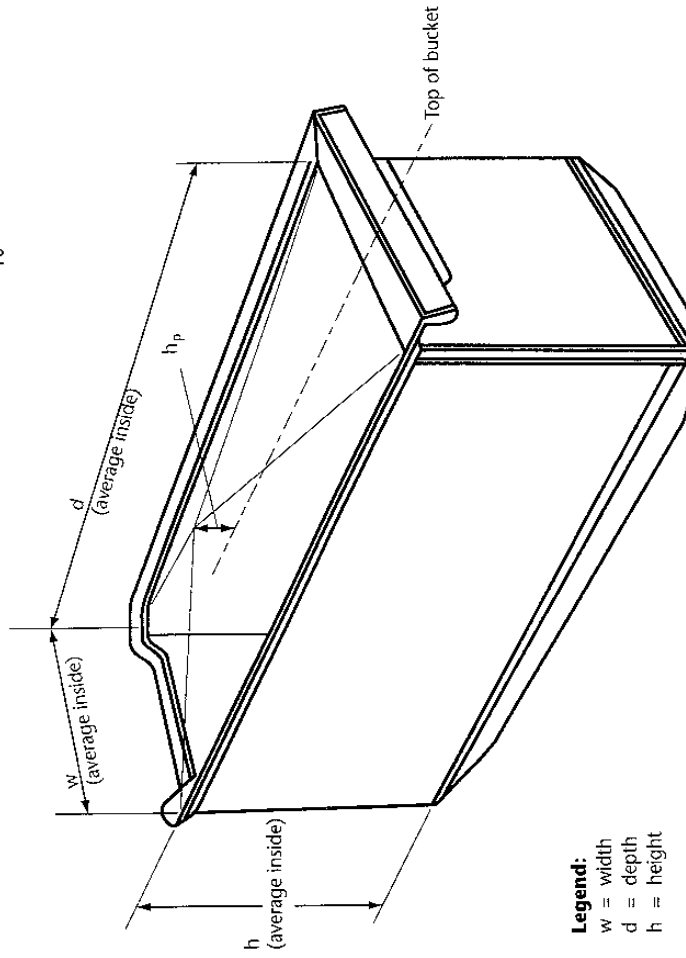
Figure 18
Volume Provided by Irregularly Shaped Ice Buckets or Free-Standing Containers
 (See Clauses 4.2.3.1, 4.2.3.3, 4.2.5, and 4.5.3.1.)

(Continued)

$$h_p = \frac{\text{Either } w \text{ or } d \text{ (whichever is less)}}{4}$$

$$\text{Volume provided, ft}^3 = \frac{(h \cdot w \cdot d) + \left(\frac{h_p \cdot w \cdot d}{3}\right)}{1728}$$

$$\text{Volume provided, L} = \frac{(h \cdot w \cdot d) + \left(\frac{h_p \cdot w \cdot d}{3}\right)}{10^6}$$



Legend:
 w = width
 d = depth
 h = height

Figure 18 (Continued)

(Continued)

$$h_p = \frac{\text{Either } w \text{ or } d \text{ (whichever is less)}}{4}$$

$$\text{Volume provided, ft}^3 = \frac{(h_{avg} \cdot w \cdot d) + \left(\frac{h_p \cdot w \cdot d}{3}\right)}{1728}$$

$$\text{Volume provided, L} = \frac{(h_{avg} \cdot w \cdot d) + \left(\frac{h_p \cdot w \cdot d}{3}\right)}{10^6}$$

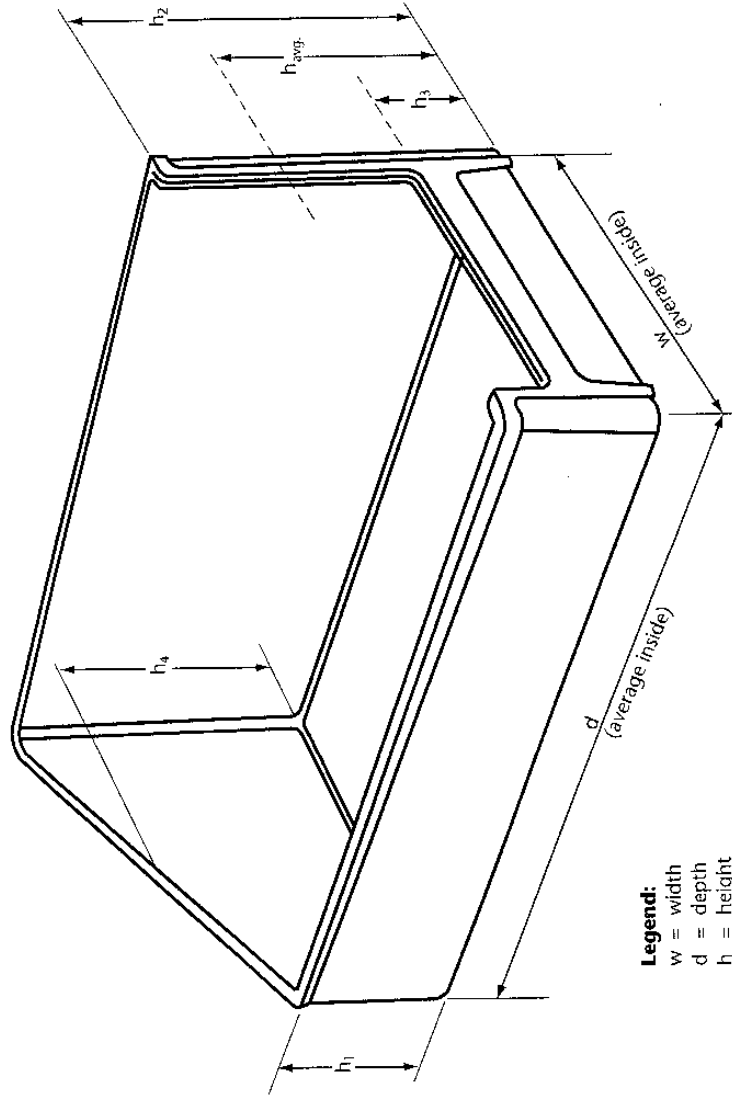
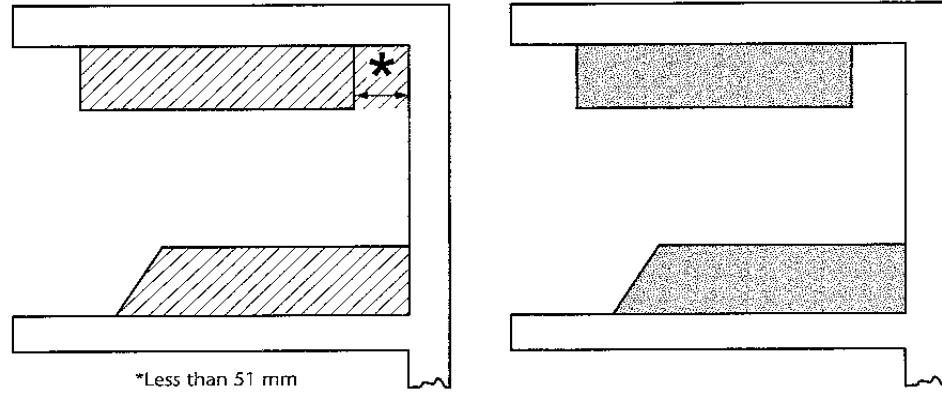
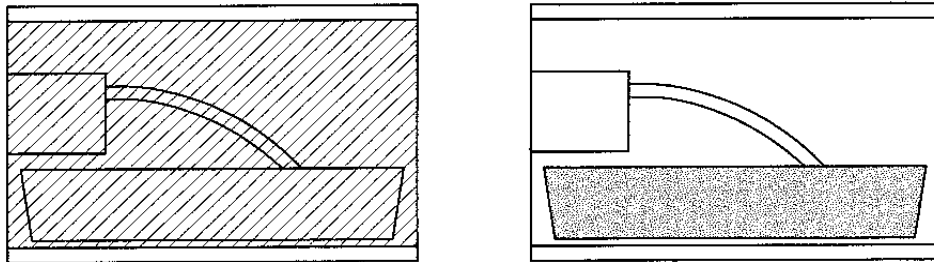


Figure 18 (Concluded)





*Less than 51 mm

Ice tray storage compartments



Legend:

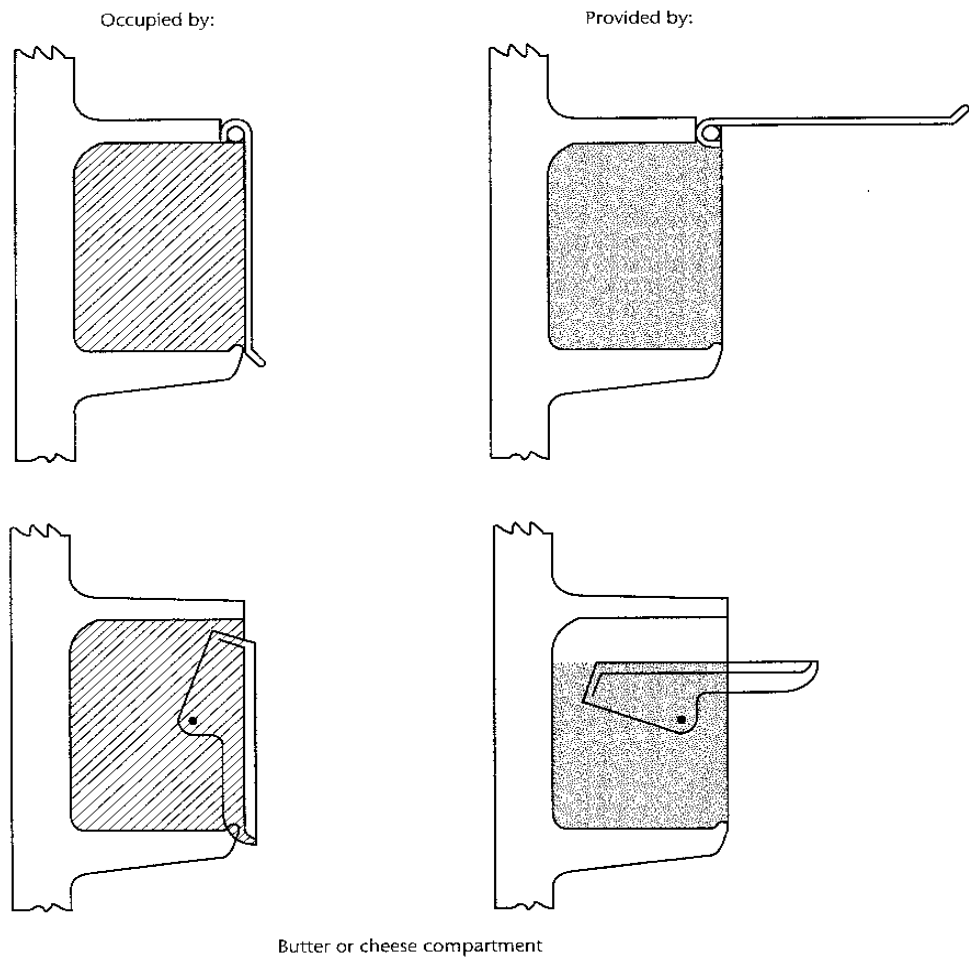
-  = space occupied
-  = space provided

Note: Volumes to be included are independent of the dimensional requirements of Clause 4. If the distance in front or behind the storage compartment is 51 mm or more, that volume shall not be deducted.

Figure 19
Volumes Occupied by and Provided by Typical
Supported Fixed Special Features

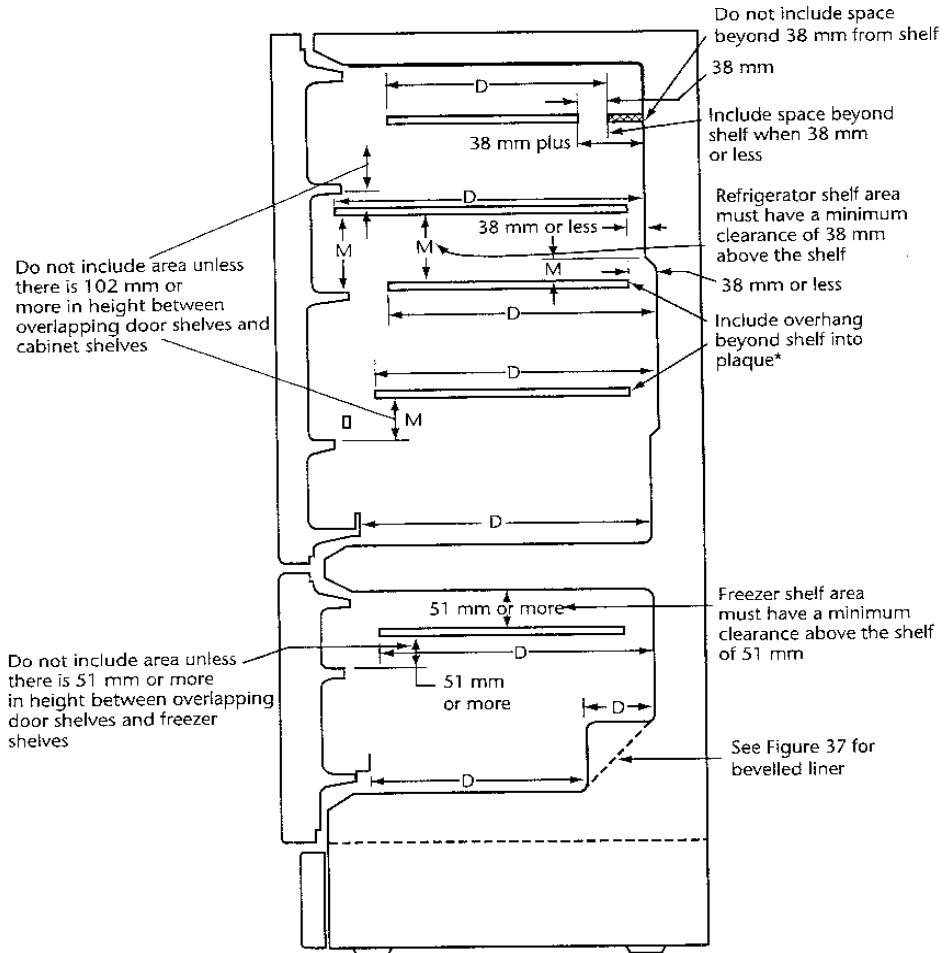
(See Clauses 4.2.3.2, 4.2.5, and 4.5.3.2.)

(Continued)



Legend:
[Hatched box] = space occupied
[Dotted box] = space provided

Figure 19 (Concluded)



Legend:

D = depth of cabinet or shelf from front edge of shelf

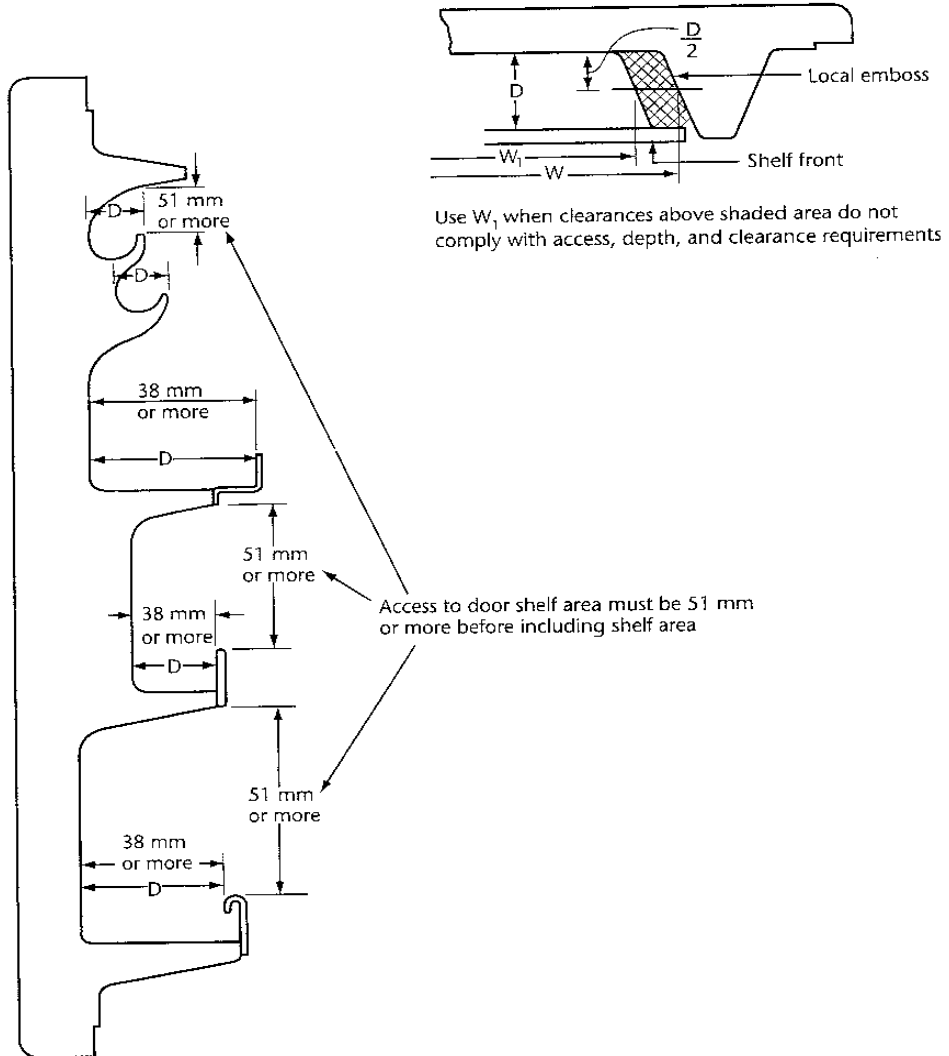
W = width of cabinet

M = dimension, 102 mm or more

**To be included, any shelf area (except on the doors) shall have at least 102 mm clearance above the shelf in the fresh food compartment and 51 mm in the freezer compartment. These clearance limitations shall not apply to the door shelves (see Figure 22). A maximum overhang of 38 mm at the rear of the main shelves in the fresh food and freezer compartments may be included in the shelf depth, provided the overhang conforms with the 102 mm and 51 mm clearance limitations.*

Figure 20
Shelf Clearance Requirements (Total Shelf Area)

(See Clauses 4.3.3.1 and 4.3.3.4.)




Legend:
 = area to be deducted
 W = width of compartment
 D = depth of compartment

Figure 22
Doors (Total Shelf Area)
 (See Clause 4.3.3.5.)

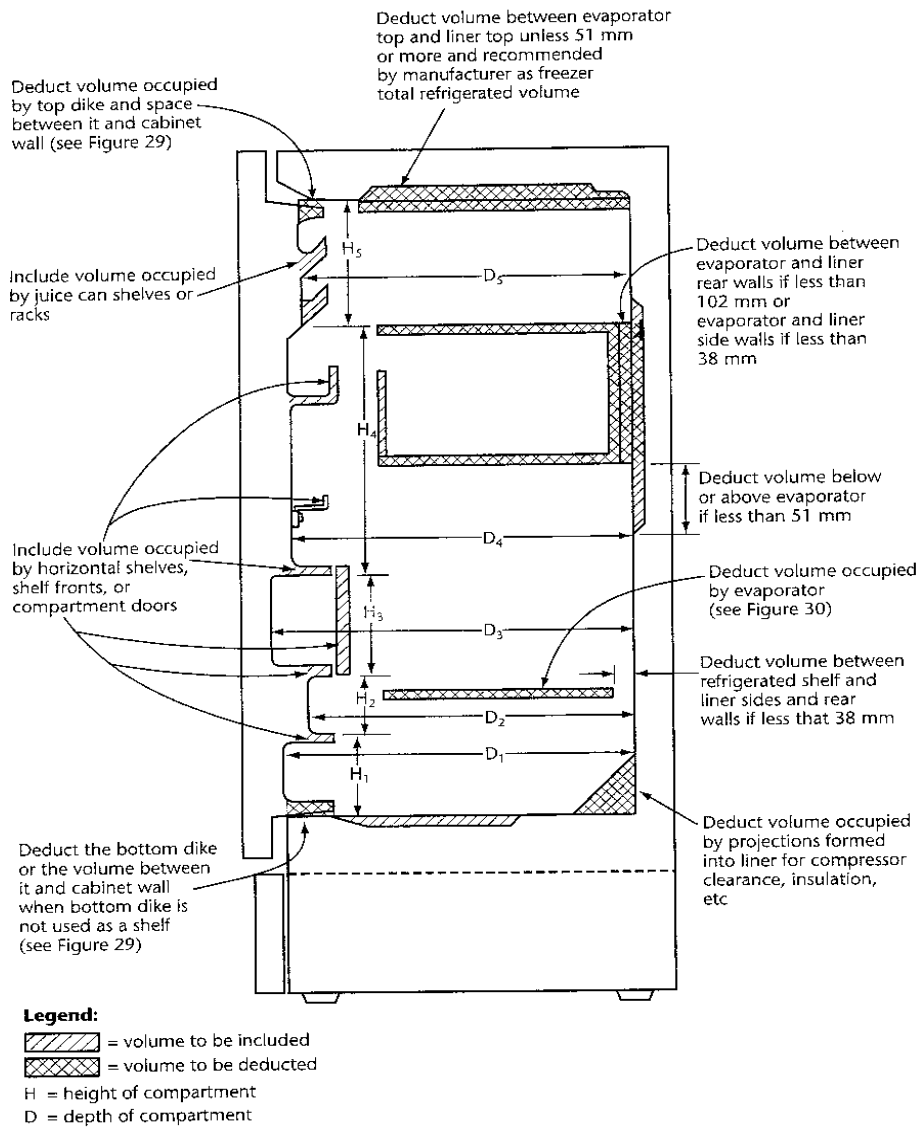
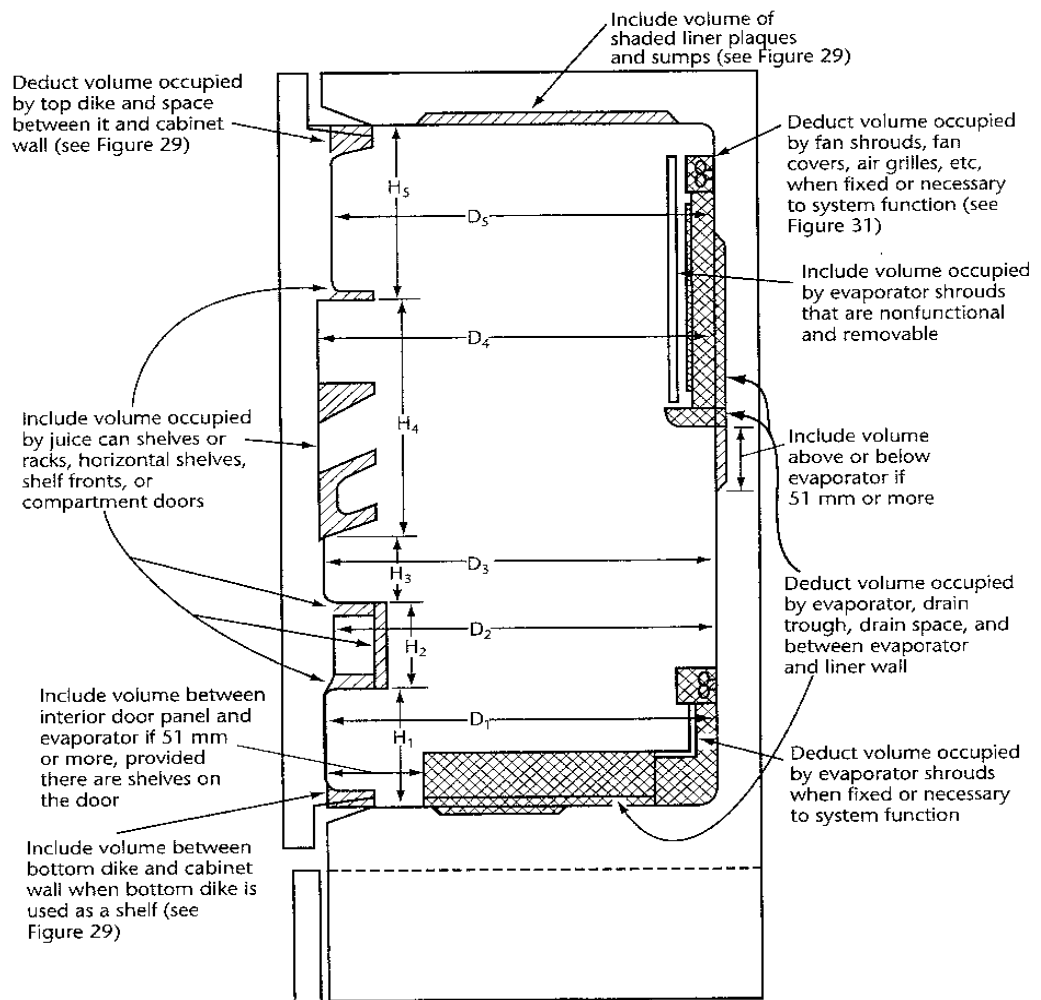


Figure 24
Freezer — Upright Type (Static Evaporator)
(Total Refrigerated Volume)
 (See Clause 4.4.3.)



Legend:
 = volume to be included
 = volume to be deducted
 H = height of compartment
 D = depth of compartment

Figure 25
Freezer — Upright Type (Dynamic Evaporator)
(Total Refrigerated Volume)
 (See Clause 4.4.3.)

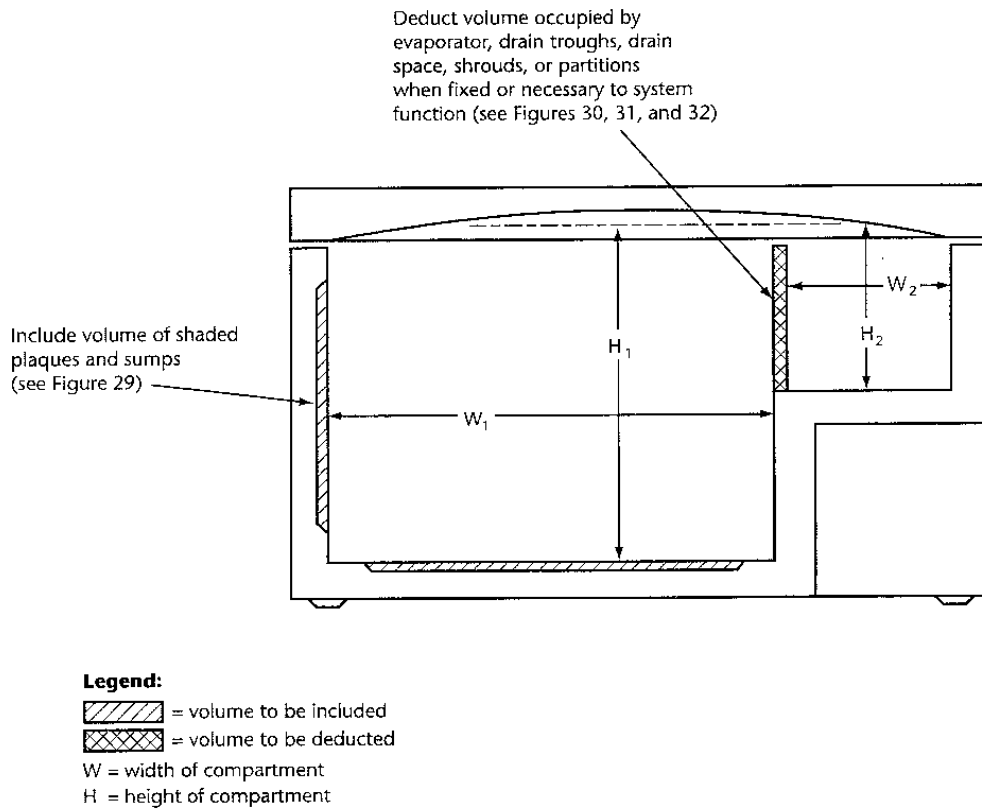


Figure 26
Freezer — Chest Type (Total Refrigerated Volume)
 (See Clause 4.4.3.)

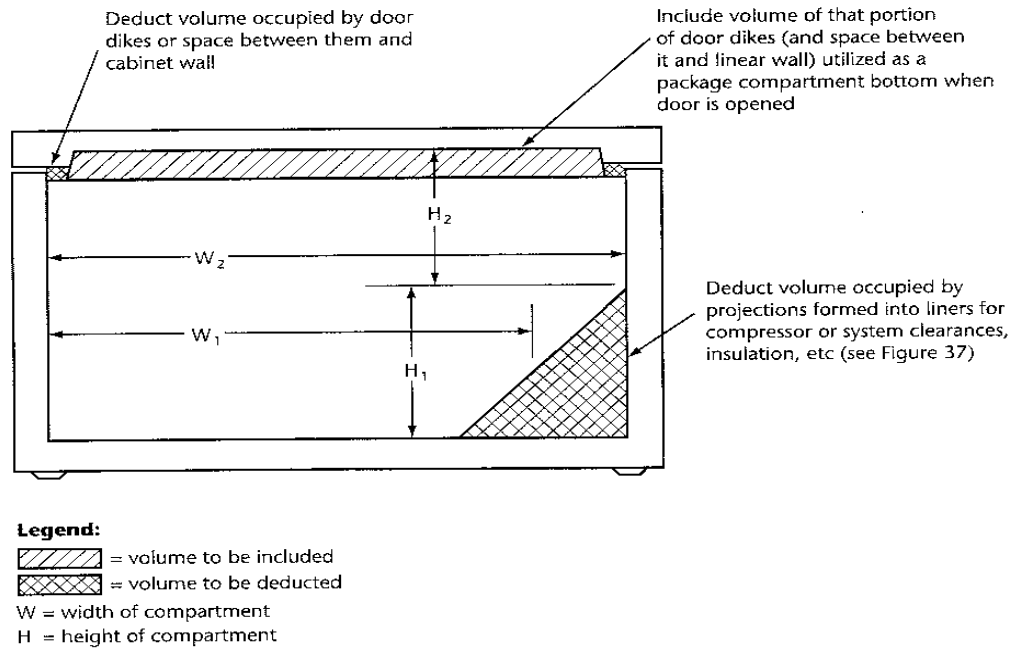


Figure 27
Freezer — Chest Type (Total Refrigerated Volume)
 (See Clause 4.4.3.)

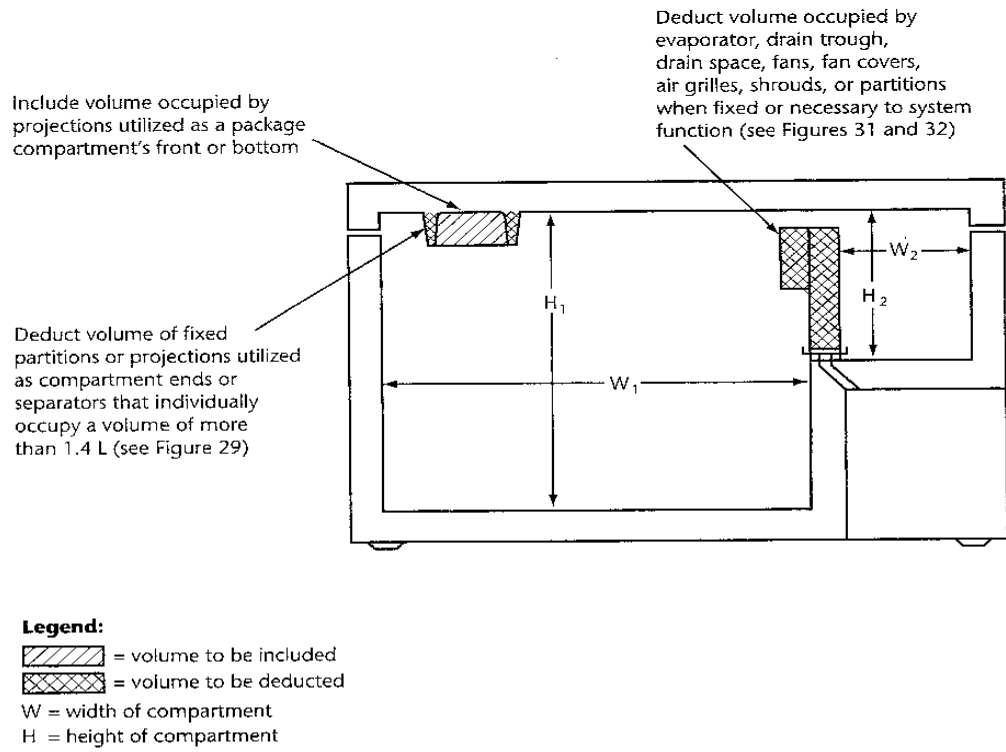
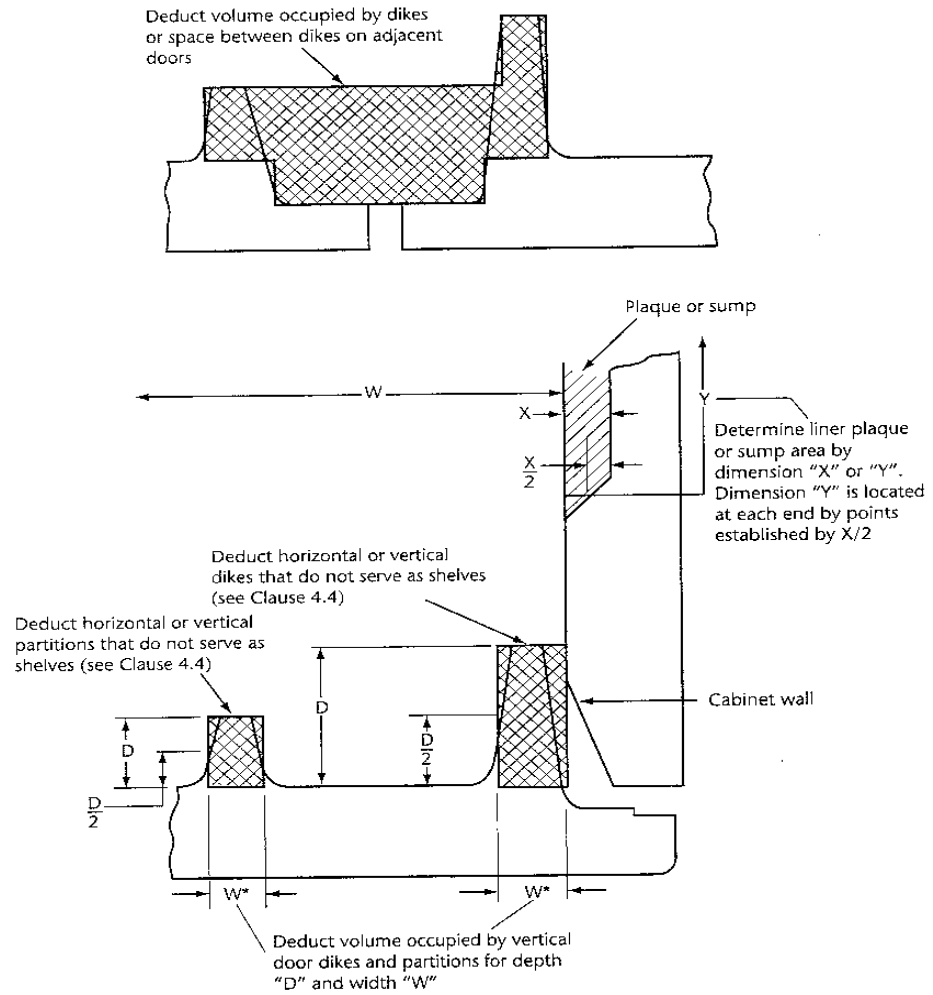


Figure 28
Freezer — Chest Type (Total Refrigerated Volume)
 (See Clause 4.4.3.)



Legend:

- = volume to be included
- = volume to be deducted

W = width of compartment
 D = depth of compartment

**Dimensions for deductible horizontal dikes shall be determined by the same method.*

Figure 29
Door Dike and Linear Plaque Dimensions
(Total Refrigerated Volume)
 (See Clauses 4.4.3.2 and 4.4.3.3 and Figures 24, 25, 26, and 28.)

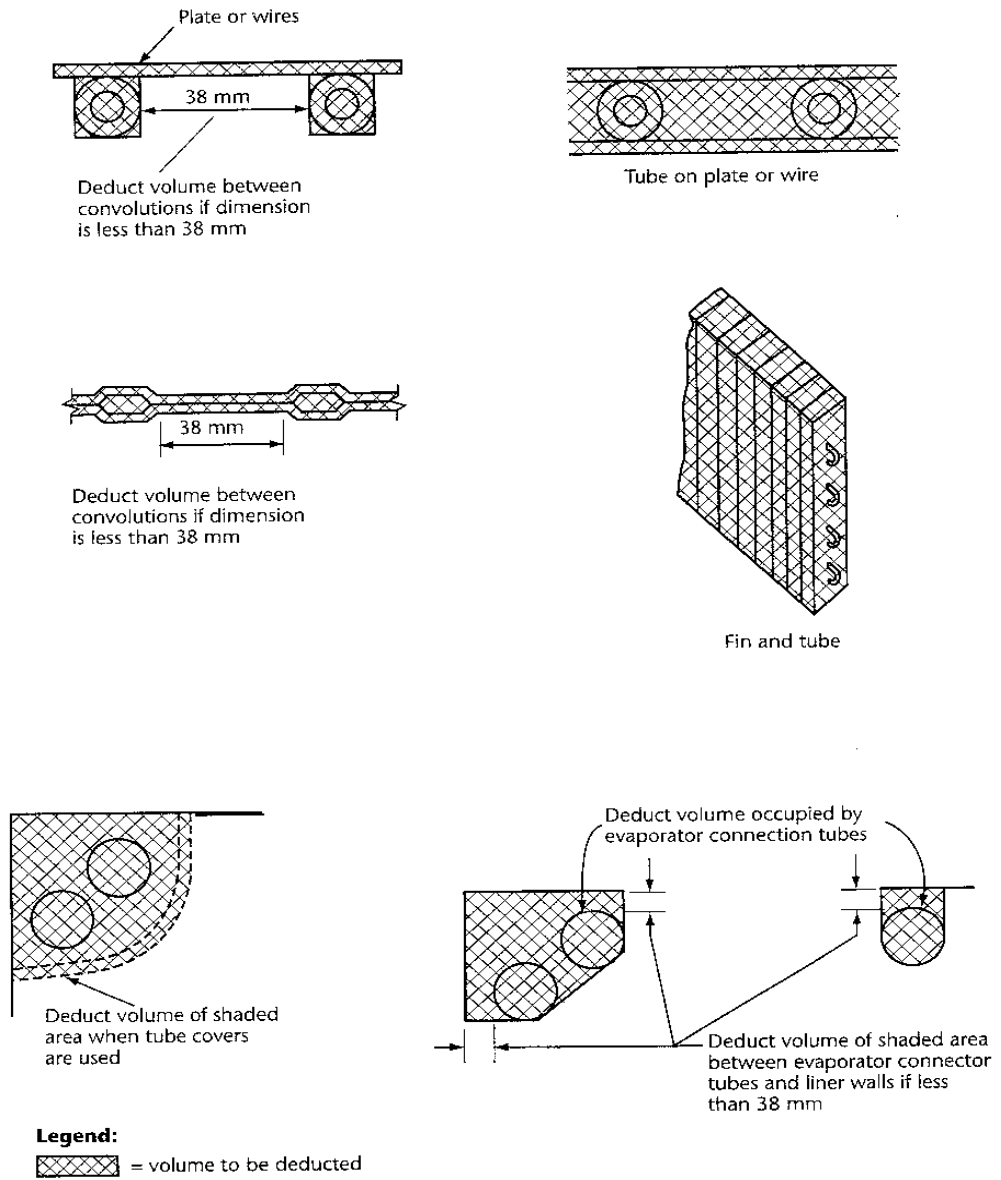


Figure 30
Types of Evaporators (Total Refrigerated Volume)
 (See Clause 4.4.3.3 and Figures 24 and 26.)

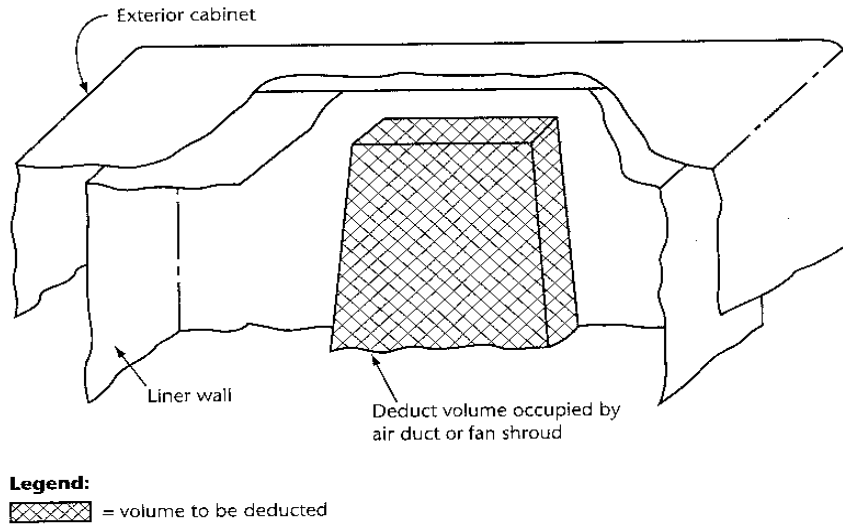


Figure 31
Volume Occupied by Air Duct (Total Refrigerated Volume)
(See Clause 4.4.3.3 and Figures 25, 26, and 28.)

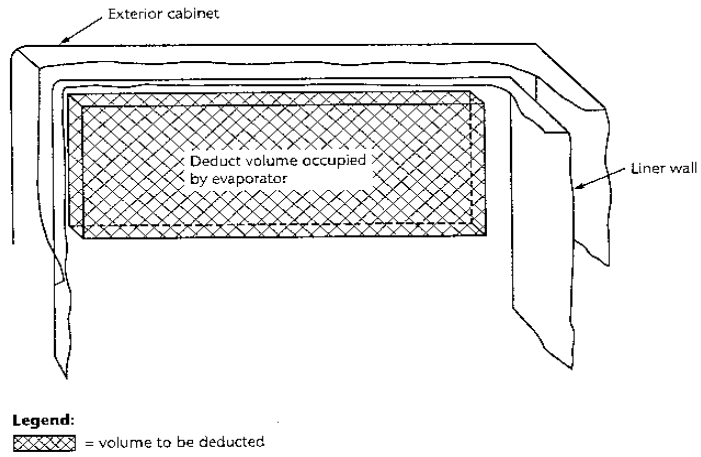
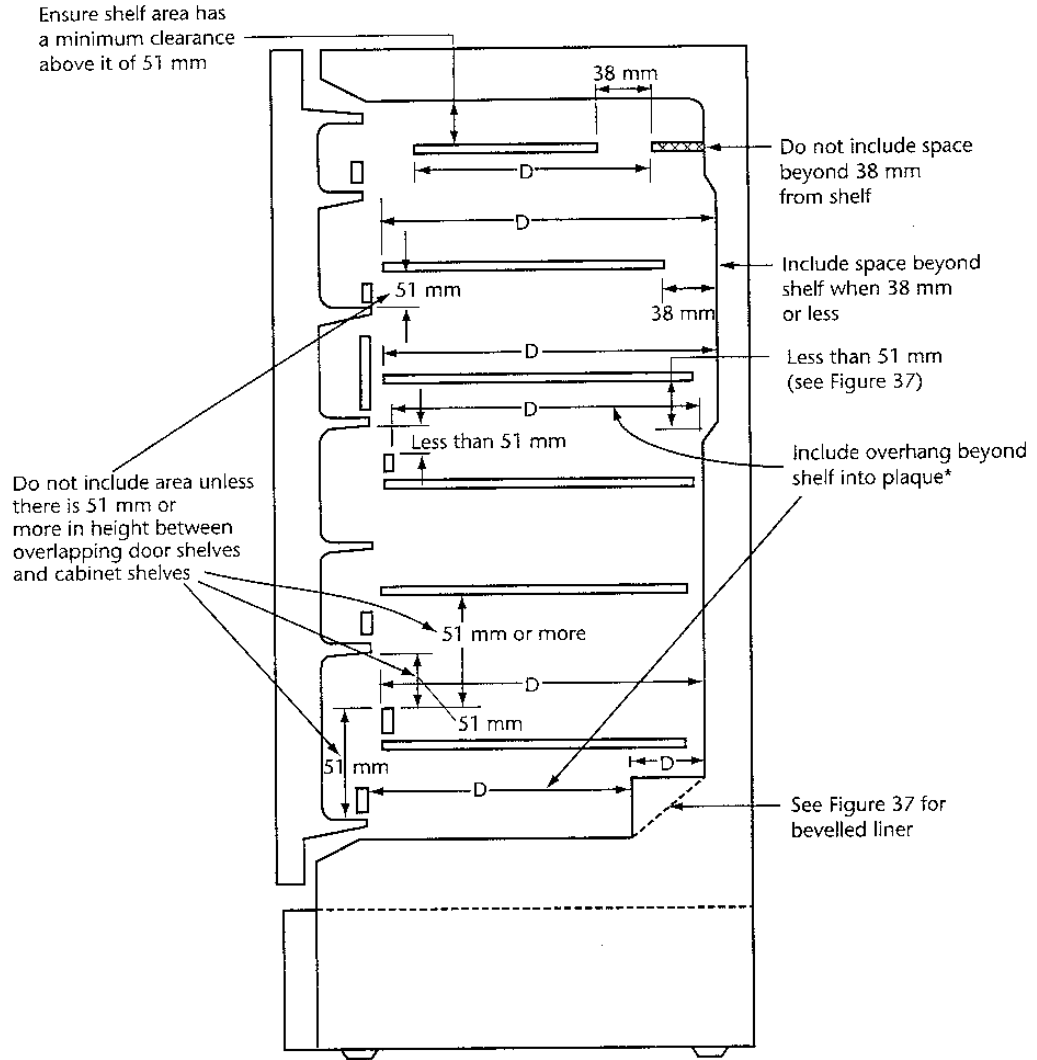


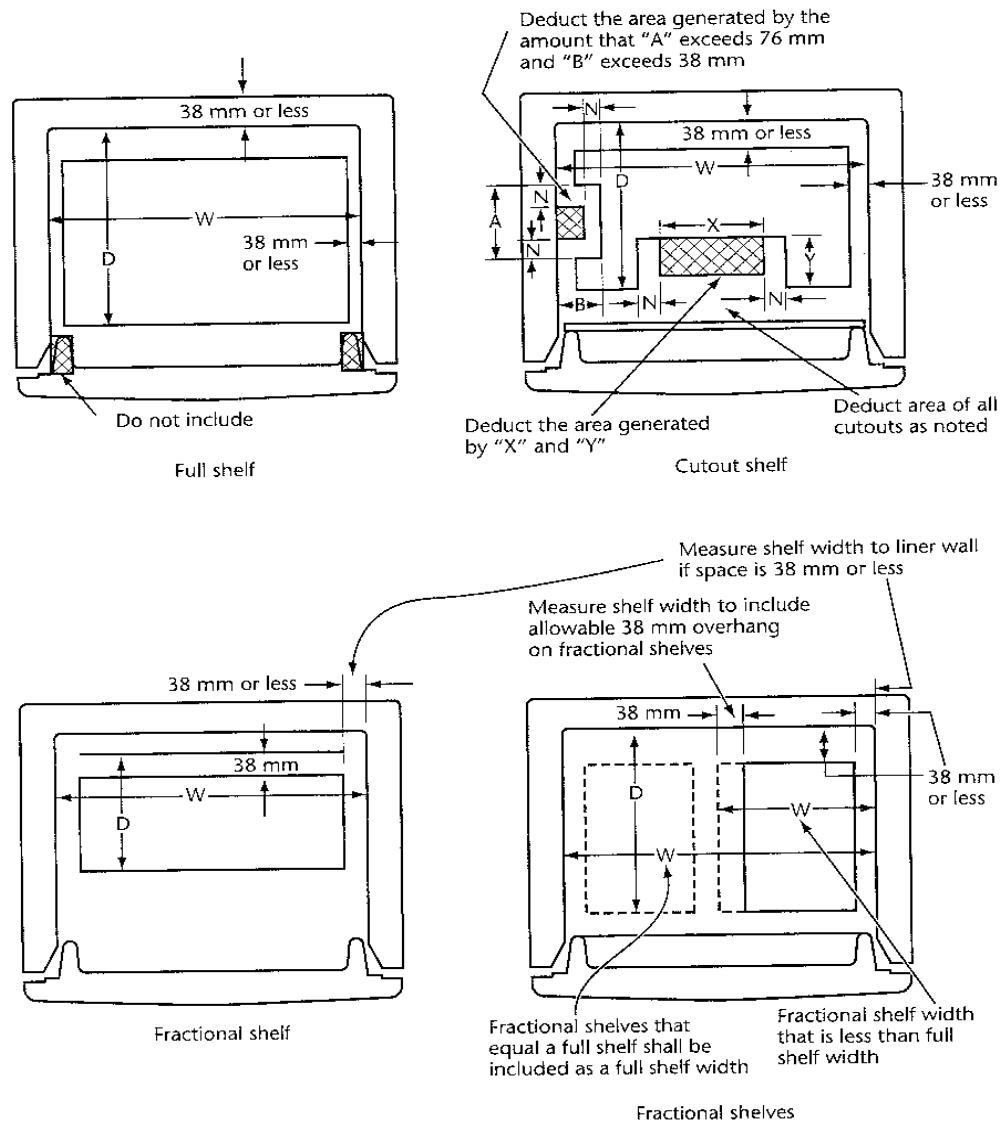
Figure 32
Volume Occupied by Evaporator in Forced-Air Systems
(Total Refrigerated Volume)
(See Clause 4.4.3.3 and Figures 26 and 28.)



Legend:
 D = depth of compartment

**To be included, any shelf area (except on the doors) shall have at least 51 mm clearance above it. This clearance limitation shall not apply to the door shelves (see Figure 35). A maximum overhang of 38 mm in front or rear of main shelves may be included in the shelf depth, provided the overhang conforms with the 51 mm clearance limitation.*

Figure 33
Freezer Shelf Clearance Requirements (Total Shelf Area)
 (See Clauses 4.6.3.1 and 4.6.3.4.)




Legend:
 = area to be deducted
 W = width of cabinet or shelf
 D = depth of compartment
 N = dimension, 38 mm

Figure 34
Width and Depth Requirements (Total Shelf Area)

(See Clauses 4.6.3.1, 4.6.3.2, and 4.6.3.3.)

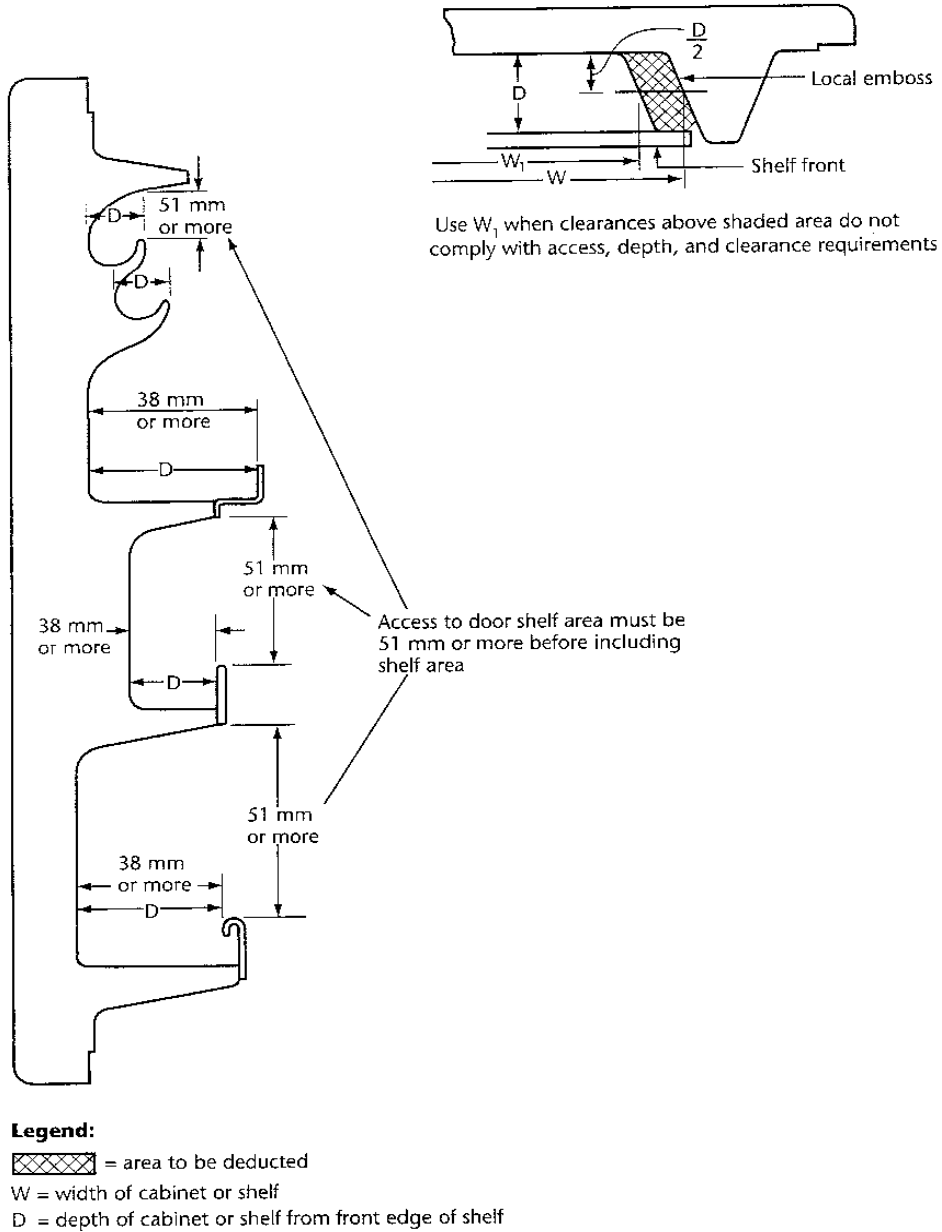
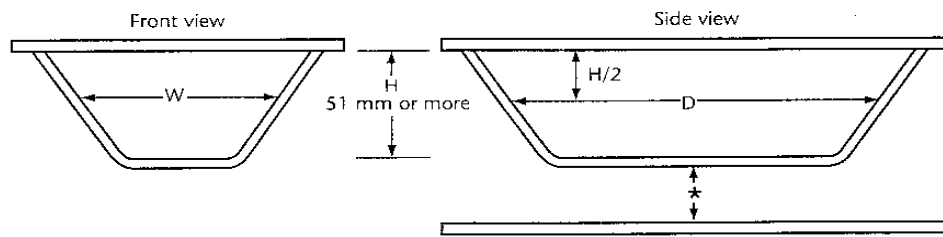


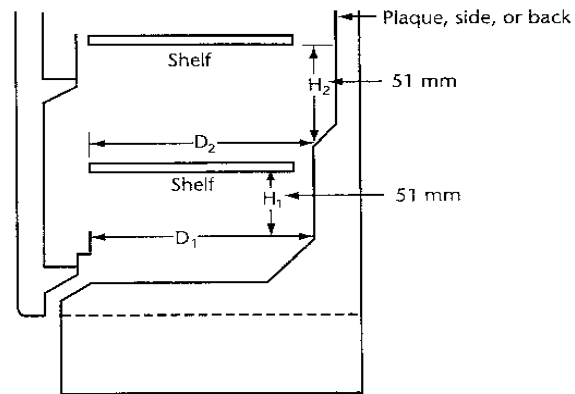
Figure 35
Doors (Total Shelf Area)
 (See Clause 4.6.3.4 and Figure 33.)



Legend:
 W = width of compartment
 H = height of compartment
 D = depth of compartment

**There shall be a minimum of 51 mm (2 in) clearance between the bottom of a suspended container and the shelf beneath the container. This clearance shall include the shelf area of both compartment and container.*

Figure 36
Suspended Containers (Total Shelf Area)
 (See Clause 4.6.3.5.)

**Legend:**

H = height of compartment
D = depth of compartment

Note: For bevelled, sloped bottoms, or plaqued liner walls, use depth or width extended to vertical line in compliance with 102 mm clearance limitation for fresh food compartments and 51 mm clearance limitation for freezer compartments.

Figure 37
Bevelled Liner Surfaces (Total Shelf Area)
(See Figures 20, 27, and 33.)

**Committee on performance and labeling of
refrigerators, refrigerator-freezers and freezers**

- 1) Dr. Abdullah alsha'lan (king saud university) - CHAIRMAN
- 2) Eng. Bandar AlGhamdi (alessa industries) - MEMBER
- 3) Eng. Mohammad. AlSawi (SASO) - MEMBER