Asia-Pacific
Economic Cooperation

Differences / synergies between energy efficiency test methods for refrigerators in APEC region and with the new IEC 62552

Desktop Research

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1. Introduction

The use of refrigerators accounts for a significant share of households' energy consumption in the APEC region. In the US, it takes up to 13% of the total household electricity consumption; in Japan above 17%; in Thailand 20%; and in China more than 40%. The energy saving potential is huge in many developing economies. For example, following the results of a study conducted by the International Copper Association and the United Nations Environment Programme, if energy efficiency standards for refrigerators in ASEAN economies could be raised to EU level, the potential related energy savings corresponding to the use of these refrigerators could reach 8,531 GWh per year.

Energy efficiency (EE) standards are commonly used in different economies to promote energy savings of household appliances. Testing methods represent one of the most fundamental elements in applying energy efficiency standards. Currently, these testing methods differ greatly among APEC economies. This creates technical barriers to trade in the region, and to further improvement of energy efficiency.

EE labelling schemes are commonly applied and widely accepted by economies in APEC, which aim is to show the actual EE level of regulated products. However, different implementation requirements exist in APEC economies because of different characteristics of products and different utilization patterns and environmental factors. These differences make it difficult to understand and compare the energy efficiency levels of refrigerators: for example, for the same product, the tested energy consumption (and efficiency) shall ideally be consistent across economies, but in reality, with different testing methods, the energy efficiency index varies. From this perspective, there is a need for harmonization of the standards for the testing method to make testing reports comparable and have a better impact on regulating the EE of refrigerators (which are widely traded within the APEC region) through concerned efforts in MV&E.

The new IEC 62552 standard has developed one performance standard for household cooling appliances which will be used worldwide for energy efficiency classes (labels) and minimum efficiency performance limits. Since the test procedures and test conditions for the determination of the energy consumption under IEC 62552-3 are quite different compared to the standards currently used by APEC economies, the values for energy consumption will be different for all existing energy labels.

This report investigates the different EE requirements and evaluation schemes in APEC economies and compares energy consumption calculation results for refrigerators in various APEC economies. Further, deep survey of test methods in APEC economies has been carried out and analysed, differences of test methods for refrigerators have been identified and key factors affecting the energy consumption have been screened out.

2. Analysis of Energy Efficiency Standards and Labelling Schemes (EE S&L) in the APEC region

2.1 Overview of APEC Energy Efficiency Standards and Labelling (EE S&L) Schemes for Refrigerators

There are 3 scenarios of Energy Efficiency (EE) requirements in APEC economies on refrigerators– EE labelling standards, EE labelling laws, and no EE requirements (table 2-1). The EE labelling laws are in higher management level compared to EE labelling standards, but economies situation is essentially influencing them to take regulations or standards or laws for EE policies.

Table 2-1: Overview of EE regulations for refrigerators in APEC

No.	Economy	Energy standards or laws Specified Name	Energy standards?	Energy laws?	No EE requirements
1	Australia	AS/NZS 4474.2:2009+A1:2011+A2:2014	√		
2	Chile	NCh3000:2006	√		
3	China	GB 12021.2-2008	√		
4	Indonesia	Gov. Reg. 70/2009	√		
5	Mexico	NOM-015-ENER-2002	√		
6	New Zealand	AS/NZS 4474.2:2009+A1:2011+A2:2014	√		
7	Philippines	PNS 396-2:2013	√		
8	Viet Nam	TCVN 7828:2013	√		
9	Thailand	law published on TIS 2186-2547 (2004)	√		
10	Canada	Law published on Jan.01, 2008		√	
11	Hong Kong, China	law published on Oct.31, 2014		√	
12	Chinese Taipei	law published on Dec.07, 2012		√	
13	Japan	law published on Mar.01, 2013		√	
14	Korea	law published on June 16, 2010		√	
15	Malaysia	law published on May 02, 2013		√	
16	Russia	Law published on Dec.27, 2010		√	
17	Singapore	law published on Jan.01, 2008		√	
18	USA	DOE published on Dec. 09, 2014 Energy star programme eligibility criteria version 5.0 published on Sept.15, 2014		√	
19	Brunei	——			√
20	Papua New Guinea	——			√
21	Peru	——			√

2.2 Comparison of APEC EE Labelling Schemes for Refrigerators

Energy efficiency labelling scheme is an effective tool being commonly used by APEC economies that have EE standards or laws. Table 2-2 provides an overview of EE labelling requirements, including evaluation method and appliances covered in different APEC economies.

It can be seen that there are 4 APEC economies that apply the MEPS-only (Minimum Efficiency Performance Standard) requirement for EE labelling: Canada, Japan, Mexico and USA. 13 APEC economies apply EE Grade or Star Ratings- Australia, Chile, China, Chinese Taipei, Hong Kong China, Korea, Malaysia, New Zealand, Philippines, Russia, Singapore, Thailand, Viet Nam, among of them, China, Korea, Malaysia, Philippine, Russia, Singapore, Thailand, and Viet Nam have regulation system of both EE Grade/Star Rating and MEPS.

For these 17 economies, the EE labelling scheme is mandatory. Detailed description of EE requirements in APEC economies is provided shown in ANNEX I. The other economies not listed than the 17 described in Table 2-2 is because economy of Indonesia is in the process of developing EE labelling system, and some economies without EE requirement do not have labelling scheme either, like Brunei, Papua New Guinea, Peru.

Table 2-2: EE labeling overview for refrigerator in APEC*(to be continued in next page)*

No.	Economy	Edition	EE evaluation	Appliance scope
1 & 2	Australia& New Zealand	Since:1986 Latest:2014	Star Ratings (1~10) *Best:10 stars* MEPS	Household refrigerators
3	Canada	Since:1992 Latest:2008	MEPS	Household refrigerator or a household combination refrigerator-freezer that has a defrost system - including a compressor-cycled automatic defrost system – and a capacity of 1100 L (39 cubic feet) or less
4	Chile	Since:2005 Latest:2013	EE Grade (G~A) *Best: Grade A*	Household refrigerators excluding the display and the special refrigerator
5	China	Since:2005 Latest:2008	EE Grade (1~5) *Best: Grade 1* MEPS	All refrigerators that exclude the built-in, display or especial used refrigerator
6	Chinese Taipei	Since:2010 Latest:2012	EE Grade (1~5) Best: Grade 1	Household refrigerator or household combination refrigerator-freezer that has a compressor-cycled system
7	Hong Kong, China	Since:2008 Latest:2014	EE Grade (1~5) *Best*: Grade 1	All refrigerators that have a compressor refrigerating system – and a capacity of 500 L or less
8	Japan	Since:1999 Latest:2013	MEPS	Household refrigerator or a household combination refrigerator-freezer
9	Korea	Since: Latest:	EE Grade (1~5) Best: Grade 1 MEPS	Household refrigerators
10	Malaysia	Since:1994 Latest:2013	Star Ratings (1~5) Best:5 stars MEPS	Household refrigerators

No.	Economy	Edition	EE evaluation	Appliance scope
11	Mexico	Since:2002 Latest:2012	MEPS	Household refrigerator or household combination refrigerator-freezer that has a compressor-cycled system – and a capacity of 1104 L (39 ft^3) or less , household freezer that has a compressor-cycled system – and a capacity of 850 L (30 ft^3) or less
12	Philippines	Since:2014	Star Ratings (1~5) Best:1 Star MEPS	Household refrigerators
13	Russia	Since:2010 Latest:2014	EE Grade (G~A++) *Best: Grade A++* MEPS	Household refrigerators. Note: Russia is taking reference to EU EE labelling format and related requirements.
14	Singapore	Since:2008 Latest:2014	Tick Rating (1~4) Best: tick 4 MEPS	Household refrigerators
15	Thailand	Since:2004 Latest:2012	EE Grade (1~5) Best: Grade 5 MEPS	Household refrigerators
16	USA	Since:1999 Latest:2014	MEPS	Household refrigerator or household combination refrigerator-freezer that has a compressor-cycled system – and a capacity of 1104 L (39 ft^3) or less , household freezer that has a compressor-cycled system – and a capacity of 850 L (30 ft^3) or less
17	Viet Nam	Since:2007 Latest:2013	EE Grade (1~5) Best: Grade 5 MEPS	Household refrigerator or household combination refrigerator-freezer that has a compressor-cycled system – and a capacity of 1000 L or less

2.3 Comparison of EE evaluation methods in EE standards or laws in APEC

For the APEC economies that have EE requirements for refrigerators, there are 3 different ways for evaluating energy efficiency in EE labelling schemes:

- Economies that use EEI (energy efficiency index) or SRI (star rating index) to define EE grades and maximum energy consumption (MEPS) for EE evaluation: Australia, New Zealand, China, Korea, Malaysia, Philippines, Singapore, Thailand, Viet Nam, ;
- Economies that only require MEPS, i.e.: Canada, Japan, Mexico, and USA.
- Economies that only require EE grades, i.e.: Chile, Hong Kong, Russia, and Chinese Taipei.

For both EEI (SRI) and MEPS as the EE evaluation methods, are determined by two testing parameters - energy consumption and total volume, which are defined in the test method standards. Another parameter that affects the EE is compartment categories (frost free refrigerators) illustrated in the testing method standard. The different calculation methods used in APEC economies (that regulate EE for refrigerators) are different as well, which are summarized in table 2-3 below. It can be seen that:

1. The compartment categories are differently regulated within the following two groups of economies.
   - Australia, New Zealand, China, Hong Kong, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Chinese Taipei;
   - Canada, USA and Mexico.
2. Adjusted volume calculation depends on compartment categories and volumes. For China, the test method standard also considers climate type and free-frost system.
3. EEI (SRI) and MEPS are calculated by adjusted volume, tested energy consumption, and factors which are in relation to compartment category or appliance category. Calculated with the different economies' test methods, different EEI (SRI) and MEPS are achieved for the same type of refrigerator. For example, frost-free refrigerators and multi-door refrigerators achieve a higher EEI and MEPS in the following economies than the others:
   - Hong Kong, Japan, Thailand, Chile and Russia for frost-free refrigerators;
   - Malaysia, Philippines and Thailand for multi-door refrigerators;
   - In China, for refrigerators with variable temperature compartment with storage volume of 100L or less, or with 400L or more with through-the-door ice dispenser function.

Table 2-3: Different calculation methods for EEI (SRI) and MEPS in different APEC economies

No.	Economies	Appliance category / compartment category	V_{adj}(adjust volume)	Base energy consumption	EEI (SRI) or MEPS
1&2	Australia/ New Zealand	1 Cellar 2 Fresh food 3 Chill 4 Ice-making 5 Short term frozen food storage 6 Freezer	$V_{adj} = V_g \times K_s$ 1)	$BEC = C_f + [C_v \times (V_{adj\ tot}^{0.67})]$ 19)	$(SRI) = 1 + [\frac{\log_e(\frac{CEC}{BEC})}{\log_e(1-ERF)}]$ 22)
3	Canada	22 kinds of appliance categories	For refrigerator and refrigerator-freezer: $AV = V_{fresh\ food} + (V_{freezer} \times AF)$ 2) For freezer: $AV = (V_{freezer} \times AF)$ 3) AF is determined by the compartment category and calculated by the follow $AF = \frac{tA - t_{FSR}}{tA - t_{FF}}$ 4)	—	$MEPS = M \times Vadj + N$ 23)
4	Chile	1 Refrigerator with one or more fresh-food storage compartments 2 Refrigerator-cellar, Cellar and Wine storage appliances 3 Refrigerator-chiller and Refrigerator with a 0-star compartment 4 Refrigerator with a one-star compartment 5 Refrigerator with a two-star compartment 6 Refrigerator with a three-star compartment 7 Refrigerator-freezer 8 Upright freezer 9 Chest freezer 10 Multi-use and other refrigerating appliances	$V_{adj\ tot} = \sum_{c=1}^{n} Vc \times Wc \times FFc \times BI \times CC$ 5) FFc: factor. Fc=1.2 where use the frost-fee refrigerating system in refrigerator. CC: climatic class factor. Wc: the different compartment factor. BI: the built-in factor. BI=1.2 where the built-in appliances under 58 cm in width	$SAEc = M \times Vadj\ tot + N + CH$ 21) CH = variable temperature compartment factor. CH=50 where have the storage volume 15L or more, and with the chill compartment temperature range	$EEI = \frac{AEc}{SAEc} x100\%$

No.	Economies	Appliance category / compartment category	V_{adj}(adjust volume)	Base energy consumption	EEI (SRI) or MEPS
5	China	1 Refrigerator without star compartment 2 Refrigerator with a one-star compartment 3 Refrigerator with a two-star compartment 4 Refrigerator with a three-star compartment 5 Refrigerator-freezer 6 Frozen food storage appliance 7 Freezer	$V_{adj}=\sum_{c=1}^{n} Vc \times Fc \times Wc \times CC$ [5] Wcis determined by the compartment category; Fcis the frost-free factor, 1.4 for frost-free refrigerator CC is climate factor	$E_{base}= (M \times Vadj\ tot + N + CH) \times Sr/365$ [20] CH is factor related with variable temperature compartment Sris a factor related withthe appliance have the storage volume 100L or less, or appliance with 400L or more with through-the-door ice dispenser function.	$H = \frac{Etest}{Ebase} x100\%$
6	Chinese Taipei	Appliance category:: 1 frost-free refrigerator –freezer with volume<400L 2 frost-free refrigerator –freezer with volume>400L 3 refrigerator –freezer with volume<400L 4 refrigerator –freezer with volume>400L 5 refrigerator	$V=V_R+K \times V_F$ V- adjust volume V_r- the volume of refrigerator compartment V_F-the volume of refrigerator compartment K- 1.56 for two-sar compartment, 1.67 for super two-star compartment, 1.78 for three or four star compartment	E.F.=V/(M×V+N) V-adjust volume M,N-factors for different appliance category	EEI=(V_{test}/E_{test})/E.F.
7	Hong Kong, China	1 A refrigerator without a frozen food compartment 2 A refrigerator with a 1-star frozen food compartment 3 A refrigerator with a 2-star frozen food compartment 4 A refrigerator with a 3-star frozen food compartment 5 A refrigerator with a 4-star frozen food compartment 6 A Category 5 refrigerator incorporating means to prevent the formation of frost on contents 7 A refrigerating appliance in which the entire storage volume is intended for freezing food. 8 A Category 7 refrigerating appliance incorporating means top revent the formation of frost.	$V_{adj}= \sum V_i \times \Omega$ [6] $\Omega = \frac{T_a - T_i}{T_a - T_r}$ [7]	$E_{av}=M \times Vadj + N$ [21]	$I_e= \frac{E}{E_{av}} \times 100\%$

No.	Economies	Appliance category / compartment category	V_{adj}(adjust volume)	Base energy consumption	EEI (SRI) or MEPS
8	Japan	Refrigerators and Refrigerator-freezers: A Cooled by natural circulation B Cooled by forced air circulation, rated volume< 300 L C Cooled by forced air circulation, rated volume> 300 L, with 1 door in fresh food compartment D Cooled by forced air circulation, rated volume> 300 L, with ≥2 door in fresh food compartment Freezer: A Cooled by natural circulation B Cooled by forced air circulation, rated volume< 300 L C Cooled by forced air circulation, rated volume> 300 L	For refrigerator and refrigerator-freezer: $V_2 = K \times V_f + V_{other}$ [8)] For freezer: $V_2 = K \times V_f$ [9)] K is determined by the compartment category, K=2.20 for three-star compartment; K=1.87 for two-star compartments; K=1.54 for one-star compartments.		MEPS=$M \times Vadj + N$ [24)]
9	Malaysia	Appliance category: one-door/ two-doors Compartment category: 1 Cellar compartment 2 Fresh food compartment 3 Chill compartment 4 One-star compartment (*) 5 Two-star compartment (**) 6 Three-star or more compartment (*** or (***)*)	$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$ [10)] K_C is determined by the compartment category	For one-door refrigerator, $EER_{average} = 1.37 \times V_{adj} - 63.3$ Fortwo-door refrigerator, $EER_{average} = 0.409 \times V_{adj} + 119.5$	SRI=$(\frac{EERtest}{EERaverage}-1)\times 100\%$ EER_{test} = $\frac{\text{total adjusted volume}}{\text{energy consumption in daily}}$

No.	Economies	Appliance category / compartment category	V_{adj}(adjust volume)	Base energy consumption	EEI (SRI) or MEPS
10	Mexico	18 kinds of appliance categories	$AV = V_a + (V_c \times AF)$ [11] $AF = \frac{t-t_c}{t-t_a}$ [12]		MEPS=$M \times Vadj + N$ [25]
11	Philippines	Appliance category: one-door/ two-doors/ frost free Compartment category: 1 Cellar compartment 2 Fresh food compartment 3 Chill compartment 4 One-star compartment (*) 5 Two-star compartment (**) 6 Three-star or more compartment (*** or (***)*)	$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$ [13]	—	EEF =$\frac{V_{adj}}{E_{daily}}$
12	Russia	1 Refrigerator with one or more fresh-food storage compartments 2 Refrigerator-cellar, Cellar and Wine storage appliances 3 Refrigerator-chiller and Refrigerator with a 0-star compartment 4 Refrigerator with a one-star compartment 5 Refrigerator with a two-star compartment 6 Refrigerator with a three-star compartment 7 Refrigerator-freezer 8 Upright freezer 9 Chest freezer 10 Multi-use and other refrigerating appliances	$V_{adj\ tot} = \sum_{c=1}^{n} Vc \times Wc \times FFc \times BI \times CC$ FFc:factor. Fc=1.2 where use the frost-fee refrigerating system in refrigerator. CC: climatic class factor. Wc: the different compartment factor. BI: the built-in factor. BI=1.2 where the built-in appliances under 58 cm in width	SAEc =$M \times Vadj\ tot + N + CH$ CH = variable temperature compartment factor. CH=50 where have the storage volume 15L or more, and with the chill compartment temperature range	EEI = $\frac{Aec}{SAEc} x100\%$

No.	Economies	Appliance category / compartment category	V_{adj}(adjust volume)	Base energy consumption	EEI (SRI) or MEPS
13	Singapore	Appliance category: without freezer/ with freezer/ with freezer, through the door ice dispenser Compartment category: 1 Cellar compartment 2 Fresh food compartment 3 Chill compartment 4 One-star compartment (*) 5 Two-star compartment (**) 6 Three-star compartment 7 Four-star compartment	$V_{adj}= \sum V_i \times K$[14]	—	**AEC=** $M \times Vadj + N$[26]
14	Thailand	Appliance category: One door refrigerator, manually defrosted andsemi-automatically defrosted 1 - V_{adj}< 100 2 - Vadj≥ 100 Two door refrigerator, manually defrosted, semiautomatically and automaticall defrosted 3 - V_{adj}<450 4 - Vadj≥ 450 Compartment category: 1 Cellar compartment 2 Fresh food compartment 3 Chill compartment 4 One-star compartment (*) 5 Two-star compartment (**) 6 Three-star or more compartment (*** or (***)*)	$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$[15]		**AEC=** $M \times Vadj + N$[27]

No.	Economies	Appliance category / compartment category	V_{adj}(adjust volume)	Base energy consumption	EEI (SRI) or MEPS
15	USA	42 kinds of appliance category	For refrigerator and refrigerator-freezer: av = (VF × CR) + VFF[16)] CR=1.0 for all refrigerator, CR=1.47 for others For freezer: av = (VF × CRF) + VFF [17)] CRF=1.76		MEPS=$M \times Vadj + N$[28)]
16	Viet Nam	Appliance category: 1 Cellar compartment 2 Fresh food compartment 3 Chill compartment 4 One-star compartment (*) 5 Two-star compartment (**) 6 Three-star or more compartment (*** or (***)*)	$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$[18)]	**For refrigerator** E_{max} = 0,302 V_{adj} + 386 For Refrigerator-freezer and freezer E_{max} = 0,451 V_{adj} + 515	R = $\frac{E_{max}(MEPS)}{E_{annual}}$

Note in above formulations:

AF – in Canada and Mexico, formula 2), 3), 12),

Wc—in Chile, China and Russia, formula 5),6),

Ω—in Hong Kong, China, formula 6), 8)

K –in Japan, Singapore, formula 9), 10), 15),

Kc -- in Malaysia, the Philippine, Thailand, and Viet Nam, formula 11), 14), 16), 19),

CR – in USA, formula 17)

CRF –in USA, formula 18)

Above are the different compartment factors, and are determined by the compartment categories. For Canada, China, Hong Kong, Mexico the different compartment factors are calculated by formulations and are related with the ambient temperature, the fresh food compartment (refrigerator compartment) temperature and concerned compartment temperature.

V_{***} is compartment volume in the above formulations.

Cf, Cv --in Australia and New Zealand, in the formulations 20), are the factors which are related with the appliance categories.

M, N – in Chile, China, Hong Kong China, Canada, Japan, Mexico, Singapore, Thailand, USA of formulation of 21), 22), 23), 25), 26), 27), 28), 29), 30), are the factors which are related with the appliance categories.

2.4 Examples of EEI (SRI) Calculation in EE standards of APEC Region

Aiming to understand EE levels in different economies of APEC, four types of refrigerators (upright refrigerator, upright refrigerator-freezer, chest freezer and upright frost-free refrigerator-freezer) have been selected to compare results in estimating EE levels, EEI (SRI) and MEPS in APEC economies. The energy consumption and volume are adopted constant values declared by manufactures.

Exact samples of the upright refrigerator, upright refrigerator-freezer, chest freezer and upright frost-free refrigerator-freezer are shown in Figure 2-1, 2-2, 2-3, 2-4.

Figure 2. 1: Upright Refrigerator (energy consumption of 0.30kWh/24h, the volume of 60 L)

Figure2. 2: Upright Refrigerator-freezer (The energy consumption is 0.90kWh/24h. Total volume is 160 L, the fresh food compartment is 100 L, and the frozen food compartment is 60 L.)

Figure2. 3: Chest Freezer (The energy consumption is 0.90kWh/24h. Total volume is 160 L)

Figure2. 4: Upright Frost-free Refrigerator-freezer (The energy consumption is 0.90kWh/24h. Total volume is 160 L, the fresh food compartment is 100 L, and the frozen food compartment is 60 L)

Comparison results are illustrated in Figure 2-5 and Table 2-4. In Figure 2-5, it can be again seen that adjusted volumes are related to compartment categories. EEI (SRI) values are different within APEC economies for the same product category due to different testing method standards, as shown in table 2-4. It should be mentioned here that related EE grade are regulated differently in economies, for example, in Australia, there are 10 levels of EE grade with the best ranked in grade 10, while in China, Hong Kong, Malaysia, Philippines, Thailand, and Viet Nam, there are five levels. Singapore adopts 4 levels with 4 tick as the best. Chile and Russia are taking the grade of A to G with level A as the best. That is one of reasons causing different EE levels for the same product. For example, for the upright refrigerator, it is an EE product in Chile, but in the Australia and New Zealand it is ranked in lower EE level.

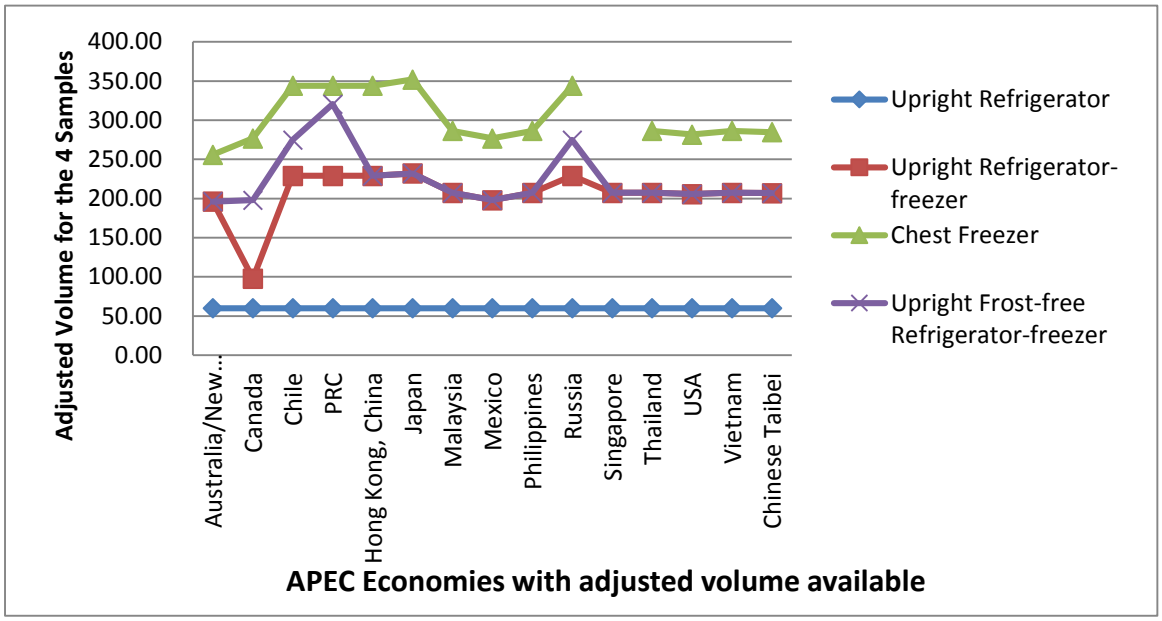


Figure2.5: Comparison of adjusted volumes for the 4 examples

Table 2-4: EE labeling grade comparison for the 4 samples in APEC economies

Economy	Best Grade	Worst Grade	Upright Refrigerator	Upright Refrigerator-freezer	Chest Freezer	Upright Frost-free Refrigerator-freezer
Australia/New Zealand	10	1	4	2	2	2
Chile	A	G	A	B	B	B
PRC	1	5	1	5	5	4
Hong Kong, China	1	5	2	4	5	3
Chinese Taipei	1	5	1	5	-	5
Malaysia	5	1	5	4	3	4
Philippines	1	5	3	3	5	5
Russia	A	G	A	B	B	B
Singapore	4	1	3	1	--	1
Thailand	5	1	5	5	3	5
Viet Nam	5	1	5	5	5	5

Conclusion:

1. APEC economies apply EE laws and standards to regulate their EE policies according to economies situation and circumstance, with exception of Brunei, Papua New Guinea and Peru;
2. Labelling scheme based on EE standards are mandatory implemented in 17 economies, with exception of Indonesia is in the process of EE labelling development, Brunei, Papua New Guinea and Peru without EE policies.
3. EEI (SRI) + MEPS, EEI (SRI) or MEPS are three different ways to regulate the EE labelling scheme in APEC. And they are determined by factors of testing energy consumption, total volume and compartment/appliances category regulated in the EE standards. This has been reflected the EEI (SRI) and MEPS calculation formula as well.
4. Those differently tested energy consumption, total volume and EE standards regulations of compartment/appliances categories have caused different EE levels for the same type of refrigerator.
5. Four types of refrigerator (upright refrigerator, upright refrigerator-freezer, chest freezer, and upright frost-free refrigerator-freezer), with assumption of constant energy consumption and volume for each, have been selected to understand the direct EE levels because of differences of calculation method in different EE laws or EE standards, it is clearly shown that because of the different situation in APEC economies even the same energy consumption and volume for the appliance the EEG or MEPS.
6. To deep understand key factors that lead to different tested energy consumption, total volume in economies, a thorough understanding and investigation of APEC economies EE test methods as well as laboratory test is needed to be further screened out main influencing factors. And this will be conducted in chapter 3 of this report, and the laboratory test has been carried out and analysed in another report.

3. Analysis of Test Methods in the APEC region

3.1 Overview of Test Method Standards for Refrigerators

There are 4 scenarios for test method standards in APEC economies (table 3-1):

1. China and Japan have national testing method standards which are similar to the new international standard IEC 62552:2015;
2. Chile, Hong Kong China, Indonesia, Malaysia, Philippines, Russia and Singapore have no national standards, but use IEC 62552:2007;
3. Australia, Canada, Mexico, New Zealand, Thailand, Viet Nam and USA have national standards which are different from the IEC 62552:2007, i.e. Thailand national testing standard is referred to ISO 7371:1955 and ISO 8561:1955;
4. Other economies like Peru, Brunei, Papua New Guinea do not regulate the EE of refrigerators.

Table 3-1: Overview of test method standards for Refrigerator in APEC

No.	Economy	Standard	Similar to IEC 62552:2015	IEC 62552:2007	National standards	No EE test methods
1	China	GB/T 8059-2015	√			
2	Japan	JIS C 9801:2015	√			
3	Chile	IEC 62552:2007		√		
4	Hong Kong, China			√		
5	Indonesia			√		
6	Malaysia			√		
7	Philippines			√		
8	Russia			√		
9	Singapore			√		
10	Korea	KS C 9305:2002		√		
11	Australia				√	
12	Canada				√	
13	Chinese Taipei	CNS 2062:2000			√	
14	Mexico	USA test standard NOM-015-ENER-2012 C300-08			√	
15	USA				√	
16	New Zealand				√	
17	Thailand	TIS 2186-2547(2004)			√	
18	Viet Nam	TCVN 7829:2013			√	
19	Peru	——				√
20	Brunei	——				√
21	Papua New Guinea	——				√

3.2 Comparison of Test Methods Standards for Refrigerators in APEC economies

Energy consumption and volume are two important parameters for EE testing. Detailed test methods from each economy are summarized in ANNEX II. The following four standards because they are widely used and referred, have been selected to conduct detailed comparisons and propose a harmonization roadmap with reference to the new IEC 62552-3 for APEC economies: IEC 62552:2015, IEC 62552:2007, AS/NZS 4474.1:2007+A1:2008+A2:2011, and USA Standard.

The following factors are key elements in energy testing methods for refrigerators:

- Test conditions, including ambient temperature, humidity, air circulation, vertical ambient temperature gradient and so on;
- Measuring instruments, including temperature probes, humidity, watt-hour meters, measurement of storage temperature (fresh-food, cellar, chill and frozen-food storage), test packages and M-packages;
- Installation of refrigerators, temperature device setting, anti-condensation heaters setting, power supply voltage and frequency, all shelves setting, accessories setting;
- Determination method of the energy, target temperature conditions, storage plan of test packages, storage plan of all storage temperature sensors and test period.

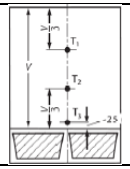
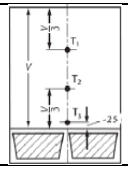
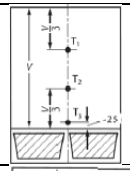
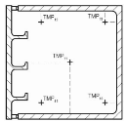
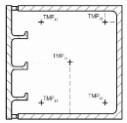
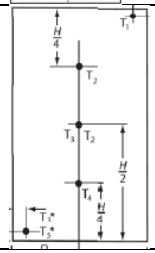
Detailed investigation for specific element in energy consumption testing for the 4 groups of standards has been summarized in table 3-2. Above mentioned elements are clearly and specifically described in the table. And volume testing methods investigation has been concluded in table 3-3. From table 3-2 and table 3-3, above four factors are very different in IEC 62552:2007, Australia Standard, and USA Standard.
The new IEC 62552 was to develop one performance standard for household cooling appliances which will be used worldwide for energy efficiency classes (label) and minimum efficiency performance limits. The draft of the new global standard was finished in March 2013.
This new standard has modified energy consumption testing with corrections for the IEC 62552-2007, with points described as in below:

- Appliances are tested in empty condition (currently loaded with packages);
- Tests are to be performed at two ambient temperatures (16℃ and 32℃ instead of 25℃ only);
- The fresh food compartment temperature is reduced to 4℃;
- Using cylinder is easy and fast to achieve stable testing status;
- A new adaptive test algorithm is introduced in energy consumption testing;
- Volumes measurement will be based on the ‘cooled volume’.

The new standard is structured as Part 1 – General requirements, Part 2 – Performance requirements, Part 3 – Energy consumption and volume. The testing method of energy consumption is more related to the specifications or configurations of the latest refrigerator, which also reflects the actual installation and usage environment in home. It is simple and easily reproducible condition for quick adaptation. However, a complex data processing will be arose after application the new IEC 60552 standard.

Table 3-2: Test method analysis results for energy consumption

Key Factors for Testing		**IEC 62552:2015**	**IEC 62552:2007**	**AS/NZS 4474.1:2007+ A1:2008+A2:2011**	**Appendices A and B to Subpart B of Part 430 (HRF-1-2008)**
Ambient temperature		16℃and 32℃	25℃or 32℃	32.0±0.5℃	32.2±0.6℃
Ambient humidity		Not exceed 75%	Not exceed 75%	No requirements	No requirements
Air circulation		Not exceed 0.25m/s	Not exceed 0.25m/s	Not exceed 0.25m/s	Not exceed 0.254m/s
Vertical ambient temperature gradient		1K/m	1K/m	1K/m	0.9K/m
Precision of temperature control device		±0.5K	±0.5K	±0.5℃	±0.3℃
Precision of humidity control device		±0.3K	±0.3K	No requirements	±0.3℃
Precision of watt-hour meters		2%（k=2）or 8wh/day, whichever is larger	No exact requirement but with cases setting，ie.,1% of reading	2%（k=2）	0.5%
Interval time		60s	60s	60s	60s
Measurement method of temperature	Fresh food	Cylinder1 with 18mm diameter and 18mm long	Cylinder2 with 15.2mm diameter and 15.2mm long	Cylinder3 with 25mm diameter and 25mm long	Cylinder4 with 29mm diameter and 29mm long
	Frozen food	Cylinder1	M-packages1[1)]	Cylinder3	M-packages2[2)]
	Frozen food （frost free）	Cylinder1	M-packages	Cylinder3	Cylinder4 or M-packages
	Cellar	Cylinder1	Cylinder2	Cylinder3	No requirements
	Chill	Cylinder1	M-packages	No requirements	No requirements
Test packages		Not use	Especial requirements	Not use	Special requirements
platform		The bottom of the platform shall not be less than 0.05 m above the	The bottom of the platform shall not be less than 0.05 m above the test room	The bottom of the platform shall not be less than 0, 3 m above the test room floor and shall extend at least	A platform must be used if the floor temperature is not within 3 °F (1.7 °C) of the measured ambient

Key Factors for Testing		IEC 62552:2015	IEC 62552:2007	AS/NZS 4474.1:2007+ A1:2008+A2:2011	Appendices A and B to Subpart B of Part 430 (HRF-1-2008)
		test room floor and shall extend at least 0,3 m beyond, all sides of the refrigerating appliance, except at the rear where it shall extend to the vertical partition.	floor and shall extend at least 0,3 m beyond, all sides of the refrigerating appliance, except at the rear where it shall extend to the vertical partition.	0,3 m beyond, but not extend 0.6m, all sides of the refrigerating appliance, except at the rear where it shall extend to the vertical partition.	temperature. If a platform is used, it is to have a solid top with all sides open for air circulation underneath, and its top shall extend at least 1 foot (30.5 cm) beyond each side and front of the unit under test and extend to the wall in the rear.
Location of temperature censor	Fresh food		Specified for fresh food compartment		
	Frozen food	 (h＜1m and more specifications for other situations)		 (h＜1m and more specifications for other situations)	
	Cellar	Same to fresh food compartment		Same to fresh food compartment	No requirements
	Chill	Same to fresh food compartment		Same to fresh food compartment	No requirements
Temperature-control setting		The target temperature setting	The target temperature setting	The target temperature setting	Middle, Warmest or Coldest
Target temperature	Fresh food	4℃	5℃	3℃	3.9℃
	Frozen food	-18℃	-18 ℃	-15℃	-17.8
	Cellar	12℃	12℃	12℃	Wine cellar:12.8℃
	Chill	2℃	3℃	0℃	-
	0 star	0℃	-	-	-
	1 star	-6	-6	Ice-making: no requirements.	-

Key Factors for Testing		**IEC 62552:2015**	**IEC 62552:2007**	**AS/NZS 4474.1:2007+ A1:2008+A2:2011**	**Appendices A and B to Subpart B of Part 430 (HRF-1-2008)**
	2 star	-12	-12	Short term frozen average: -9℃	Refrigerator: -9.4℃
	3 star	-18	-18	-15℃	Refrigerator-freezer: -17.8℃
accessories setting	Ice cube	In normal position	Removed	No requirement	In normal position
	Auto ice maker	The ice delivery mechanism shall remain functional, but not making ice while testing energy consumption	Not in operation	No requirement	be inoperative
anti-condensation heaters setting		Adjustable, in 'on' and 'off' status	Adjustable, shall be on.	Remain operational	Remain operational
Load processing efficiency		specified	–	–	–
Steady state acceptance criteria		For ①no defrost control cycle or where stability is established for a period between defrosts(SS1)②steady state determined between defrosts(SS2) ③ defrost and recover period（DF1 or DF2）	The storage temperatures and energy consumption values during two period of at least 24h -both comprising a full number of operating cycles –agree with 0,5K and 3%	For those with temperature control cycles, temperature shall not vary by more than 0.5k. And for those without, temperature shall not vary by more than 0.3K.	Average temperature in each measured compartment taken at 4minute intervals, or less, during a stabilization period are not changing at a rate greater than 0.042°F (0.023°C) per hour
Determination method of the energy		Stead energy+defrost and recovery energy+automatic ice making energy(where applicable)+load processing efficiency(optional)	For frost-free system, beginning of the initiation of defrosting cycle and termination at the initiation of next defrosting cycle, the average energy. For other system, a whole number of operating cycle, the average energy	For frost-free system, in the beginning of the initiation of defrosting cycle and termination at the initiation of next defrosting cycle or reach to 24h. For other system, shall be a whole operating cycle	For frost-free system, in the beginning of the initiation of defrosting cycle and termination at the initiation of next defrosting cycle. For long-time and variable defrost, two parts shall be chosen. For other system, shall be a whole number of operating cycle
Test period		Standard energy consumption +automatic ice making energy(where applicable) +load processing	It shall be of at least 24 h. If an operating cycle starts but is not completed during 24 h, the test shall	①Thermal stability can be attained: a)Without automatic defrost system, not less than 6h b)With automatic defrost system,	①Including 2 or more complete cycle at least 3h. If incomplete cycling (less than 2 compressor cycles) occurs during a 24-hour

Key Factors for Testing	IEC 62552:2015	IEC 62552:2007	AS/NZS 4474.1:2007+ A1:2008+A2:2011	Appendices A and B to Subpart B of Part 430 (HRF-1-2008)
	efficiency(optional)	continue until the end of that operating cycle. If one operating cycle is not completed during 48 h, the test shall be terminated after 48 h, except for food freezers and refrigerator/freezers where there is no air exchange between the food freezer compartment and other compartments, in which case the test shall be terminated after 72 h.	not less than 6h and include a number of complete defrost control cycles c) With automatic defrost system and duration is more than 24h, at least 24h. ②Thermal stability can't be attained: a) no less than 24h; b) with automatic defrost system and duration is more than 24h, at least 24h.	period, the test result of 24- hour period will be used ② With automatic defrost system, from the start of defrost and recovery period to the start of next defrost and recovery period.
Energy consumption calculation	①Just do one test and interpolation is not required, If all compartment's temperatures are at or below their target temperatures. ②Linear interpolation between two test points. The temperature difference between test runs in each compartment used for interpolation shall not exceed 4 K. If there are two valid interpolation results, minimum value of these represents the interpolated energy consumption ③Triangulation using three (or more) test points, where two (or more) user-adjustable temperature controls are adjusted.	①Just do one test and interpolation is not required, If all compartment's temperatures are at or below their target temperatures. ②Linear interpolation between two test points. For one temperature control setting, the energy consumption is determined by interpolation from the results of two tests at one compartment's target temperature and the other compartments' temperature are below their target temperatures. For two temperature control settings, the energy consumption is determined by the average value of two interpolated energy consumptions and each compartment used for interpolation shall in the same trends: warmer or colder than target temperatures in each test.	①Just do one test and interpolation is not required, If all compartment's temperatures are at or below their target temperatures. ②Linear interpolation both points lie within ±2℃ of the target temperature for each compartment, or one point lies within ±1℃ of the target temperature for that compartment and one point lies within ±4℃ of the target temperature. If there are more than one valid interpolation results, maximum value of these represents the interpolated energy consumption ③Triangulation using three (or more) test points, where two (or more) user-adjustable temperature controls are adjusted.	①Using the test result of measured highest temperature of compartment and interpolation is not required, If all compartment's temperatures are at or below their target temperatures. ②Linear interpolation between two test points which bound the appliance's target temperature.

Note:

1) the package requirements for IEC 62552:2007 as below :

The test packages used in the tests shall be in the form of rectangular parallelepipeds. Their size, prior to freezing, and their mass, packaging included, shall be in accordance with Table 3.

Test packages shall be checked regularly and shall not present visible holes or cracks on the wrapper.

The packages shall consist of the following.

- A suitable filling material containing, per 1 000 g:
  - ✓ 230 g of oxyethylmethyl cellulose;
  - ✓ 764,2 g of water;
  - ✓ 5 g of sodium chloride;
  - ✓ 0,8 g of 6-chloro-m-cresol.

The freezing point of this material is -1 °C (its thermal characteristics correspond to those of lean beef).

- The following alternative composition of test packages with a freezing point near − 5 °C may be used:
  - ✓ 232 g of oxyethylmethyl cellulose;
  - ✓ 725 g of water;
  - ✓ 43 g of sodium chloride;
  - ✓ 0,6 g of 6-chloro-m-cresol.

In case of dispute, the composition of test package a) shall be used as the reference test package.

For the measurement of chill compartments, only test package b), with a freezing point of -5 °C, shall be used.

- A wrapper, consisting of a sheet of plastic or any other suitable material of such a nature that exchange

of moisture with the ambient medium is negligible. After filling, the wrapping sheet shall be sealed. It is advisable to use a laminated sheet, consisting of layer of high-pressure polyethylene, easily sealable, 120 µm thick, together with an external sheet of polyethyleneterephthalate approximately 12.5 µm thick, the two layers being bonded together.

2) the package requirements for IEC 62552:2007 as below

The packages shall be sealed and shall contain a liner or wrapper that makes them moisture and vapor-proof. The packages shall be filled to a density of 35±5 lbs per cubic foot (560±80kg/m³) with hardwood sawdust that has been water-soaked or, alternately, is an equivalent package of frozen food such as chopped spinach.

Table 3-3: Test method analysis result for volume

IEC 62552:2015	IEC 62552:2007	AS/NZS 4474.1:2007+ A1:2008+A2:2011	USA test standard
① Gross volume and storage volume are not defined in this standard ② When the **volume** is determined, internal fittings such as shelves, removable partitions, containers and interior light housings shall be considered as not being in place, but as a part of volume. The air ducts required for proper cooling and operation of the unit, temperature control housings shall be in place and be deducted from volume.	① Gross volume and storage volume are defined in this standard, using the storage volume to calculate the EEI or MEPS. ②When measure the storage volume, the gross volume and the volume which couldn't be used for storing food should be measured. The storage volume is the gross volume menus no used volume.	① Gross volume and storage volume are defined in this standard, using the storage volume to calculate the EEI or MEPS. ②When the gross volume is determined, internal fittings such as shelves, removable partitions, containers, evaporators, temperature control and light house shall be considered as not being in place. If air ducts, fans and evaporators that are in space of compartment liner shall be considered in determining gross volume, oppositely those parts should be deduced.	① Gross volume and storage volume are defined in this standard, using the storage volume to calculate the EEI or MEPS. ②When measure the storage volume, the gross volume and the volume which couldn't be used for storing food should be measured. The storage volume is the gross volume menus no used volume.

According to the relationship table and analysis result, the research team will use the IEC 62552:2015, IEC 62552:2007, AS/NZS 4474.1:2007+A1:2008+A2:2011 and USA test standards in step 3- laboratory testing.

4. Conclusion

18 APEC economies deploy EE policies of laws or standards to regulate their market, and EE labeling scheme based on EE standards are mandatory implemented in those 18 economies except Indonesia since it is developing the EE labeling program. Brunei, Papua New Guinea and Peru has not taken EE policies according to their economy circumstance.

For economies that have EE labeling, EEI (SRI) +MEPS or EEI(SRI) or MEPS are three different ways to evaluate products EE level. The indexes are determined by factors of testing energy consumption, total volume and calculation method related to compartment/appliances category regulated in the EE standards.

Four types of refrigerator (upright refrigerator, upright refrigerator-freezer, chest freezer, and upright frost-free refrigerator-freezer), with assumption of constant energy consumption and volume for each, have been selected to understand the direct EE levels because of differences of calculation method in different EE laws or EE standards , it is clearly shown that because of the different situation in APEC economies even the same energy consumption and volume for the appliance the EEG or MEPS. But for energy consumption and volume are essential parameters to reflect a refrigerator's energy conservation.

Detailed comparison of energy consumption and volume test methods in economies EE test methods have been conducted that the IEC 62552:2015, IEC 62552:2007, AS/NZS 4474.1:2007+A1:2008+A2:2011, and USA Standard are 4 groups standards that widely accepted and applied or referred. The later three ones have large difference with IEC 62552:2015 in the aspects of test conditions, measuring instruments, installation of refrigerators, and determination method of the energy.

These differences result in huge cost to the manufacturers regarding design and testing, and creates uncertainties regarding design itself and hampers technological innovations (on design is energy efficient for this economy, and less for that economy). Deployment of best practice products and policies is limited by different test methods across economies, giving non-comparable energy efficiency test results; a much improved test method will be published by IEC in 2015 that should be fit for global harmonization**.**

The testing method of energy consumption in the IEC 62552:2015 has achieved many improvements compared to the IEC 62552:2007. It is more related to the specifications or configurations of the latest refrigerator, which also reflects the actual installation and usage environment in home. It is simple and easily reproducible condition for quick adaptation. However, a complex data processing will be arose after application the new IEC 60552 standard.

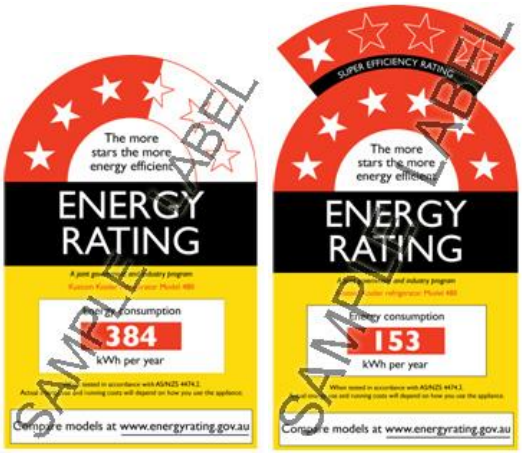
Harmonization of energy efficiency test method of refrigerators is therefore of critical importance for APEC economies, as a means to ensure coherence, allow for best practices exchange and enhanced Monitoring Verification &Enforcement, as well as to facilitate technological innovations for further improvement of energy efficiency for refrigerators.

Annex I EE Standards or Laws for Refrigerator in the APEC Region

Australia

Energy label scheme: Australia has mandatory energy labelling program for household refrigerators since 1986, and latest updated on 2014. These were revised (re-graded) in 2000 and again in 2010 to take account of the substantial improvement in the energy efficiency of products over this period (for example, new refrigerators today use 70% less energy than equivalent products from the 1980's). Until 2010, all energy labels showed possible star ratings from a minimum of 1 star to a maximum of 6 stars. In 2010, the star rating system for refrigerators was expanded to show up to 10 stars for products that have exceptional energy efficiency.

Energy label format:



Appliance category: All refrigerators shall be classified into one of the 10 product group on the following table1-1.

Table 1-1

Appliancegroup	Food storage compartment types						Configuration requirement	Defrost system requirement	Appliance designation
	Unfrozen food storage			Frozen food storage					
	cellar	Fresh food	chill	Ice-making	Short term	freezer			
1	O	Y	O	N	N	N		Automatic defrost	Refrigerator
2	O	Y	O	O	N	N			Refrigerator
3	O	Y	O	O	Y	N			Refrigerator
4	O	Y	O	O	O	Y		Cyclic defrost	Refrigerator/freezer
5T	O	Y	O	O	O	Y	Top freezer	Frost-free	Refrigerator/freezer
5B	O	Y	O	O	O	Y		Frost-free	Refrigerator/freezer

5S	O	Y	O	O	O	Y	Bottom freezer	Frost-free	Refrigerator/freezer
6C	N	N	N	O	O	Y	Chest		Freezer
6U	N	N	N	O	O	Y	Upright	Not frost-free	Freezer
7	N	N	N	O	O	Y	Upright	Frost-free	Freezer

Note:

"Y"- indicates the appliance shall have at least one compartment of each of the types marked Y.

"N"- indicates the appliance shall have no compartment of the types marked N.

"O"- indicates the appliance may or may not have any compartments from the types marked O.

Adjusted volume: The following formula 1-1 was used in calculating the adjusted volume.

$V_{adj} = V_g \times K_s$ (litres) …… formula 1-1

Where

V_g = rated gross volume of the compartment in litres.

K_s = volume adjustment factor for the food storage type of the compartment, and see table 1-2.

Table 1-2

Compartment type	Volume adjustment factor (K_s)
Cellar	0.7
Fresh food	1.0
Chill	1.1
Ice-making	1.2
Short term frozen food storage	1.4
Freezer	1.6
Claimed maximum of operating temperature range (T_m)	Volume adjustment factor (K_s)
Warmer than 6℃	$\frac{(32 - Tm)}{(32 - 3)}$
Warmer than 3℃ but no warmer than 6℃	1.0
Warmer than -2℃ but no warmer than 3℃	1.1
Warmer than -9℃ but no warmer than -2℃	1.2
Warmer than -15℃ but no warmer than -9℃	1.4
-15℃ or colder	1.6

Energy efficiency index: The star rating index(SRI) shall be determined in the following formula 1-2.

Star rating index(SRI)=$1+[\frac{\log_e(\frac{CEC}{BEC})}{\log_e(1-ERF)}]$ …… formula 1-2

Where

CEC = comparative energy consumption for the model in kWh/year.

BEC = base energy consumption for the model in kWh/y, and see formula 1-3.

ERF = energy consumption reduction factor=0.23 for all appliance groups.

Notes: if the CEC of a model is equal to its base energy consumption(BEC), its star rating index is 1.00.

The energy consumption reduction factor(ERF) is the proportion by which the CEC of a model would have to be reduced to increase its star rating index by 1.00. For all groups this is a 23%

reduction in energy consumption per additional star earned.

BEC = C_f+[C_v×$\left(V_{adj\ tot}^{0.67}\right)$] (kWh/y) ……..……..…… formula 1-3

Where

C_f= fixed allowance factor for its group in kilowatt hours per year.

C_v= variable allowance factor for tis group in kilowatt hours per litre per year.

$V_{adj\ tot}$ = total adjusted volume for the model in litres, and see the formula 1-1.

The BEC is not rouned. Factor C_f and C_v shall be in accordance with table 1-3.

Table 1-3

Appliance group	Fixed allowance factor(C_f) kWh/y	Variable allowance factor(C_v) kWh/y/L
1, 2 and 3	200	4.0
4, 5T, 5B and 5S	150	8.8
6C, 6D and 7	150	7.5

Energy efficiency grade: The star rating on energy labelling has the complex calculations processes, the factors during calculating are SRI, CEC, BEC and ERF. The star rating shall be obtained from the following table 1-4.

Table 1-4

Star rating (Energy efficiency grade)	SRI
1	SRI < 1.5
1.5	1.5≤ SRI < 2.0
2	2.0≤ SRI < 2.5
2.5	2.5≤ SRI < 3.0
3	3.0≤ SRI < 3.5
3.5	3.5≤ SRI < 4.0
4	4.0≤ SRI < 4.5
4.5	4.5≤ SRI < 5.0
5	5.0≤ SRI < 5.5
5.5	5.5≤ SRI < 6.0
6	6.0≤ SRI < 7.0
7	7.0≤ SRI <8.0
8	8.0≤ SRI <9.0
9	9.0≤ SRI <10.0
10	10.0≤ SRI

MEPS: For a refrigerating appliance model manufactured or imported, the PAEC for each unit shall not exceed the MEPS 2014 cut-off level, which is determined the formula 1-5. The PAEC shall be determined by the formula 1-4. Neither tested energy consumption of all the samples submitted for registration nor the claimed CEC shall exceed the specified MEPS level.

PAEC = E_t × $\frac{365}{1000}$ (kWh/y) …….…… formula 1-4

Where

E_t = tested energy consumption expressed in watt hours per 24 hours, rounded to the nearest whole number.

MEPS 2014 cut-off level = $[K_f + (K_v \times V_{adj\ tot})] \times K_a + A_{d\ tot} + A_{wi}$…… formula 1-5

Where

K_f= fixed allowance factor for its appliance group. (kWh/year).

K_v= variable allowance factor. (kWh/y/L).

K_a= adaptive defrost adjustment factor; K_a=1.05 where an adaptive defrost system is present (for groups 1, 5T, 5B, 5S and 7 only), or K_a=1.00 where the feature is not present (dimensionless).

$V_{adj\ tot}$ = total adjusted volume.

$A_{d\ tot}$ = an allowance which is made where the external doors provided on an appliance differ from the regular arrangement for the appliance group as described in table.

A_{wi} = an allowance of 128 kWh/y which applies where an appliance has a 'through-the-door ice dispenser', i.e. it has an automatic ice-maker coupled with a device for delivery on demand of ice externally through a door. This allowance also applies if the through-the-door dispenser also dispenser chilled water.

The fixed and variable allowance factors are determined from the group classification of the appliance and to table 1-5.

Table 1-5

Appliance group	Fixed allowance factor(K_f) kWh/y	Variable allowance factor(K_v) kWh/y/L
1	296	0.356
2	308	0.309
3	301	0.366
4	295	0.351
5T	334	0.384
5B	440	0.382
5S	607	0.180
6C	202	0.514
6U	299	0.317
7	383	0.514

The door allowance applies when the arrangement of external doors on an upright appliance differs from table 1-6, either in the number of doors on the appliance or because the compartment to which they give access are of different food storage types from table 1-6. There shall be no door allowance for chest-type appliances, irrespective of the configuration.

Table 1-6

Appliance group	External doors into compartment type	
	Fresh food storage	Freezer
1, 2 and 3	1	0
4, 5T, 5B and 5S	1	1
6U and 7	0	1

$A_{d\ tot}$ of an appliance shall be the sum of the door allowance (A_d) for each food storage compartment type. A_d shall be derived for external doors only, i.e. doors on sub-compartments do not affect door allowances, A_d for a compartment type or $A_{d\ tot}$ for an appliance may be

either positive or negative. For each door that accesses a compartment of a nominated food storage type shall be derived the formula 1-6.

$A_d = K_d \times K_s \times (L_a - L_e)$…… formula 1-6

Where

K_d= door allowance factor. (kWh/y/m), and see table 1-7.

K_s = volume adjustment factor, and see table 1-2.

L_a = sum of the lengths of the actual sealing face perimeters of all external doors to compartment of the food storage compartment type (metres)

L_e = estimated length of the sealing face perimeter of the external door of a fresh food or freezer compartment on an equivalent regular appliance (metres)

Table 1-7

Appliance group	Door allowance factor (K_d) kWh/y/m
1, 2, 3	56
4	64
5T, 5B	67
5S	74
6U	56
7	67

Canada

Energy label scheme: Canada has mandatory energy labelling program for household refrigerators since 1992, and latest updated on 2008.Household refrigerator or a household combination refrigerator-freezer that has a defrost system - including a compressor-cycled automatic defrost system – and a capacity of 1100 L (39 cubic feet) or less shall comply with maximum energy consumption limit requirements.

Energy label format:

Appliance category: All refrigerators shall be classified into one of the 22 product groups on the following table 2-1.

Table 2-1

Type (Product group)	Product group description
1	Refrigerators and refrigerator-freezers with semi-automatic or manual defrost
2	Refrigerator-freezers with partial automatic defrost
3	Refrigerator-freezers with automatic defrost with top-mounted freezer and without through-the-door ice service, and all-refrigerators with automatic defrost
4	Refrigerator-freezers with automatic defrost with side-mounted freezer and without through-the-door ice service
5	Refrigerator-freezers with automatic defrost with bottom-mounted freezer and without through-the-door ice service
5A	Refrigerator-freezers with automatic defrost and bottom-mounted freezer with through-the-door ice service
6	Refrigerator-freezers with automatic defrost with top-mounted freezer and with through-the-door ice service
7	Refrigerator-freezers with automatic defrost with side-mounted freezer and with through-the-door ice service
8	Upright freezers with manual defrost
9	Upright freezers with automatic defrost
10	Chest freezers and all other freezers
10A	Chest freezers with automatic defrost system
	Compact models: refrigerated volume < 219.5 L and an overall height < 91.4 cm
11	Compact refrigerators and refrigerator-freezers with semi-automatic and manual defrost
12	Compact refrigerator-freezers with partial automatic defrost
13	Compact refrigerator-freezers with automatic defrost with top-mounted freezer and compact all-refrigerators with automatic defrost
14	Compact refrigerator-freezers with automatic defrost with side-mounted freezer
15	Compact refrigerator-freezers with automatic defrost with bottom-mounted freezer
16	Compact upright freezers with manual defrost

17	Compact upright freezers with automatic defrost
18	Compact upright freezers and all other compact freezer
	Wine chillers
19	Wine chillers with manual defrost
20	Wine chillers with automatic defrost

Adjusted volume:The following formula 2-1 was used in calculating the adjusted volume.

For refrigerator and refrigerator-freezer,

$AV = V_{\text{fresh food}} + (V_{\text{freezer}} \times AF)$ ……formula 2-1

Where

AV = Adjusted volume, in L.

$V_{\text{fresh food}}$ = Fresh food compartment volume, in L.

V_{freezer}= Freezer compartment volume, in L.

AF = Adjustment factor, determined as indicated in formula 2-2.

$AF = \frac{tA - t_{FSR}}{tA - t_{FF}}$……formula 2-2

Where

AF = Adjustment factor.

t_A = Test room temperature, in ℃.

t_{FSR}= Freezer compartment reference temperature, in ℃.

t_{FF}= Fresh food compartment average operating temperature, in ℃.

Note: fresh food compartment average operating temperature must be 3.3℃.

For all refrigeratoronly, the adjustment factor is 1.00.

For basic refrigerator, the adjustment factor is:$AF = \frac{32.2-(-9.4)}{32.2-3.3} = 1.44$

For refrigerator-freezer, the adjustment factor is:$AF = \frac{32.2-(-15)}{32.2-3.3} = 1.63$

For freezer,

$AV = V_{\text{freezer}} \times AF$ ……formula 2-3

Where

AV = Adjusted volume, in L.

V_{freezer}= Freezer compartment volume, in L.

AF = Adjustment factor, determined as indicated in formula 2-2.

For chest and upright freezers, the adjustment factor is:$AF = \frac{32.2-(-17.8)}{32.2-3.3} = 1.73$

Energy efficiency index:No such requirements.

Energy efficiency grade:No such requirements.

MEPS: The maximum energy consumption limit requirements were determined by applying table 2-2 formulas.

Table 2-2

Type (Product group)	Maximum energy consumption limit (kWh/year)
	Effective: July 1, 2001; and for Type 3 only (≥ 410.6 L and ≤ 523.9 L) December 30, 2002
1	0.31 AV + 248.4
2	0.31 AV + 248.4
3	0.35 AV + 276
4	0.17 AV + 507.5
5	0.16 AV + 459
5A	0.18 AV + 539
6	0.36 AV + 356
7	0.36 AV + 406
8	0.27 AV + 258.3
9	0.44 AV + 326.1
10	0.35 AV + 143.7
10A	0.52 AV + 211.5
	Effective: July 1, 2001
11	0.38 AV + 299
12	0.25 AV + 398
13	0.45 AV + 355
14	0.27 AV + 501
15	0.46 AV + 367
16	0.35 AV + 250.8
17	0.40 AV + 391
18	0.37 AV + 152
	Effective: January 1, 2008
19	0.48 AV + 267
20	0.61 AV + 344

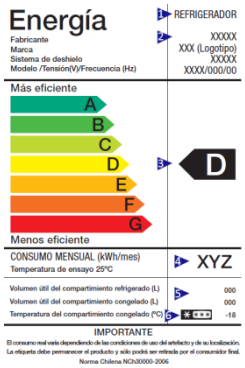
Where

AV = the total adjusted volume, expressed in litres.

Chile

Energy label scheme: Chile has mandatory energy labelling program for household refrigerators since 2005, and latest updated on 2013.All refrigerators that exclude the display or especial used refrigerator shall comply with energy efficiency grade and maximum energy consumption limit requirements. This uses grade system from G (worst) to A (best).

Energy label format:



Appliance category: All refrigerators shall be classified into one of the 10 product categories on the following table 3-1.

Table 3-1

Appliance category	Household refrigerating appliance description
1	Refrigerator with one or more fresh-food storage compartments
2	Refrigerator-cellar, Cellar and Wine storage appliances
3	Refrigerator-chiller and Refrigerator with a 0-star compartment
4	Refrigerator with a one-star compartment
5	Refrigerator with a two-star compartment
6	Refrigerator with a three-star compartment
7	Refrigerator-freezer
8	Upright freezer
9	Chest freezer
10	Multi-use and other refrigerating appliances

Adjusted volume: The following formula 3-1 was used in calculating the adjusted volume.

$V_{adj\ tot} = \sum_{c=1}^{n} Vc \times Wc \times FFc \times BI \times CC$ ..... formula 3-1

Where

n = different compartment quantity.

Vc = test storage volume. L.

FFc = factor. Fc=1.2 where use the frost-fee refrigerating system in refrigerator. Otherwise, Fc=1.0.

CC = climatic class factor. CC=1 where the climatic class is N or SN, CC=1.1 where the climatic class is ST, CC=1.2 where the climatic class is T.

Wc = the different compartment factor, and see table 3-2.

BI = the built-in factor. BI=1.2 where the built-in appliances under 58 cm in width, BI=1.0 otherwise.

Table 3-2

Compartment Type	Fresh-food storage compartment	Cellar compartment	Chill compartment	One-star compartment	Two-star compartment	Three-star compartment	Frozen food compartment	Special compartment
Tc/℃	5	10	0	-6	-12	-18	-18	Tc
Wc	1.00	0.75	1.25	1.55	1.85	2.15	2.15	$\frac{25-Tc}{20}$

Note: Tc = the design temperature of compartment or the temperature declared by manufacture.

Energy efficiency index: The energy efficiency index shall be determined in the following formula 3-2.

Energy efficiency index (EEI) = $\frac{AEc}{SAEc} x100\%$ …….…. formula 3-2

Where

AEc = Annual energy consumption of the household refrigerating appliance, (kWh/y)

SAEc = Standard annual energy consumption of the household refrigerating appliance, (kWh/y), and see formula 3-3.

The standard annual energy consumption (SAEc) is calculated in kWh/year and rounded to two decimal places, as:

$SAEc = M \times Vadj\ tot + N + CH$……..…….…. formula 3-3

Where

M = factor. KWh/L, and see table 3-3.

$V_{adj\ tot}$ = total adjusted volume.

N = factor. KWh, and see table 3-3.

CH = variable temperature compartment factor. CH=50 where have the storage volume 15L or more, and with the chill compartment temperature range. Otherwise, CH=0.

Table 3-3

Appliance category	Household refrigerating appliance description	M/(kWh/L)	N/(kWh)
1	Refrigerator with one or more fresh-food storage compartments	0.233	245
2	Refrigerator-cellar, Cellar and Wine storage appliances	0.233	245
3	Refrigerator-chiller and Refrigerator with a 0-star compartment	0.233	245
4	Refrigerator with a one-star compartment	0.643	191
5	Refrigerator with a two-star compartment	0.450	245
6	Refrigerator with a three-star compartment	0.777	303
7	Refrigerator-freezer	0.777	303
8	Upright freezer	0.539	315
9	Chest freezer	0.472	286
10	Multi-use and other refrigerating appliances	(*)	(*)

Energy efficiency grade: The energy efficiency grade shall be determined in the following table 3-4.

Table 3-4

Energy efficiency grade	Energy efficiency index(EEI)
A	**42** $\leqslant EEI < 55$
B	$55 \leqslant EEI < 75$
C	$75 \leqslant EEI < 95$
D	$95 \leqslant EEI < 110$
E	$110 \leqslant EEI < 125$
F	$125 \leqslant EEI < 150$
G	$EEI \geqslant 150$

MEPS: No such requirements.

China

Energy label scheme: China has mandatory energy labelling program for household refrigerators since 2005, and latest updated on 2013.All refrigerators that exclude the built-in, display or especial used refrigerator shall comply with energy efficiency grade and maximum energy consumption limit requirements. This uses grade system from 5 (worst) to 1 (best).

Energy label format:

Appliance category: All refrigerators shall be classified into one of the 7 product categories on the following table 4-1.

Table 4-1

Appliance category	Household refrigerating appliance description
1	Refrigerator with a 0-star compartment
2	Refrigerator with a one-star compartment
3	Refrigerator with a two-star compartment
4	Refrigerator with a three-star compartment
5	Refrigerator-freezer
6	Frozen food storage appliance
7	Freezer

Adjusted volume: The following formula 4-1 was used in calculating the adjusted volume.

$V_{adj\ tot} = \sum_{c=1}^{n} Vc \times Fc \times Wc \times CC$ ..... formula 4-1

Where

n = different compartment quantity.

Vc = test storage volume. L.

Fc = factor. Fc=1.4 where use the frost-fee refrigerating system in refrigerator. Otherwise, Fc=1.0.

CC = climatic class factor. CC=1 where the climatic class is N or SN, CC=1.1 where the climatic class is ST, CC=1.2 where the climatic class is T.

Wc = the different compartment factor, and see table 4-2.

Table 4-2

Compartment Type	Fresh-food storage compartment	Cellar compartment	Chill compartment	One-star compartment	Two-star compartment	Three-star compartment	Frozen food compartment	Special compartment
Tc/℃	5	10	0	-6	-12	-18	-18	Tc
Wc	1.00	0.75	1.25	1.55	1.85	2.15	2.15	$\frac{25-Tc}{20}$

Note: Tc = the design temperature of compartment or the temperature declared by manufacture.

Energy efficiency index: The energy efficiency index shall be determined in the following formula 4-2.

Energy efficiency index (η) =

$\frac{Etest}{Ebase} x100\%$ …….…. formula 4-2

Where

Etest = Test energy consumption. (KWh/24h)

Ebase = Base energy consumption. (kWh/24h), and see formula 4-3

The test energy consumption for a model shall be the average for the three units which are tested to determine the label particulars.

$E_{base} = (M \times Vadj\ tot + N + CH) \times Sr/365$…….…. formula 4-3

Where

M = factor. KWh/L, and see table 4-3.

$V_{adj\ tot}$ = total adjusted volume.

N = factor. KWh, and see table 4-3.

CH = variable temperature compartment factor. CH=50 where have the storage volume 15L or more, and with the chill compartment temperature range. Otherwise, CH=0.

Sr = through-the-door ice dispenser factor. Sr=1.10 where have the storage volume 100L or less, or 400L or more with through-the-door ice dispenser function. Otherwise, Sr=1.00.

Table 4-3

Appliance category	Household refrigerating appliance description	M/(kWh/L)	N/(kWh)
1	Refrigerator with a 0-star compartment	0.221	233
2	Refrigerator with a one-star compartment	0.611	181
3	Refrigerator with a two-star compartment	0.428	233
4	Refrigerator with a three-star compartment	0.624	223
5	Refrigerator-freezer	0.697	272
6	Frozen food storage appliance	0.530	190
7	Freezer	0.567	205

Energy efficiency grade: The energy efficiency grade shall be determined in the following table 4-4.

Table 4-4

Energy efficiency grade	Energy efficiency index(η)	
	Refrigerator-freezer	Other category(1, 2, 3, 4, 6, 7)
1	η≤40%	η≤50%

2	40%<η≤50%	50%<η≤60%
3	50%<η≤60%	60%<η≤70%
4	60%<η≤70%	70%<η≤80%
5	70%<η≤80%	80%<η≤90%

MEPS: The test and rated energy consumptions shall not more than the maximum energy consumption limit (E_{max}). The E_{max} see the following table 4-5.

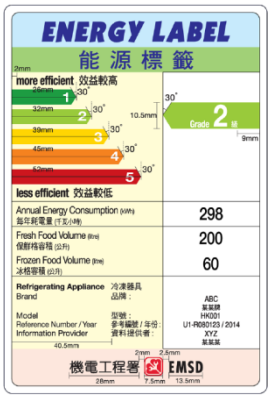
Table 4-5

Appliance category	Household refrigerating appliance description	E_{max}/kWh/24h
1	Refrigerator with a 0-star compartment	$0.8 \times E_{base}$
2	Refrigerator with a one-star compartment	$0.8 \times E_{base}$
3	Refrigerator with a two-star compartment	$0.8 \times E_{base}$
4	Refrigerator with a three-star compartment	$0.8 \times E_{base}$
5	Refrigerator-freezer	$0.7 \times E_{base}$
6	Frozen food storage appliance	$0.9 \times E_{base}$
7	Freezer	$0.9 \times E_{base}$

Hong Kong, China

Energy label scheme: Hong Kong has mandatory energy labelling program for household refrigerators since 2008, and latest updated on 2014.All refrigerators that have a compressor refrigerating system – and a capacity of 500 L or less shall comply with energy efficiency grade and maximum energy consumption limit requirements. This uses grade system from 5 (worst) to 1 (best).

Energy label format:



Appliancecategory: All refrigerators shall be classified into one of the 8 product categories on the following table5-1.

Table 5-1

Appliance category	Household refrigerating appliance description
1	A refrigerator without a frozen food compartment
2	A refrigerator with a 1-star frozen food compartment
3	A refrigerator with a 2-star frozen food compartment
4	A refrigerator with a 3-star frozen food compartment
5	A refrigerator with a 4-star frozen food compartment
6	A Category 5 refrigerator incorporating means to prevent the formation of frost on contents
7	A refrigerating appliance in which the entire storage volume is intended for freezing food.
8	A Category 7 refrigerating appliance incorporating means top revent the formation of frost.

Adjusted volume: The adjusted volume V_{adj} is calculated as formula 5-1.

$V_{adj} = \sum V_i \times \Omega$ ……formula 5-1

Where

V_i = the measured storage volume of an individual compartment

Ω = the weighting factor given by the formula 6-2.

$\Omega = \frac{T_a - T_i}{T_a - T_r}$ ……formula 5-2

Where

T_a = test room ambient temperature which is taken as 25℃

T_i = the rated temperature in the individual compartment concerned

T_r = the rated temperature in the fresh food compartment which is taken as 5℃

A summary of eight simple equations for calculating the adjusted volume of each refrigerating appliance category is shown in table 6-2.

Table 5-2

Appliance category	Adjusted volume (in litre)
1	V_r
2	$V_r + 1.55 \times V_{ffc}$
3	$V_r + 1.85 \times V_{ffc}$
4	$V_r + 2.15 \times V_{ffc}$
5	$V_r + 2.15 \times V_{ffc}$
6	$V_r + 2.15 \times V_{ffc}$
7	$2.15 \times V_{ffc}$
8	$2.15 \times V_{ffc}$

Where

V_r= Storage volume of fresh food compartment

V_{ffc}= storage volume of frozen food compartment

For refrigerating appliances with additional chill compartment and/or cellar compartment, additional terms obtained by calculating formula 6-3 shall be added to these equations.

$V_{adj} = V_r \times \frac{T_a - T_r}{T_a - T_r} + V_{ffc} \times \frac{T_a - T_{ffc}}{T_a - T_r}$ ……formula 5-3

Energy efficiency index: The energy consumption index (I_ε) of a refrigerating appliance is defined as the ratio of the actual energy consumption of the refrigerating appliance to the Average Appliance Energy Consumption, and see formula 6-4.

Energy consumption index (I_ε) = $\frac{E}{E_{av}} \times 100\%$ ……formula 5-4

Where

E = actual annual energy consumption of the refrigerating appliance measured in energy consumption test.

E_{av} = average annual energy consumption as determined from table 6-3.

Table 5-3

Appliance category	Average annual energy consumption (kWh/yr)
1	$V_{adj} \times 0.233 + 245$
2	$V_{adj} \times 0.643 + 191$
3	$V_{adj} \times 0.450 + 245$
4	$V_{adj} \times 0.657 + 235$
5	$V_{adj} \times 0.777 + 303$
6	$1.35 \times (V_{adj} \times 0.777 + 303)$(note)
7	Chest freezer: $V_{adj} \times 0.446 + 181$ Upright freezer: $V_{adj} \times 0.472 + 286$
8	Chest freezer: $1.35 \times (V_{adj} \times 0.446 + 181)$(note) Upright freezer: $1.35 \times (V_{adj} \times 0.472 + 286)$(note)

Note: The figure 1.35 in these equations is the correction factor for no-frost models

Energy efficiency grade: The energy efficiency grade shall be determined as shown in table

5-4.

Table 5-4

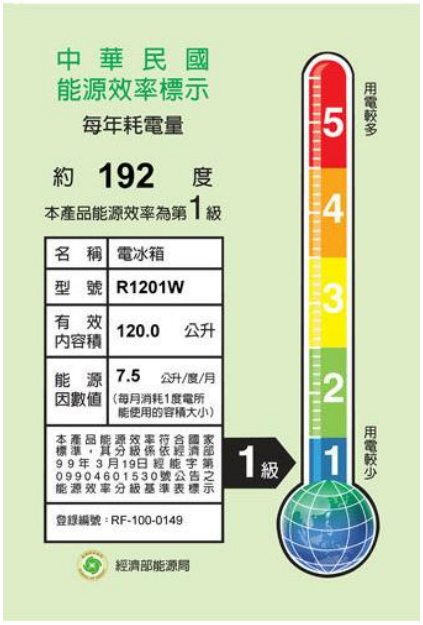
Energy efficiency grade	Energy consumption index: I_ε(%)
1	$I_\varepsilon \leq 35$
2	$35 < I_\varepsilon \leq 44$
3	$44 < I_\varepsilon \leq 55$
4	$55 < I_\varepsilon \leq 69$
5	$69 < I_\varepsilon$

MEPS: No such requirements.

Chinese Taipei

Energy label scheme: Japan has mandatory energy labelling program for household refrigerators since 2010 and latest updated on 2012.Household refrigerator or a household combination refrigerator-freezer shall comply with maximum energy consumption limit requirements.
This uses grade system from 5 (worst) to 1 (best).

Energy label format:



Appliancecategory: All refrigerators shall be classified into one of the 8 product categories on the following table 6-1.
Table 6-1

Appliance category	Household refrigerating appliance description
1	A frost-free refrigerator-freezer with volume <400L
2	A frost-free refrigerator-freezer with volume >400L
3	A refrigerator-freezer with volume <400L
4	A refrigerator-freezer with volume >400L
5	A refrigerator

Adjusted volume: The adjusted volume V_{adj} is calculated as formula 5-1.
$V = V_R + K \times V_F$……..……formula 6-1
Where
V = adjusted volume, L
V_R = the measured storage volume of fresh food compartment, L
K = the compartment factor, is equal to 1.56 for two-star compartment, is 1.67 for super two-star compartment, is 1.78 for three star or four star compartment
V_F = the measured storage volume of frozen food compartment, L

Energy factor value: Energy factor value (E.F.) is determined by table 6-2

Table 6-2

Appliance category	Household refrigerating appliance description	E.F.
1	A frost-free refrigerator-freezer with volume <400L	E.F.=V/(0.037V+24.3)
2	A frost-free refrigerator-freezer with volume >400L	E.F.=V/(0.031V+21.0)
3	A refrigerator-freezer with volume <400L	E.F.=V/(0.033V+19.7)
4	A refrigerator-freezer with volume >400L	E.F.=V/(0.029V+17.0)
5	A refrigerator	E.F.=V/(0.033V+15.8)

Energy efficiency index: The energy efficiency index of a refrigerating appliance is defined by the formula6-2.

Energy efficiency index = $\frac{V_{test}/E_{test}}{\text{E.F.}} \times 100\%$ ……..……formula 6-2

Where

V_{test} = measured storage volume, L

E_{test}=actual monthly energy consumption of the refrigerating appliance measured in energy consumption test, kWh/month.

E.F. = energy factor value is determined from table 5-2.

Energy efficiency grade: The energy efficiency grade shall be determined as shown in table 6-3.

Table 6-3

Energy efficiency grade	Energy consumption index: EEI (%)
1	EEI>121
2	114＜EEI≤121
3	107＜EEI≤114
4	100＜EEI≤107
5	EEI≤100

MEPS: No such requirements.

Japan

Energy label scheme: Japan has mandatory energy labelling program for household refrigerators since 1999 and latest updated on 2013.Household refrigerator or a household combination refrigerator-freezer shall comply with maximum energy consumption limit requirements.

Energy label format:

Appliance category: All refrigerators shall be classified into one of these product categories on the following table7-1.

Table 7-1

Appliancecategory	Refrigerators and Refrigerator-freezers	Freezer
A	Cooled by natural circulation	Cooled by natural circulation
B	Cooled by forced air circulation, rated volume< 300 L	Cooled by forced air circulation, rated volume< 300 L
C	Cooled by forced air circulation, rated volume> 300 L, with 1 door in fresh food compartment	Cooled by forced air circulation, rated volume> 300 L
D	Cooled by forced air circulation, rated volume> 300 L, with ≥2 door in fresh food compartment	Empty

Adjusted volume: The adjusted volume V_{adj} is calculated as formula 7-1 and 7-2.

For refrigerator and refrigerator-freezer:

$V_2 = K \times V_f + V_{other}$ …….…. formula 7-1

V_{other} = rated volume of compartment except for frozen food compartment.

V_f = rated volume of frozen food compartment

K = factor. K=2.20 for three-star compartment; K=1.87 for two-star compartments; K=1.54 for one-star compartments.

For freezer:

$V_2 = K \times V_f$……..…. formula 7-2

V_f = rated volume of frozen food compartment

K = factor. K=2.20 for three-star compartment; K=1.87 for two-star compartments; K=1.54 for one-star compartments.

Energy efficiency index: No such requirements.

Energy efficiency grade: No such requirements.

MEPS: The maximum energy consumption limit requirements were determined by applying table 7-2 formulas.

Table 7-2

Appliancecategory	Maximum energy consumption limit(kWh/y)	
	Refrigerators and Refrigerator-freezers	Freezer
A	$0.844V_2+155$	$0.844V_2+155$
B	$0.774V_2+220$	$0.774V_2+220$
C	$0.302V_2+343$	$0.302V_2+343$
D	$0.296V_2+374$	Empty

Where

V_2 = Adjusted volume, in litres.

Korea

Energy label scheme: Korea has mandatory energy labelling program for household refrigerators since 1993and latest updated on 2010.Household refrigerator or a household combination refrigerator-freezer shall comply with maximum energy consumption limit requirements.
This uses grade system from 5 (worst) to 1 (best).
Energy label format:

Appliance category: All refrigerators shall be classified into one of these product categories on the following table 8-1.
Table 8-1

Adjusted Volume (in Litre)		$\sum\{(\text{compartment volume}) \times \text{K(ajusted value)} \times \text{F(auto} - \text{deforest1.2, outside 1.0)}$			-K Value - (4 star: 2.15 2 star: 1.85)
Maximum Energy Consumption	Refrigerator	0.037AV+16.35			-
	Refrigerator-freezer with volume < 500L	0.025AV+29.45			
	Refrigerator-freezer with volume > 500L	0.043AV+16.19			
	Refrigerator-freezer with volume > 500L (H/B, Disp.)	0.043AV+16.19+2.6(Disp.) +0.022×(refrigerate HOME BAR Gasket length[cm]) +0.036×(freeze HOME BAR Gasket length[cm])			- H/B, Disp. The adjusted value assigned on the model
	Refrigerator-freezer with volume > 1000L (H/B, Disp.)	0.021AV+33.25+2.6(Disp.) +0.022×(refrigerate HOME BAR Gasket length[cm]) +0.036×(freeze HOME BAR Gasket length[cm])			
Rate of Energy Consumption	Rate Index	Adjusted Volume<500L	Adjusted Volume >500L	Adjusted Volume >1000L	Volume differentiation
	1	1.60≤R	1.90≤R	2.20≤R	Maximum energy consumption/energy consumption per month
	2	1.45≤R<1.60	1.75≤R<1.90	1.95≤R<2.20	
	3	1.30≤R<1.45	1.60≤R<1.75	1.70≤R<1.95	
	4	1.15≤R<1.30	1.45≤R<1.60	1.45≤R<1.70	
	5	1.00≤R<1.15	1.00≤R<1.45	1.00≤R<1.45	

Malaysia

Energy label scheme: Malaysia has mandatory energy labelling program for household refrigerators since 1994, and latest updated on 2013.All refrigerators shall comply with energy efficiency grade and maximum energy consumption limit requirements. This uses grade system from 5 (best) to 1 (worst).

Energy label format:

Appliancecategory:All refrigerators shall be classified into one of these product categories on the following table9-1.

Table 9-1

Appliance category	Description of household refrigerator
One-door	Refrigerator
Two-doors	

Adjusted volume: The following formula 9-1 was used in calculating the adjusted volume.

$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$ ……formula 9-1

Where

n – Different compartment quantity.

Vc – Test storage volume (L)

Kc – Different compartment factor, and see table 9-2.

Table 9-2

Compartment category	Kc (Tc)
Cellar compartment	0,71 (12℃)
Fresh food compartment	1,00 (4℃)
Chiller compartment	1,07 (2℃)
One-star compartment (*)	1,36 (-6℃)
Two-star compartment (**)	1,57 (-12℃)
Three-star or more compartment (*** or (***)*)	1,79 (-18℃)

Energy efficiency index: The energy efficiency index shall be determined in the following formula 10-2.

Star index (energy efficiency index) = $(\frac{EERtest}{EERaverage}-1)\times 100\%$…… formula 9-2

Where

EER_{test} = Test energy efficiency ratio, and see formula 9-3.

$EER_{average}$ = Average energy efficiency ratio, and see formula 9-4 and 9-5.

$EER_{test} = \frac{\text{total adjusted volume}}{\text{energy consumption in daily}}$ ..... formula 9-3

For one-door refrigerator,

$EER_{average} = 1.37 \times V_{adj} - 63.3$ ..... formula 9-4

For two-door refrigerator,

$EER_{average} = 0.409 \times V_{adj} + 119.5$ ..... formula 9-5

Energy efficiency grade: The energy efficiency grade shall be determined as shown in table 9-3.

Table 9-3

Star rating (Energy efficiency grade)	Star index value
5	+25%≤Star Index
4	+10%≤Star Index＜+25%
3	-10%≤Star Index＜+10%
2	-25%≤Star Index＜-10%
1	Star Index＜-25%

MEPS: The maximum energy consumption limit requirements were determined by applying table 9-4.

Table 9-4

Appliance category	Minimum Energy Performance Standards(MEPS)
One-door	MEPS's value = 2 Star
Two-doors	

Mexico

Energy label scheme: Mexico has mandatory energy labelling program for household refrigerators since 2002, and latest updated on 2012. Household refrigerator or household combination refrigerator-freezer that has a compressor-cycled system – and a capacity of 1104 L(39 ft^3) or less shall comply with maximum energy consumption limit requirements. Household freezer that has a compressor-cycled system – and a capacity of 850 L(30 ft^3) or less shall also comply with maximum energy consumption limit requirements.

Energy label format:

Appliance category: All refrigerators shall be classified into one of the 18 product groups on the following table10-1.

Table 10-1

Appliancecategory	Household refrigerating appliance description
1	Refrigerator only. Conventional and refrigerator-freezer (R/F) with manual or semiautomatic defrosting.
2	Refrigerator-freezer with partially automatic defrosting
3	Refrigerator-freezer with auto-defrosting and top-mounted freezer, without ice dispenser, and refrigerator only with auto-defrosting
4	Refrigerator-freezer with auto-defrosting and side-mounted freezer, without ice dispenser
5	Refrigerator-freezer with auto-defrosting and bottom-mounted freezer, without ice dispenser
6	Refrigerator-freezer with auto-defrosting and top-mounted freezer, with ice dispenser
7	Refrigerator-freezer with auto-defrosting and side-mounted freezer, with ice dispenser
8	Vertical freezer with manual defrosting
9	Vertical freezer with auto-defrosting
10	Horizontal freezer and all other freezers, except compact freezer
11	Refrigerator and compact refrigerator-freezer with manual defrosting
12	Compact refrigerator-freezer with partially automatic defrosting
13	Compact refrigerator-freezer with auto-defrosting and top-mounted freezer and compact refrigerator only with auto-defrosting
14	Compact refrigerator-freezer with auto-defrosting and side-mounted freezer
15	Compact refrigerator-freezer with auto-defrosting and bottom-mounted freezer
16	Compact vertical freezer with manual defrosting
17	Compact vertical freezer with auto-defrosting
18	Compact horizontal freezer

Adjusted volume: The following formula 10-1 was used in calculating the adjusted volume.

$AV = V_a + (V_c \times AF)$ …… formula 10-1

Where

AV = Adjusted volume, in litres.

V_a = Fresh food compartment volume, in litres.

V_c = Freezer compartment volume in a refrigerator appliance in litres.

AF = Adjustment factor, determined as indicated in formula 11-2.

$AF = \frac{t-t_c}{t-t_a}$……formula 10-2

Where

AF = Adjustment factor.

t = test room temperature.

t_c= freezer compartment reference temperature.

t_a = food compartment average operating temperature.

Note: Food compartment average operating temperature must be 3.3℃.

For refrigerator only, the adjustment factor is 1.00.

For conventional refrigerators, the adjustment factor is:$AF = \frac{32.2-(-9.4)}{32.2-3.3} = 1.44.$

For refrigerator-freezer, the adjustment factor is:$AF = \frac{32.2-(-15)}{32.2-3.3} = 1.63.$

For horizontal and vertical freezers, the adjustment factor is:$AF = \frac{32.2-(-17.8)}{32.2-3.3} = 1.73.$

Energy efficiency index: No such requirements.

Energy efficiency grade:No such requirements.

MEPS: The following table 10-2 formulas were used in calculating the maximum allowable values of energy consumptions (E_{max}) requirements.

Table 10-2

Appliancecategory	E_{max} formula	Appliancecategory	E_{max} formula
1	0.31AV+248.4	10	0.35AV+143.7
2	0.31AV+248.4	11	0.38AV+299.0
3	0.35AV+276.0	12	0.25AV+398.0
4	0.17AV+507.5	13	0.45AV+355.0
5	0.16AV+459.0	14	0.27AV+501.0
6	0.36AV+356.0	15	0.46AV+367.0
7	0.36AV+406.0	16	0.35AV+250.8
8	0.27AV+258.3	17	0.40AV+391.0
9	0.44AV+326.1	18	0.37AV+152.0

Where

AV = Adjusted volume, in litres.

New Zealand

In New Zealand all refrigerators have the same requirements with Australia.

Philippines

Energy label scheme: Philippines has mandatory energy labelling program for household refrigerators since 2014.All refrigerators shall comply with energy efficiency grade and maximum energy consumption limit requirements. This uses grade system from 5 (worst) to 1 (best).

Energy label format:

Appliancecategory: All refrigerators shall be classified into one of these product categories on the following table 11-1.

Table 11-1

Appliancecategory	EEF
Single Door Appliance	170 L/kWh/24h
Two Door direct cooling Appliance	107 L/kWh/24h
Frost Free Appliance	126 L/kWh/24h

Adjusted volume: The following formula 8-1 was used in calculating the adjusted volume.

$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$ ……formula 11-1

Where

n – Different compartment quantity.

Vc – Test storage volume (L)

Kc – Different compartment factor, and see table 11-2.

Table 11-2

Compartment category	Kc (Tc)
Cellar compartment	0,71 (12℃)
Fresh food compartment	1,00 (4℃)
Chiller compartment	1,07 (2℃)
One-star compartment (*)	1,36 (-6℃)
Two-star compartment (**)	1,57 (-12℃)
Three-star or more compartment (*** or (***)*)	1,79 (-18℃)

Energy efficiency index: The energy efficiency index shall be determined in the following formula 11-2.

EEF (energy efficiency index) $= \frac{\text{total adjusted volume}}{\text{energy consumption in daily}}$ ..... formula 12-2

Energy efficiency grade: The energy efficiency grade shall be determined as shown in table 11-3.

Table 10-3

Appliancecategory		1 star	2 star	3 star	4 star	5 star
Single Door Appliance	EEF range	170 to 178	179 to 198	199 to 244	245 to 269	270 and up
Two Door direct cooling Appliance	EEF range	107 to115	116 to 219	220 to 231	232 to 250	251 and up
Frost Free Appliance	EEF range	126 to145	146 to 157	158 to 194	195 to 204	205 and up

MEPS: The following table 11-4 was used in calculating the maximum allowable values of energy consumptions (E_{max}) requirements.

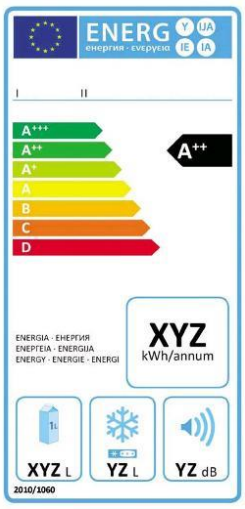
Table 11-4

Appliancecategory	Maximum allowable values of energy consumptions(kWh/year)
Single Door Appliance	V_{adj}*365/170
Two Door direct cooling Appliance	V_{adj}*365/107
Frost Free Appliance	V_{adj}*365/126

Russia

Energy label scheme: Russia has mandatory energy labelling program for household refrigerators since 2010, and latest updated on 2014.All refrigerators that exclude the display or especial used refrigerator shall comply with energy efficiency grade and maximum energy consumption limit requirements. This uses grade system from G (worst) to A++ (best).

Energy label format:



Appliance category: All refrigerators shall be classified into one of the 10 product categories on the following table 12-1.

Table 12-1

Appliance category	Household refrigerating appliance description
1	Refrigerator with one or more fresh-food storage compartments
2	Refrigerator-cellar, Cellar and Wine storage appliances
3	Refrigerator-chiller and Refrigerator with a 0-star compartment
4	Refrigerator with a one-star compartment
5	Refrigerator with a two-star compartment
6	Refrigerator with a three-star compartment
7	Refrigerator-freezer
8	Upright freezer
9	Chest freezer
10	Multi-use and other refrigerating appliances

Adjusted volume: The following formula 12-1 was used in calculating the adjusted volume.

$V_{adj\ tot} = \sum_{c=1}^{n} Vc \times Wc \times FFc \times BI \times CC$ …… formula 12-1

Where

n = different compartment quantity.

Vc = test storage volume. L.

FFc = factor. Fc=1.2 where use the frost-fee refrigerating system in refrigerator. Otherwise, Fc=1.0.

CC = climatic class factor. CC=1 where the climatic class is N or SN, CC=1.1 where the climatic class is ST, CC=1.2 where the climatic class is T.

Wc = the different compartment factor, and see table 13-2.

BI = the built-in factor. BI=1.2 where the built-in appliances under 58 cm in width, BI=1.0 otherwise.

Table 12-2

Compartment Type	Fresh-food storage compartment	Cellar compartment	Chill compartment	One-star compartment	Two-star compartment	Three-star compartment	Frozen food compartment	Special compartment
Tc/℃	5	10	0	-6	-12	-18	-18	Tc
Wc	1.00	0.75	1.25	1.55	1.85	2.15	2.15	$\frac{25-\mathrm{Tc}}{20}$

Note: Tc = the design temperature of compartment or the temperature declared by manufacture.

Energy efficiency index:The energy efficiency index shall be determined in the following formula 12-2.

Energy efficiency index (EEI) = $\frac{\mathrm{AEc}}{\mathrm{SAEc}}\mathrm{x}100\%$ ……..…..… formula 12-2

Where

AEc = Annual energy consumption of the household refrigerating appliance, (kWh/y)

SAEc = Standard annual energy consumption of the household refrigerating appliance, (kWh/y), and see formula 13-3.

The standard annual energy consumption (SAEc) is calculated in kWh/year and rounded to two decimal places, as:

SAEc =$\mathrm{M} \times \mathrm{Vadj\ tot} + \mathrm{N} + \mathrm{CH}$……..…… formula 12-3

Where

M = factor. KWh/L, and see table 12-3.

$V_{adj\ tot}$ = total adjusted volume.

N = factor. KWh, and see table 12-3.

CH = variable temperature compartment factor. CH=50 where have the storage volume 15L or more, and with the chill compartment temperature range. Otherwise, CH=0.

Table 12-3

Appliance category	Household refrigerating appliance description	M/(kWh/L)	N/(kWh)
1	Refrigerator with one or more fresh-food storage compartments	0.233	245
2	Refrigerator-cellar, Cellar and Wine storage appliances	0.233	245
3	Refrigerator-chiller and Refrigerator with a 0-star compartment	0.233	245
4	Refrigerator with a one-star compartment	0.643	191
5	Refrigerator with a two-star compartment	0.450	245
6	Refrigerator with a three-star compartment	0.777	303
7	Refrigerator-freezer	0.777	303
8	Upright freezer	0.539	315
9	Chest freezer	0.472	286

10	Multi-use and other refrigerating appliances	(*)	(*)

Energy efficiency grade: The energy efficiency grade shall be determined in the following table 11-4.

Table 12-4

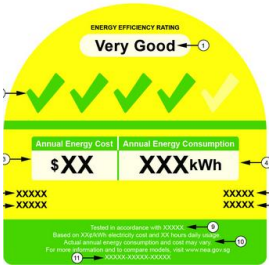
Energy efficiency grade	Energy efficiency index(EEI)
A	**42** $\leqslant EEI <$ 55
B	55 $\leqslant EEI <$ 75
C	75 $\leqslant EEI <$ 95
D	95 $\leqslant EEI <$ 110
E	110 $\leqslant EEI <$ 125
F	125 $\leqslant EEI <$ 150
G	$EEI \geqslant$ 150

MEPS:No such requirements.

Singapore

Energy label scheme: Singapore has mandatory energy labelling program for household refrigerators since2008, and latest updated on2014.All refrigerators shall comply with energy efficiency grade and maximum energy consumption limit requirements. This uses grade system from 4 (best) to 1 (worst).

Energy label format:



Appliance category: All refrigerators shall be classified into one of these product categories on the following table 13-1.

Table 13-1

Appliance category	Description of household refrigerator
1	Without freezer
2	With freezer
3	With freezer, through-the-door ice dispenser

Adjusted volume: The following formula 12-1 was used in calculating the adjusted volume.

$V_{adj} = \sum V_i \times K$ ……formula 13-1

Where

V_i = the rated storage volume of an individual compartment.

K = the volume correction factor given by the table 13-2.

Table 13-2

Compartment Type	K
Fresh food compartment	1.00
Four-star compartment	1.79
Three-star compartment	1.79
Two-star compartment	1.57
One-star compartment	1.36
Chill compartment	1.13
Cellar compartment	0.75

Energy efficiency index: The energy efficiency index shall be determined in the following table13-3 formula.

Table 13-3

Appliancecategory	Energy efficiency

	index
Without freezer	$368+0.892\times V_{adj\ tot}$
With freezer	$465+1.378\times V_{adj\ tot}$
With freezer, through-the-door ice dispenser	$585+1.378\times V_{adj\ tot}$

Energy efficiency grade: The energy efficiency grade shall be determined as shown in table 13-4.

Table 13-4

Ticks (Energy efficiency grade)	Without freezer	With freezer	With freezer, through-the-door ice dispenser
1	(index ×0.64)≥ AEC ＞(index ×0.461)	(index×0.585)≥ AEC ＞(index ×0.427)	(index ×0.56)≥ AEC ＞(index×0.409)
2	(index ×0.461)≥AEC ＞(index×0.332)	(index ×0.427)≥ AEC＞ (index×0.312)	(index×0.409)≥ AEC ＞(index×0.298]
3	(index ×0.332)≥ AEC＞(index×0. 239)	[index ×0.312] ≥ AEC ＞ [index ×0.228]	(index×0.298)≥ AEC ＞(index ×0.218)
4	(index ×0. 239]≥AEC	(index×0.228)≥ AEC	(index ×0.218) ≥ AEC
5			

Note: AEC is the test energy consumption in year.

MEPS: The following table 13-5 was used in calculating the maximum allowable values of energy consumptions requirements.

Table 13-5

Appliancecategory	Maximum annual energy consumption(kWh/year)
Without freezer	$(368+0.892\times V_{adj\ tot}) \times 0.64$
With freezer	$(465+1.378\times V_{adj\ tot}) \times 0.585$
With freezer, through-the-door ice dispenser	$(585+1.378\times V_{adj\ tot}) \times 0.56$

Note: $V_{adj\ tot}$ is the adjusted volume of the refrigerator.

Thailand

Energy label scheme: Thailand has voluntary energy labelling program for household refrigerators since 1994, and latest updated on 2012.All refrigerators shall comply with maximum energy consumption limit requirements. This uses grade system for refrigerators from 5 (best) to 1 (worst).

Energy label format:

Appliance category: All refrigerators shall be classified into one of these product categories on the following table 14-1.

Table 14-1

Appliance category	Refrigerator type
	One door refrigerator, manually defrosted andsemi-automatically defrosted
1	- V_{adj}< 100
2	- V_{adj}≥ 100
	Two door refrigerator, manually defrosted, semiautomatically and automatically defrosted
3	- V_{adj}< 450
4	- V_{adj}≥ 450

Adjusted volume: The following formula 14-1 was used in calculating the adjusted volume.

$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$ ……formula 13-1

Where

n – Different compartment quantity.

Vc – Test storage volume (L)

Kc – Different compartment factor, and see table 14-2.

Table 14-2

Compartment category	Kc (Tc)
Cellar compartment	0,71 (12℃)
Fresh food compartment	1,00 (4℃)
Chiller compartment	1,07 (2℃)
One-star compartment (*)	1,36 (-6℃)

Two-star compartment (**)	1,57 (-12℃)
Three-star or more compartment (*** or (***)*)	1,79 (-18℃)

Energy efficiency index: No such requirements

Energy efficiency grade: The energy efficiency grade shall be determined as shown in table 14-3.

Table 14-3

Energy efficiency grade	One door V_{adj}< 100	One door V_{adj}≥ 100	Two door V_{adj}< 450	Two door V_{adj}≥ 450
1				
2				
3	AEC≤0.74V_{adj}+278	AEC≤0.43V_{adj}+158	AEC≤ 0.43V_{adj}+423	AEC≤ 0.74V_{adj}+423
4	AEC≤0.68V_{adj}+255	AEC≤0.39V_{adj}+145	AEC≤ 0.39V_{adj}+388	AEC≤ 0.68V_{adj}+388
5	AEC≤0.62V_{adj}+233	AEC≤0.36V_{adj}+133	AEC≤ 0.36V_{adj}+354	AEC≤ 0.62V_{adj}+354

Note: AEC is the test energy consumption in year.

MEPS: The following table 14-4 was used in calculating the maximum allowable values of energy consumptions requirements.

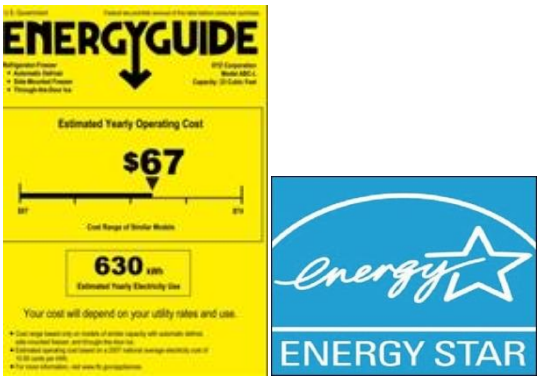
Table 14-4

Maximum energy consumption(kWh/y)			
One door V_{adj}< 100	One door V_{adj}≥ 100	Two door V_{adj}< 450	Two door V_{adj}≥ 450
0.80V_{adj}+300	0.46V_{adj}+171	0.46V_{adj}+457	0.80V_{adj}+457

USA

Energy label scheme: USA has mandatory energy labelling program for household refrigerators since 1999, and latest updated on 2014. Household refrigerator or household combination refrigerator-freezer that has a compressor-cycled system – and a capacity of 1104 L(39 ft^3) or less shall comply with maximum energy consumption limit requirements. Household freezer that has a compressor-cycled system – and a capacity of 850 L(30 ft^3) or less shall also comply with maximum energy consumption limit requirements.

Energy label format:



Appliance category: All refrigerators shall be classified into one of these product groups on the following table 15-1.

Table 15-1

Appliance category	Household refrigerating appliance description
1	Refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost
1A	All-refrigerators—manual defrost
2	Refrigerator-freezers—partial automatic defrost
3	Refrigerator-freezers—automatic defrost with top-mounted freezer without an automatic icemaker
3-BI	Built-in refrigerator-freezer—automatic defrost with top-mounted freezer without an automatic icemaker
3I	Refrigerator-freezers—automatic defrost withtop-mounted freezer with an automatic icemaker without through-the-door ice service
3I-BI	Built-in refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker without through-the-door ice service
3A	All-refrigerators—automatic defrost
3A-BI	Built-in All-refrigerators—automatic defrost
4	Refrigerator-freezers—automatic defrost withside-mounted freezer without an automatic icemaker
4-BI	Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker
4I	Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service
4I-BI	Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without through-the-door ice service
5	Refrigerator-freezers—automatic defrost with bottom-mounted freezer

	without an automatic icemaker
5-BI	Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker
5I	Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service
5I-BI	Built-In Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without through-the-door ice service
5A	Refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service
5A-BI	Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service
6	Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service
7	Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service
7-BI	Built-In Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service
8	Upright freezers with manual defrost
9	Upright freezers with automatic defrost without an automatic icemaker
9I	Upright freezers with automatic defrost with an automatic icemaker
9-BI	Built-In Upright freezers with automatic defrost without an automatic icemaker
9I-BI	Built-in upright freezers with automatic defrost with an automatic icemaker
10	Chest freezers and all other freezers except compact freezers
10A	Chest freezers with automatic defrost
11	Compact refrigerator-freezers and refrigerators other than all-refrigerators with manual defrost
11A	Compact all-refrigerators—manual defrost
12	Compact refrigerator-freezers—partial automatic defrost
13	Compact refrigerator-freezers—automatic defrost with top-mounted freezer
13I	Compact refrigerator-freezers—automatic defrost with top-mounted freezer with an automatic icemaker
13A	Compact all-refrigerators—automatic defrost
14	Compact refrigerator-freezers—automatic defrost with side-mounted freezer
14I	Compact refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker
15	Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer
15I	Compact refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker
16	Compact upright freezers with manual defrost
17	Compact upright freezers with automatic defrost
18	Compact chest freezers

Adjusted volume: The following formulas 15-1 and 15-2 were used in calculating the adjusted volume.

For electric refrigerators,

av = (VF × CR) + VFF ……formula 15-1

Where

VF = Freezer compartment test volume in litres.

VFF = Fresh food compartment test volume in litres.

CR = Dimensionless adjustment factor of 1.47 for refrigerators other than all-refrigerators, or 1.0 for all-refrigerators.

For electric Refrigerator-Freezers,

av = (VF × CRF) + VFF……..……formula 15-2

Where
VF = Freezer compartment test volume in litres.
VFF = Fresh food compartment test volume in litres.
CRF = Dimensionless adjustment factor of 1.76.
Energy efficiency index: No such requirements

Energy efficiency grade: No such requirements

MEPS: The following table 15-2 formulas were used in calculating the maximum allowable values of energy consumptions (E_{max}) requirements.
Table 15-2

Appliancecategory	E_{max} formula	Appliancecategory	E_{max} formula
1	0.282av + 225.0	7-BI	0.362av + 502.6
1A	0.240av + 193.6	8	0.197av + 193.7
2	0.282av + 225.0	9	0.305av + 228.3
3	0.285av + 233.7	9I	0.305av + 312.3
3-BI	0.323av + 264.9	9-BI	0.348av + 260.9
3I	0.285av + 317.7	9I-BI	0.348av + 344.9
3I-BI	0.323av + 348.9	10	0.257av + 107.8
3A	0.323av + 348.9	10A	0.362av + 148.1
3A-BI	0.283av + 228.5	11	0.319av + 252.3
4	0.301av + 297.8	11A	0.277av + 219.1
4-BI	0.361av + 357.4	12	0.209av + 335.8
4I	0.301av + 381.8	13	0.417av + 339.2
4I-BI	0.361av + 441.4	13I	0.417av + 423.2
5	0.312av + 317.0	13A	0.324av + 259.3
5-BI	0.332av + 336.9	14	0.241av + 456.9
5I	0.312av + 401.0	14I	0.241av + 540.9

5I-BI	0.332av + 420.9	15	0.417av + 339.2
5A	0.327av + 475.4	15I	0.417av + 423.2
5A-BI	0.347av + 499.9	16	0.306av + 225.7
6	0.297av + 385.4	17	0.359av + 351.9
7	0.302av + 432.8	18	0.327av + 136.8

Where
av = Total adjusted volume, expressed in litres.

Viet Nam

Energy label scheme: Viet Nam has mandatory energy labelling program for household refrigerators since 2007, and latest updated on 2013. Household refrigerator or household combination refrigerator-freezer that has a compressor-cycled system – and a capacity of 1000 L or less shall comply with maximum energy consumption limit requirements. This uses grade system from 5 (best) to 1 (worst).

Energy label format:

Appliance category: All refrigerators shall be classified into one of these product groups on the following table 16-1.

Table 16-1

Appliance category	Description of household refrigerator
1	Refrigerator
2	Refrigerator-freezer
3	Freezer

Adjusted volume: The following formula 16-1 was used in calculating the adjusted volume.

$V_{adj}=\sum_{c=1}^{n}(V_c \times K_c)$ ……formula 16-1

Where

n – Different compartment quantity.

Vc – Test storage volume (L)

Kc – Different compartment factor, and see table 16-2.

Table 16-2

Compartment category	Kc (Tc)
Cellar compartment	0,71 (12℃)
Fresh food compartment	1,00 (4℃)
Chiller compartment	1,07 (2℃)
One-star compartment (*)	1,36 (-6℃)
Two-star compartment (**)	1,57 (-12℃)
Three-star or more compartment (*** or (***)*)	1,79 (-18℃)

Energy efficiency index:The energy efficiency index shall be determined in the following formula 16-2.

$R = \frac{E_{max(MEPS)}}{E_{annual}}$ ……formula 16-2

Where

E_{annual}– Test energy consumption (kWh/year);

E_{max} – Maximum energy consumption per year (kWh/year), and see table 16-4.

Energy efficiency grade: The energy efficiency grade shall be determined in the following table 16-3.

Table 16-3

Level (Energy efficiency grade)	Energy consumption index (R)
1	$R \leq 1,0$
2	$1,0 < R \leq 1,2$
3	$1,2 < R \leq 1,4$
4	$1,4 < R \leq 1,6$
5	$R > 1,6$

MEPS: The maximum energy consumptions for refrigerator and freezer were determined in accordance with table 16-4.

Table 16-4

Appliance category	MEPS(kWh/year)
Refrigerator	$E_{max} = 0,302\ V_{adj} + 386$
Refrigerator-freezer and freezer	$E_{max} = 0,451\ V_{adj} + 515$

Where

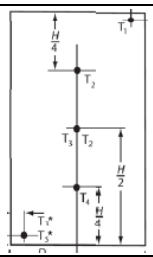
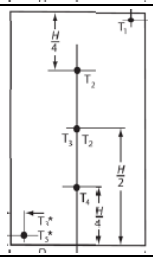
E_{max} = Maximum energy consumption per year (kWh/year)

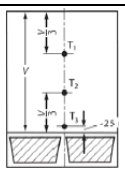
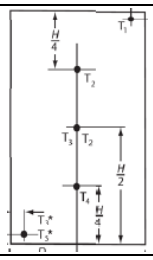
Annex II Test Methods for Refrigerators in APEC Region

Australia/ New Zealand

Table 1 Australia and New Zealand test method for refrigerators

Test conditions	
Test ambient temperature	32.0±0.5℃
humidity	No requirements
air circulation	Not exceed 0.25m/s
vertical ambient temperature gradient	1K/m
Measuring instruments	
temperature control device	±0.5℃,nearest 0.1℃
humidity control device	No requirements
watt-hour meters	Not greater than 2% at the 95% confidence level. Nearest 1Wh
Time interval	60s
measurement of storage temperature (fresh-food)	Air temperature sensors: Comprising a thermocouple soldered into a drilling in the end of a solid copper cylinder 25mm diameter and 25mm long is equivalent to slightly more than 10 g of water.
measurement of storage temperature (cellar)	Air temperature sensors
measurement of storage temperature (chill)	Air temperature sensors
measurement of storage temperature (frozen-food storage)	Air temperature sensors
test packages	Not use
M-packages	Not use
Platform	The bottom of the platform shall not be less than 0, 3 m above the test room floor and shall extend at least 0,3 m beyond, but not extend 0.6m, all sides of the refrigerating appliance, except at the rear where it shall extend to the vertical partition.
Installation of refrigerators	Each refrigerating appliance shall be placed on a wooden solid-top platform1 painted dull black and open for free air circulation under the platform. The vertical partitions shall present no discontinuity. They shall be of such a height that they extend at least 0,3 m above the top of the refrigerating appliance. Circulation of air around the refrigerating appliance shall be restricted by surrounding the refrigerating appliance with three vertical partitions made of wood, 16 mm to 30 mm thick, painted dull black and arranged as follows: a) One of the partitions shall be placed parallel to the rear of the refrigerating appliance: for free-standing

	appliances, against the stops; for built-in appliances, at the distance specified by the manufacturer in connection with the required overall space. At the rear of this partition there shall be a sufficient air gap to the room wall (W 30 mm) to minimize the influence of adjacent structures. b) The two other partitions shall be parallel to the sides of the cabinet, and shall be fixed on the platform 0,3 m from the sides of the cabinet; they shall be 0,3 m wide. The refrigerating appliance shall be so placed or shielded as to prevent direct radiation to or from the space cooling or heating equipment or windows in the test room, and shall be placed far enough away from all other objects in the test room to ensure that the air surrounding the refrigerating appliance is at ambient temperature.
Temperature-control setting	The target temperature setting
anti-condensation heaters setting	Remain operational
all shelves setting	Remain
accessories setting	Ice cube empty
power supply voltage and frequency	240V±1%, 50Hz±1%
target temperature (cellar)	Average: 12℃
target temperature (chill)	Average: 0℃
target temperature (fresh food storage)	Average: 3℃
target temperature (frozen-food storage *)	Ice-making: no requirements.
target temperature (frozen-food storage **)	Short term frozen average: -9℃
target temperature (frozen-food storage ***)	Freezer Average: -15℃ Special frozen: claimed maximum operating temperature.
storage plan of cellar compartment temperature sensors	
storage plan of chill compartment temperature sensors	

storage plan of fresh food compartment temperature sensors	
storage plan of frozen-food storage temperature sensors	
determination method of the energy	1.directly from the results of a single test run. 2.by interpolation.
test period	At least 24h

Chinese Taipei

Table 2 Chinese Taipei test method for refrigerators

Test conditions	
Test ambient temperature	30.0±1.0℃,
humidity	75±5%
air circulation	No requirements
vertical ambient temperature gradient	
Measuring instruments	
temperature control device	No requirements
humidity control device	No requirements
watt-hour meters	No requirements
Time	30s
measurement of storage temperature (fresh-food)	Air temperature sensors: Comprising a thermocouple soldered into a drilling in the end of a solid copper cylinder 30mm diameter and 30mm long .
measurement of storage temperature (frozen-food storage)	Air temperature sensors: Comprising a thermocouple soldered into a drilling in the end of a solid copper cylinder 30mm diameter and 30mm long .
test packages	No loading
M-packages	No loading
Platform	The bottom of the platform shall not be less than 0, 3 m above the test room floor and shall extend at least 0,3 m beyond, but not extend 0.6m, all sides of the refrigerating appliance, except at the rear where it shall extend to the vertical partition.
Installation of refrigerators	The surface of each side, front and top of a refrigerator or freezer shall be at least 300mm from the walls around the appliance for the purpose of heat dissipation. The rear shall be placed parallel to the back wall at the minimum distance specified by the manufacturer. The distance is equal to 65mm If it is not specified. When there is a temperature difference that is more than 2℃between the ground temperature and the surrounding temperature, refrigerators or freezers shall be placed on a wooden platform of which height shall not be less than 100mm.
Temperature-control setting	Setting for the target temperature.
anti-condensation heaters setting	Where anti-condensation heaters and other electrical device for user adjust, shall be on.

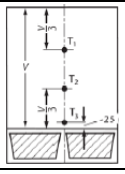
all shelves setting	In normal position. Basket in freezer compartment removes.
accessories setting	All accessories are in normal position, Auto ice maker shall be inoperative Ice cube empty.
power supply voltage and frequency	110V or 220±2%V; 60±1% Hz
target temperature (cellar)	No such compartment
target temperature (chill)	No such compartment
target temperature (fresh food storage)	Average: 3.0±0.5℃
target temperature (frozen-food storage *)	No such compartment
target temperature (frozen-food storage **)	Average: -12±0.5℃
target temperature (frozen-food storage super**)	Average: -15±0.5℃
target temperature (frozen-food storage ***)	Average: -18±0.5℃
storage plan of cellar compartment temperature sensors	No such compartment
storage plan of chill compartment temperature sensors	No such compartment
storage plan of fresh food compartment temperature sensors	Temperature sensor position shall be at a 1/3 height between the bottom of the fresh food compartment and the evaporator. And it shall be placed at the centre of the distance from the internal surface of the door to the rear of the compartment. Simultaneously, it shall be placed at the centre of the distance between the left side and right side. Where there is no evaporator inside this compartment or the evaporator is vertical plate, temperature sensor shall be placed at 1/3 height from the top to the bottom. And it shall be placed at the centre of the distance from the front door to the rear and from the left side to the right side. Where the bottom of fresh food compartment is not horizontal which leads to compartment temperature fails to be determined, the sensor shall be placed at point A , a horizontal distance of no more than 30mm (refer to figure 2). Where the temperature sensor position is over or under a shelf 30mm or less, then it shall be placed at the

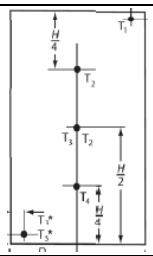
	geometric centre over the shelf as figure 3 shown. Determination of the height H. Where the evaporator is vertical plate (figure 4), the height shall be measured from below the horizontal part. Where the evaporator slopes as figure 5 shown, the height is given by the following formula: $H = \frac{H_1+H_2}{2}$ Where the wide of evaporator is less than 1/2 wide of fresh food compartment, it shall be determined as the method shown in figure 6. Where there are more than 2 separate fresh food compartments, each of these 2 compartments temperature shall be determined separately.
storage plan of frozen-food storage temperature sensors	Where frozen food compartment temperature is determined. Test load and ice is not needed. The sensor position shall be placed at 1/3 height from the bottom of compartment to the internal top. Simultaneously, it shall be placed at the centre between the left side and right side and between the front door and the rear. Where the bottom of compartment is not horizontal that leads to the temperature fails to be determined, or the distance from sensor to the wall is less than 30mm, the sensor shall be placed at the position specified horizontal surface, and it is required at least 30mm to the wall. Where the position is less than 30mm to the evaporator, the position shall be placed 30mm over the evaporator. Where the rear of compartment is not a flat plate, effective depth shall be a average value by measuring different depths. Where there are more than 2 separate frozen food compartments, each of these 2 compartments temperature shall be determined separately.
determination method of the energy	1.directly from the results of a single test run during which temperature of all compartment are at or below the target temperature.
test period	At least 24h

USA

Table 3 USA test method for refrigerators

Test conditions	
Test ambient temperature	32.2±0.6℃
humidity	No requirements
air circulation	0.254
vertical ambient temperature gradient	The test room vertical ambient temperature gradient in any foot of vertical distance from 2 inches (5.1 cm) above the floor or supporting platform to a height of 1 foot (30.5 cm) above the top of the unit under test is not to exceed 0.5 °F per foot (0.9 °C per meter).
Measuring instruments	
temperature control device	±0.3℃,nearest 0.1℃
humidity control device	±0.3℃
watt-hour meters	0.01kW. Nearest 1Wh
Time	60s
measurement of storage temperature (fresh-food)	Air temperature sensors: Comprising a thermocouple soldered into a drilling in the end of a solid copper cylinder 29mm diameter and 29mm long is equivalent to slightly more than 20 g of water.
measurement of storage temperature (cellar)	No requirements
measurement of storage temperature (chill)	No requirements
measurement of storage temperature (frozen-food storage)	Air temperature sensors
test packages	No requirements
M-packages	No requirements
Platform	A platform must be used if the floor temperature is not within 3 °F (1.7 °C) of the measured ambient temperature. If a platform is used, it is to have a solid top with all sides open for air circulation underneath, and its top shall extend at least 1 foot (30.5 cm) beyond each side and front of the unit under test and extend to the wall in the rear.
Installation of refrigerators	Each refrigerating appliance shall be placed on a wooden solid-top platform1 painted dull black and open for free air circulation under the platform. The vertical partitions shall present no discontinuity. They shall be of such a height that they extend at least 0,3 m above the top of the refrigerating appliance. Circulation of air around the refrigerating appliance shall be restricted by surrounding the refrigerating appliance with three vertical partitions made of wood, 16 mm to 30 mm thick, painted dull black and arranged as follows: a) One of the partitions shall be placed parallel to the rear of the

	refrigerating appliance: for free-standing appliances, against the stops; for built-in appliances, at the distance specified by the manufacturer in connection with the required overall space. At the rear of this partition there shall be a sufficient air gap to the room wall (W 30 mm) to minimize the influence of adjacent structures. b) The two other partitions shall be parallel to the sides of the cabinet, and shall be fixed on the platform 0,3 m from the sides of the cabinet; they shall be 0,3 m wide. The refrigerating appliance shall be so placed or shielded as to prevent direct radiation to or from the space cooling or heating equipment or windows in the test room, and shall be placed far enough away from all other objects in the test room to ensure that the air surrounding the refrigerating appliance is at ambient temperature.
Temperature-control setting	Middle, Warmest or Coldest
anti-condensation heaters setting	Remain operational
all shelves setting	In normal position. Basket in freezer compartment removes.
accessories setting	Auto ice maker shall be inoperative Ice cube empty Basket removable
power supply voltage and frequency	115V±1V, 60Hz
target temperature (cellar)	No requirements
target temperature (chill)	No requirements
target temperature (fresh food storage)	All refrigerator: 3.9℃ Refrigerator: 3.9℃ Refrigerator-freezer: 3.9℃
target temperature (frozen-food storage *)	No requirements
target temperature (frozen-food storage **)	No requirements
target temperature (frozen-food storage ***)	Refrigerator: -9.4℃ Refrigerator-freezer: -17.8℃
storage plan of cellar compartment temperature sensors	No requirements
storage plan of chill compartment temperature sensors	No requirements
storage plan of fresh food compartment temperature sensors	

storage plan of frozen-food storage temperature sensors	
determination method of the energy	1.by interpolation.
test period	At least 24h

IEC 62552:2007

Table 4 IEC 62552:2007 test method for refrigerators

Test conditions	
Test ambient temperature	25℃or 32℃
humidity	Not exceed 75%
air circulation	Not exceed 0.25m/s
vertical ambient temperature gradient	1K/m
Measuring instruments	
temperature control device	±0.5K;
humidity control device	±0.3K;
watt-hour meters	Nearest 0.001Wh
Time	60s
measurement of storage temperature (fresh-food)	Air temperature sensors: Comprising a thermocouple soldered into a drilling in the end of a solid copper cylinder 15.2mm diameter and 15.2mm long.
measurement of storage temperature (cellar)	Air temperature sensors
measurement of storage temperature (chill)	M-packages
measurement of storage temperature (frozen-food storage)	M-packages
test packages	The test packages used in the tests shall be in the form of rectangular parallelepipeds. Their size, prior to freezing, and their mass, packaging included, shall be in accordance with Table 3. Test packages shall be checked regularly and shall not present visible holes or cracks on the wrapper. The packages shall consist of the following. a) A suitable filling material containing, per 1 000 g: – 230 g of oxyethylmethylcellulose; – 764,2 g of water; – 5 g of sodium chloride; – 0,8 g of 6-chloro-m-cresol. The freezing point of this material is -1 °C (its thermal characteristics correspond to those of lean beef). b) The following alternative composition of test packages with a freezing point near − 5 °C may be used: – 232 g of oxyethylmethylcellulose; – 725 g of water; – 43 g of sodium chloride; – 0,6 g of 6-chloro-m-cresol. In case of dispute, the composition of test package a) shall be used as the reference test package.

	For the measurement of chill compartments, only test package b), with a freezing point of -5 °C, shall be used. c) A wrapper, consisting of a sheet of plastic or any other suitable material of such a nature that exchange of moisture with the ambient medium is negligible. After filling, the wrapping sheet shall be sealed. It is advisable to use a laminated sheet, consisting of layer of high-pressure polyethylene, easily sealable, 120 µm thick, together with an external sheet of polyethyleneterephthalate approximately 12,5 µm thick, the two layers being bonded together.
M-packages	Some of the 500 g packages (50 mm×100 mm×100 mm) shall be equipped for temperature measurement, being fitted with thermocouples or another temperature-measuring device giving equivalent precision, which shall be inserted in the geometrical centre of the packages in direct contact with the filling material. All precautions shall be taken to minimize extraneous conduction of heat. These packages are called M-packages.
Platform	The bottom of the platform shall not be less than 0.05 m above the test room floor and shall extend at least 0,3 m beyond, all sides of the refrigerating appliance, except at the rear where it shall extend to the vertical partition.
Installation of refrigerators	Each refrigerating appliance shall be placed on a wooden solid-top platform1 painted dull black and open for free air circulation under the platform. The vertical partitions shall present no discontinuity. They shall be of such a height that they extend at least 0,3 m above the top of the refrigerating appliance. Circulation of air around the refrigerating appliance shall be restricted by surrounding the refrigerating appliance with three vertical partitions made of wood, 16 mm to 30 mm thick, painted dull black and arranged as follows: a) One of the partitions shall be placed parallel to the rear of the refrigerating appliance: for free-standing appliances, against the stops; for built-in appliances, at the distance specified by the manufacturer in connection with the required overall space. At the rear of this partition there shall be a sufficient air gap to the room wall (W 30 mm) to minimize the influence of adjacent structures. b) The two other partitions shall be parallel to the sides of the cabinet, and shall be fixed on the platform 0,3 m from the sides of the cabinet; they shall be 0,3 m wide. The refrigerating appliance shall be so placed or shielded as to prevent direct radiation to or from the space cooling or heating

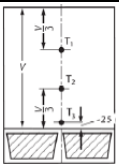
	equipment or windows in the test room, and shall be placed far enough away from all other objects in the test room to ensure that the air surrounding the refrigerating appliance is at ambient temperature.
Temperature-control setting	Setting for the target temperature.
anti-condensation heaters setting	Where anti-condensation heaters and other electrical device for user adjust, shall be on.
all shelves setting	in normal position
accessories setting	All accessories are in normal position, Auto ice maker shall be inoperative Ice cube empty
power supply voltage and frequency	different
target temperature (cellar)	Average: 12℃ Minimum: 8℃ Maximum: 14℃
target temperature (chill)	Average: +3℃
target temperature (fresh food storage)	Average: 5.0℃ Minimum: 0℃ Maximum: 10℃
target temperature (frozen-food storage *)	Maximum allowable temperature of warmest test package: -6℃
target temperature (frozen-food storage **)	Maximum allowable temperature of warmest test package: -12℃
target temperature (frozen-food storage ***)	Maximum allowable temperature of warmest test package: -18℃
storage plan of cellar compartment temperature sensors	See figure 14
storage plan of chill compartment temperature sensors	M packages
storage plan of fresh food compartment temperature sensors	
storage plan of frozen-food storage temperature sensors	Warmest temperature position
determination method of the energy	1.directly from the results of a single test run during which temperature of all compartment are at or below the target temperature. 2.by interpolation.
test period	At least 24h

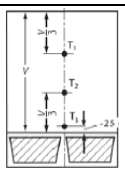
Table 3 – Test package dimensions and mass

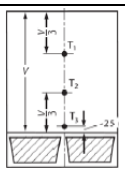
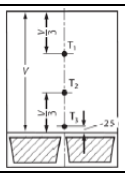
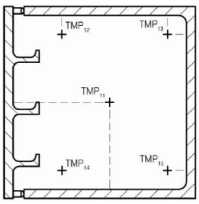
Dimensions mm	**Tolerance** mm	**Mass** g	**Tolerance** %
25* 50□*100	□2.0 for dimensions 25 and 50 3,0 for dimensions 100 and 200	125	□□
50□*50 *100		250	
50□*100□*100		500	
25*□100□*200		500	
50*□100*□200		1 000	

IEC 62552:2015

Table 5 IEC 62552:2015 test method for refrigerators

Test conditions	
Test ambient temperature	25℃and 32℃
humidity	Not exceed 75%
air circulation	Not exceed 0.25m/s
vertical ambient temperature gradient	1K/m
Measuring instruments	
temperature control device	±0.5K;
humidity control device	±0.3K;
watt-hour meters	Nearest 0.001Wh
Time	60s
measurement of storage temperature (fresh-food)	Air temperature sensors: Comprising a thermocouple soldered into a drilling in the end of a solid copper cylinder 18mm diameter and 18mm long.
measurement of storage temperature (cellar)	Air temperature sensors
measurement of storage temperature (chill)	Air temperature sensors
measurement of storage temperature (frozen-food storage)	Air temperature sensors
test packages	No requirements
M-packages	No requirements
Platform	The bottom of the platform shall not be less than 0.05 m above the test room floor and shall extend at least 0,3 m beyond, all sides of the refrigerating appliance, except at the rear where it shall extend to the vertical partition.
Installation of refrigerators	Each refrigerating appliance shall be placed on a wood or wood product (e.g. plywood or reconstituted wood sheeting) solid-top platform painted dull black and open for free air circulation under the platform. A suspended floor meeting the other specifications of a platform is considered to be a platform. As an alternative to black paint, a wooden platform or floor may be covered with a low emissivity dark colored, non-glossy, smooth, impermeable surface (such as linoleum). The surface behind the appliance shall be rigid, vertical and made of wood or wood product and painted dull black. This surface shall be continuous, extend not less than 0,3 m to each side of, and above, the appliance. The surface may be fixed to the wall of the test room with a gap of □0,03 m or be in the form of a fixed partition within the test room. Where the unit under test has a fan forced condenser, shielding shall be included (where applicable) to ensure that hot condenser exhaust

	does not directly affect any adjacent product under test. Side partitions are not required for testing units with a front exhaust. Where a product has any type of hot wall condenser at the back and / or side, a continuous wood or wood product partition painted dull black, parallel to each side of the appliance and fixed on the platform 0,3 m from the sides of the appliance shall be used. The partitions shall extend at least 0,3 m above the appliance and shall be at least 0,3 m deep. Where necessary (e.g. where there are side-wall condensers), the side partitions shall be extended so they are deep enough to shield any adjacent appliance under test from direct radiation from the condenser. Some products may have both wall condensers and fan forced condensers, so both of the above rules need to be applied in this case. Products with fan forced condensers may have side partitions fitted for testing if the test laboratory chooses to do so.
Temperature-control setting	Setting for the target temperature.
anti-condensation heaters setting	Where anti-condensation heaters and other electrical device for user adjust, shall be on or off.
all shelves setting	shall be removed,
accessories setting	All accessories shall be removed, Auto ice maker shall be removed, Ice cube empty
power supply voltage and frequency	different
target temperature (pantry)	Average: 17℃
target temperature (cellar)	Average: 12℃
target temperature (chill)	Average: 2℃
target temperature (fresh food storage)	Average: 4.0℃
target temperature (frozen-food storage 0)	Average: 0℃
target temperature (frozen-food storage *)	Average: -6℃
target temperature (frozen-food storage **)	Average: -12℃
target temperature (frozen-food storage ***)	Average: -18℃
storage plan of cellar compartment temperature sensors	

storage plan of chill compartment temperature sensors	
storage plan of fresh food compartment temperature sensors	
storage plan of frozen-food storage temperature sensors	
determination method of the energy	1. Directly from the results of a single test run during which temperature of all compartment are at or below the target temperature. 2. by interpolation.
test period	Stead state +automatic ice making energy(where applicable) +load processing efficiency(optional)

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