PEET Workshops 2021

Domestic Refrigeration Appliances: 2 December 2021

- Attached is the discussion document prepared for the 4E PEET discussions on Domestic Refrigeration Appliances.
- Participation in the online forum is limited to 4E Member countries, although each Member is allowed multiple participants.
- All participants will need to **register in advance** to attend. Please register on the 4E Members site here:

  https://www.iea-4e.org/events/members-peet/peet-workshops-2021-domestic-refrigerators/
- Once you have registered, meeting details and the Agenda will be forwarded to you

	2 December *Start times*
New Zealand	23.30
Australia	21.30
Japan/Korea	19.30
China (Beijing)	18.30
EU	11.30
UK	10.30
Nth America (East)	5.30

The following questions arise from the discussion document on domestic refrigeration appliances produced by Paul Waide and may be worthy of further consideration.

In addition, if you have any specific questions relating to policies for refrigerators that you would like answered, please forward these to Mark Ellis (mark@energyellis.com):

Q1: Why should domestic refrigeration appliances not use similar or harmonised test methods and/or performance metrics?

Q2: Are the varying number of product categories between the jurisdictions justified from a technical perspective?

Q3: Do the features below need separate categories or would it be better to apply a feature bonus adjustment factor?

- Position of the freezer relative to the fresh food compartment?
- Through the door ice-makers or drinks dispensers?
- No. of external doors
- Auto-defrost of the frozen food compartment.

Q4: Do the features below need separate feature bonus adjustment factors?

- Built-in versus freestanding
- Climate class
- Transparent doors.

Q5: What is preventing the inclusion of low noise and transparent door domestic refrigeration appliances within all 4E jurisdictions S&L regulations?

Q6: What is the reason for the large differences in thresholds currently observed?

Background document to PEET 2021 discussion of domestic refrigeration appliances

November 2021

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PEET efficiency trends analysis 2021

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Disclaimer

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Glossary

AV	adjusted volume
IEA	International Energy Agency
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MEPS	minimum energy performance standard
NA	not available (or applicable)
PEET	Product Energy Efficiency Trends project
Rating	the set of rated values and operating conditions
Rated value	a quantity value assigned, generally by a manufacturer, for a specified operating condition
TR	Top Runner
UEC	unit energy consumption

1. Introduction

This report presents 2021 findings of the IEA 4E Product Energy Efficiency Trends (PEET) project. This work follows upon previous PEET projects but applies a different methodological approach as follows. For the PEET 2021 work a survey was sent to each 4E member economy to request information on:

- changes made to product energy efficiency regulations and test procedures in the period of July 2020 to June 2021
- pending changes to product energy efficiency regulations and test procedures in the period of July 2021 and beyond.

In order to ensure a consistent approach when discussing application of policy measures and test/methodological standards the convention applied in this report is to reference them based on when they enter into effect and not when they are first issued.

Based on the findings received and processed in July 2021 it was decided to conduct in-depth investigations into the developments in energy efficiency regulations and test procedures applicable to the following four product groups:

- Electric motors
- Televisions (and when relevant) electronic displays
- Domestic refrigeration appliances
- Room air conditioners.

which constituted the set of products where the greatest changes in 4E economy regulations had occurred or were pending within the periods in question.

The analysis presented in this report addresses each of these products in turn and is being developed according to the following indicative timetable.

Proposed Date (webinar)	Topic/scope	Draft Report	Final Report
4-8 October	Electric Motors	09-Sep	30-Sep
18-22 October	Televisions	17-Sep	04-Oct
15-19 November	ExCo week		
29 Nov-3 Dec	Domestic Refrigeration Appliances	08-Nov	22-Nov
13-17 Dec	RAC	22-Nov	06-Dec

For each product the analysis presents:

- A summary of the of the existing regulations in place per 4E economy and the recent or pending changes
- A comparison of the scope of the regulations in 4E economies
- A comparison of the efficiency levels applied in the 4E economies.

For the comparison of efficiency levels normalisation methods are applied (either as per previous PEET work or amended/updated as explained in each case).

Whenever relevant a synthesis of necessary information on test procedures and/or product types is provided but only to the extent that it facilitates the above analyses and their communication.

The intention of this work is not to produce a definitive account or public facing report but to foster and facilitate a common basis for discussion of the issues addressed among 4E members. This report will not be published and is solely for 4E member's use. It is also a living document being added to per the schedule outlined above.

This specific report presents background information to inform the discussion on domestic refrigeration appliances.

2. Findings for domestic refrigeration appliances

This report discusses the status of 4E policy measures (MEPS/Top Runner/labelling) for domestic refrigeration appliances including recent or pending changes. In doing so it considers and compares the policy measures in terms of:

- the type of regulation (MEPS/Top Runner, Energy Labels)
- the principal type of domestic refrigeration appliances addressed
- the characteristics of the principal domestic refrigeration appliances which are within or without of scope
- the level of stringency of the policy requirements.

In the case of comparisons of stringency the following principal types of domestic refrigeration appliances are considered:

- refrigerator-freezers of a direct cool (manual defrost for freezer compartment) type
- refrigerator-freezers of a frost free (auto-defrost) type.

These are chosen because they correspond to the most important types of domestic refrigeration appliance found in the market; and, consequently, that have the greatest energy savings potential from the adoption of energy saving regulations.

In addition, there have been important developments in testing and standardisation methods that have a major bearing on the extent to which domestic refrigeration performance is accurately captured by regulations and on the comparison of regulatory stringency. Thus, the discussion considers test procedure and standardisation developments when relevant to the policy development and comparison discussion. The remainder of the report is structured as follows:

- Section 3 provides a summary of domestic refrigeration appliance types and major standards
- Section 4 summarises the status of the regulations in the 4E economies
- Section 5 compares the scope of the domestic refrigeration appliance regulations in place for each of the principal types
- Section 6 reports findings on the comparison of the stringency of the refrigerator-freezer regulations in force (or that are pending)
- Section 7 proposes potential topics for discussion among 4E policymakers.

3. Summary of domestic refrigeration appliance types and major standards

Before exploring the developments in domestic refrigeration appliance energy efficiency regulations its useful to consider the major types of domestic refrigeration appliance and how they can be grouped for comparison of regulatory measures. Domestic refrigeration appliance covers a wide variety of products and technologies of which the main types are:

- refrigerator-freezers i.e. appliances that are designed to store fresh food but also be capable of freezing food and storing it - these by far the most important group in all 4E economies
- refrigerators i.e. appliances to be used to store fresh food
- freezers i.e. appliances to be freeze food and/or store frozen food of which the dominant types are upright or chest although hybrids of the two also exist.

Among the broad groupings there are many variants with regard to:

- the inclusion/use of compartments with other design temperatures (of which there are many types)
- the configurations of the compartments and the number of external doors
- the choice of defrost method
- whether the appliance is freestanding or built-in
- the ambient temperatures the appliance is designed to operate under
- opaque of transparent doors
- the noise level (i.e. low noise types).

In addition, there are distinctions which could apply due to whether:

- refrigeration cycles other than electric vapour-compression are included
- DC and AC appliances are included.

Summary of developments in test and rating standards relevant to domestic refrigeration appliances

There are now essentially two sets of domestic refrigerator energy performance test procedures in use in 4E economies. This means the 4E economies can be grouped as follows with regards to the test method applied:

- those economies that align to the IEC 62552 test method (Australia China, European Economies, Japan and Korea (New Zealand is expected to align to this method soon))
- those that align to the US DOE/CSA-C300-15 method (USA and Canada).

The main distinctions are:

- the US DOE/CAS-C300-15 method tests energy consumption at a single steady-state ambient temperature of 32.2°C
- the IEC method tests energy consumption at two steady-state ambient temperatures of 32°C and 16°C – a weighting is then applied to the two values to produce a single overall energy consumption value. The weighting is chosen to produce an interpolated energy consumption value that corresponds to the most representative local ambient temperature. The weightings

applied in the 4E economies that use (or are about to use) the IEC method are intended to interpolate to the following representative steady state ambient temperatures:

Economy	Representative ambient test temperature
Australia/New Zealand (for MEPS) (for energy labelling)	 32°C 22°C
China	23.7°C
European economies	25°C
Japan	25°C
Korea	25°C

Note: Australia and New Zealand's (pending) representative ambient temperature values are distinct between the cases applicable for MEPS and energy labelling because a policy decision was taken to aim to align the MEPS levels to those applied in the USA and Canada.

- the IEC method tests auxiliary loads independently
- the IEC method allows for the energy used to process loads (i.e. the appliance energy consumption effect of thermal loads such as ambient/warm food or humid air ingress from door openings) to be tested independently
- the internal compartment test temperatures applied differ such that in Canada and the USA frozen food compartments are at -15°C whereas -18°C is used under the IEC method (for 3 and 4 star frozen food compartments). Also, the refrigerator compartment temperature used in Canada and the USA is 3.3°C whereas 4°C is used under the IEC method. Other compartment types (and design temperatures) are also recognised under the IEC method of which the main ones are shown below:

Storage conditions and target temperature per compartment type

Group	Compartment type	Note	Storage conditions		T_c
			T_{min}	T_{max}	
Name	*Name*	*no.*	°C	°C	°C
Unfrozen compartments	Pantry	(1)	+14	+20	+17
	Wine storage	(2) (6)	+5	+20	+12
	Cellar	(1)	+2	+14	+12
	Fresh food	(1)	0	+8	+4
Name	*Name*	*no.*	°C	°C	°C
Chill compartment	Chill	(3)	-3	+3	+2
Frozen compartments	0-star & ice-making	(4)	*n.a.*	0	0
	1-star	(4)	*n.a.*	-6	-6
	2-star	(4) (5)	*n.a.*	-12	-12
	3-star	(4) (5)	*n.a.*	-18	-18
	freezer (4-star)	(4) (5)	*n.a.*	-18	-18

Notes:

(1) T_{min} and T_{max} are the average values measured over the test period (average over time and over a set of sensors).
(2) The average temperature variation over the test period for each sensor shall be no more than ± 0,5 kelvin (K). During a defrost and recovery period the average of all sensors is not permitted to rise more than 1,5 K above the average value of the compartment.
(3) T_{min} and T_{max} are the instantaneous values during the test period.
(4) T_{max} is the maximum value measured over the test period (maximum over time and over a set of sensors).
(5) If the compartment is of the auto-defrosting type, the temperature (defined as the maximum of all sensors) is not permitted to rise more than 3,0 K during a defrost and recovery period.
(6) T_{min} and T_{max} are the average values measured over the test period (average over time for each sensor) and define the maximum allowed temperature operating range.
n.a = not applicable

Similarities between the methods include:

- the means of measuring volume and compartment temperature (which are now essentially aligned)
- the means of testing the impact of auto-defrost on the appliance's energy consumption.

Overall, the recent developments constitute considerably greater alignment than has previously been the case as a large number of economies are now coalescing around the IEC test method (more details of which are given in the Appendix). However, even among these economies there are differences in the representative test temperature adopted and in the treatment of processing loads, which means that normalisation is still needed for policy benchmarking to be conducted.

4. Summary of domestic refrigeration appliance regulations in 4E economies

Due to regional regulatory harmonisation for the purposes of comparison the following groupings of economies can be applied:

- Australia and New Zealand
- Canada and the USA
- the EU, Switzerland and the UK.

Thus, these economies are grouped under the same colour coding and are believed to have directly aligned policies in place.

The status of MEPS/TR requirements is summarised in Table 1. The full list of regulations and related links can be found in the Appendix.

Table 1: MEPS/Top Runner and label requirements currently in place for domestic refrigeration appliances

	MEPS or TR				Mandatory energy labels			
	Refrigerators	Refrigerator-freezers	Freezers	Specalised types	Refrigerators	Refrigerator-freezers	Freezers	Specalised types
Australia/ New Zealand	✓	✓	✓		✓	✓	✓	
Canada/ USA	✓	✓	✓		✓	✓	✓	
China	✓	✓	✓	✓	✓	✓	✓	✓
EU/ Switzerland/ UK	✓	✓	✓	✓	✓	✓	✓	✓
Japan	✓	✓	✓		✓	✓	✓	
Korea	✓	✓	✓	✓	✓	✓	✓	✓

From this table it can be seen that:

- all 4E economies have MEPS/TR requirements in place for domestic refrigeration appliances
- all 4E economies have energy label requirements in place for domestic refrigeration appliances
- some also have MEPS and labelling in place for what might be termed specialised appliances.

The specialised types covered are:

- Australia and New Zealand include wine storage appliances (either uniquely or as a dedicated compartment type within an appliance with other such compartments)
- China has specific requirements for:
  - wine storage appliances
  - a correction factor bonus for appliances with transparent doors
- European economies include the following specialised appliance categories
  - dedicated low noise refrigerating appliances with fresh food compartment(s)
  - low noise refrigerating appliances with transparent doors
  - other low noise refrigerating appliances, with the exception of low noise combi appliances with a frozen compartment

  - wine storage appliances with transparent doors
  - other wine storage appliances
- Korea regulates kimchi refrigerators[1] but these are a managed under a different section of the regulations than the provisions which apply to all other domestic refrigeration appliances.

Changes in these regulations have either recently occurred or are due to occur in most 4E economies as set out in sections 4.1 and 4.2.

4.1 Changes in the period of July 2020-June 2021

Table 2 shows for which 4E economies changes in domestic refrigeration appliance MEPS/TR, energy label, test procedure, policy scope, product categorisation and energy efficiency metric occurred in the period from July 2020 to June 2021.

Table 2: Changes in MEPS or Top Runner for domestic refrigeration appliances in the period July 2020-June 2021

	MEPS/TR	Mandatory label	Test procedure	Scope	Product catgeorisation	EE metric
Australia/ New Zealand						
Canada/ USA						
China						
EU/ Switzerland/ UK	✓	✓	✓	✓	✓	✓
Japan						
Korea						

The European economies recently updated every aspect of their MEPS and labelling regulations for domestic refrigeration appliances. This includes new test methods, changes in scope, revisions to product categorisation, and the adoption of a new energy efficiency metric.

4.2 Pending changes after June 2021

Table 3 shows for which 4E economies changes in domestic refrigeration appliance MEPS/TR, energy label, test procedure, policy scope, product categorisation and energy efficiency metric are set to occur in the period post June 2021.

[1] https://en.wikipedia.org/wiki/Kimchi_refrigerator

Table 3: Pending changes in MEPS or Top Runner for domestic refrigeration appliances in the period post June 2021

	MEPS/TR	Mandatory label	Test procedure	Scope	Product catgeorisation	EE metric
Australia/ New Zealand	✓	✓	✓	✓	✓	✓
Canada/ USA			✓			
China						
EU/ Switzerland/ UK	✓	✓	✓	✓	✓	✓
Japan	✓	✓				
Korea		✓				

Australia have amended their MEPS and labelling requirements with effect from August 2021. This includes a complete revision of the test procedure that applies, bringing this into line with IEC 6552:2015. It also entails minor amendments to the product categorisation. It is also noteworthy that the new MEPS are designed to align with the current Canadian/US MEPS that date back to 2014. By contrast the revised energy labelling requirements use a different method to determine the energy performance as is discussed in the subsequent sections.

New Zealand currently apply the MEPS and labelling requirements set out in AS/NZS 4474.1:2007.but expect to formally adopt the AS/NZS IEC 62552 test procedure and AS/NZS 4474 MEPS and labelling requirements in June 2022.

The USA adopted a change in energy performance test procedure in that will take effect from April 11th 2022; however, this is being applied in a manner that does not affect the ambition of the MEPS.

Japan have indicated that new Top Runner requirements for refrigerators (including refrigerator-freezers) and freezers are expected to be issued in 2023. Japan's mandatory Energy Saving Label[2] indicates whether an appliance has met the Top Runner requirements (in green) or not (in red) so any change in the Top Runner threshold automatically causes a change in the Energy Saving Label.

Korea are understood to have updated their energy labelling requirements for refrigerator-freezers with effect from October 2021.

[2] https://www.certification-japan.com/en/other-services/japan-energy-saving-label-program/

5. Comparison of scope of domestic refrigeration appliance policies in 4E economies

This section reviews the scope of domestic refrigeration appliance MEPS/TR and labelling efficiency regulations in place in 4E economies (section 5.1). Section 5.2 comments on the significance of differences in regulatory scope or product categorisation.

5.1 Scope of domestic refrigeration appliance policies in 4E economies

In this section for each 4E economy grouping details are presented on the overall regulatory scope, the primary product group categorisation, the use of additional product feature weighting factors when calculating the energy efficiency (EE) metric, and some relevant aspects of the energy performance test procedure and how it is applied to calculate the energy performance metrics used in the MEPS/TR and labelling regulations.

Australia and New Zealand

The Australian and New Zealand requirements apply to household vapour-compression refrigeration appliances that:

(a) has one or more compartments that are controlled at specific temperatures; and

(b) is intended for the storage and preservation of foodstuff that require refrigeration at specified temperature conditions; and

(c) is cooled by natural convection or a forced convection system whereby the cooling is produced using vapour compression cycle technology; and

(d) can be connected to mains power; and

(e) is ordinarily supplied for household use.

Provisions do not apply to:

For subsection 23(2) of the Act, this Determination does not cover the following:

(a) products which have a total volume of less than 80 litres and that are designed exclusively for use in caravans and other vehicles including:

(i) mobile homes;

(ii) campervans;

(iii) rail cars; and

(iv) boats;

(b) portable products that:

(i) have a chest configuration; or

(ii) have a upright configuration and have a total volume of less than 80 litres;

Note: they do cover portable products that have an upright configuration and have a total volume of 80 litres or greater.

(c) products that have a total volume of less than 30 litres where the refrigeration function is secondary, such as boiled and cooled water dispensers

(d) products that have no options for connection to a 230 volt or 400 volt mains electricity supply at 50 hertz

(e) products that cool using technologies other than the vapour compression cycle

(f) wine storage appliances.

Note: They do cover household refrigerating appliances that have one or more wine storage compartments in addition to other compartment types.

(g) stand alone ice-makers.

Australia and New Zealand differentiates 10 primary categories of domestic refrigerating appliance as follows (see the final column):

Table 4: Product categorisation for domestic refrigerating appliances in Australia and New Zealand

Refrigerating appliance designation (see Note 1)	Compartment type (see Note 4)								Configuration requirements (see Note 5)	Defrost system requirements (see Note 6)	Group (see Note 14)
	Unfrozen compartments					Frozen compartments					
	Wine storage	Cellar or pantry	Fresh food	Chill	Zero-star	One-star	Two-star	Freezer (three or four- star)			
Refrigerator	O	O	Y	O	O	N	N	N		Automatic defrost in all	1
Cooled appliance	L	L	L	L	L	N	N	N			
Refrigerator	O	O	Y	O	O	O	N	N			2
Cooled appliance	L	L	L	L	L	O	N	N			
Refrigerator	O	O	Y	O	O	O	Y	N			3
Cooled appliance	L	L	L	L	L	O	Y	N			
Refrigerator/freezer	O	O	Y	O	O	O	O	Y		Automatic defrost in unfrozen compartments (see Note 7)	4
Cooled appliance	L	L	L	L	L	O	O	Y			
Refrigerator/freezer	O	O	Y	O	O	O	O	Y	Bottom freezer	Automatic defrost in all	5B
Refrigerator/freezer	O	O	Y	O	O	O	O	Y	Side by side	Automatic defrost in all	5S
Refrigerator/freezer	O	O	Y	O	O	O	O	Y	Not Group 5S or 5B	Automatic defrost in all	5T
Cooled appliance	L	L	L	L	L	O	O	Y			
Freezer	N	N	N	N	N	O	O	Y	Chest		6C
Cooled appliance	N	N	N	N	N	L	L	L			
Freezer	N	N	N	N	N	O	O	Y	Upright	Manual defrost	6U
Cooled appliance	N	N	N	N	N	L	L	L			
Freezer	N	N	N	N	N	O	O	Y	Upright	Automatic defrost in all	7
Cooled appliance	N	N	N	N	N	L	L	L			

EE metric weighting factors

In addition to these categories Australia/New Zealand applies the following feature allowances for products when determining MEPS (they do not apply for energy labelling):

- an allowance of 52kWh/year is applied for appliances with a through-the-door icemaker (this allowance does not apply to compact products)
- an allowance of 40kWh/year is applied for built-in appliances unless these are within the group 5S in which case the allowance is 100kWh/year (this allowance does not apply to compact products).

Test procedure characteristics

Australia/New Zealand's energy performance test method is aligned to IEC 62552; Australia/New Zealand applies the following aspects in how this is implemented:

- for energy labelling purposes the steady state energy consumption at 16°C is weighted at 192 days out of 365 and that at 32°C at 173 days out of 365 to produce the total annual energy consumption (representative of 22°C)
- for MEPS purposes only the steady state energy consumption at 32°C is used (this is because the MEPS levels have been chosen to align to the Canadian and US MEPS)
- adjusted volume is calculated at a 22°C ambient test temperature for energy labelling purposes and 32°C for MEPS purposes
- ΔE load processing energy is included explicitly for energy labelling but suppliers have the choice of whether to measure it or apply default values determined through a formula
- auxiliary energy is measured explicitly for energy labelling.

Canada and the USA

The scope of the MEPS and labelling regulations applied for domestic refrigerators, refrigerator-freezers and freezers is:

Combination refrigerator-freezer, a household combination refrigerator-freezer, that has a defrost system, including a compressor-cycled automatic defrost system and a capacity of 1105 L (39 cubic feet) or less.

Refrigerator, a household refrigerator that has a capacity of 1105 L (39 cubic feet) or less and that has a defrost system including a compressor-cycled automatic defrost system. It does not include:

- a household refrigerator that uses an absorption refrigeration system, or
- a miscellaneous refrigeration product

Freezer, a household freezer that has a capacity of 850 L (30 cubic feet) or less.

The regulations in Canada and the USA differentiate 32 distinct categories of domestic refrigerator and refrigerator-freezers as follows:

Table 5: Product categorisation for domestic refrigerating appliances in Canada and the USA

Product type	
1	Refrigerators and refrigerator-freezers with semi-automatic or manual defrost
1A	All refrigerators with manual defrost
2	Refrigerator-freezers with partial automatic defrost
3	Refrigerator-freezers with automatic defrost and top-mounted freezer without through-the-door ice service
3-BI	Built-in refrigerator-freezers with automatic defrost with top-mounted freezers without an automatic icemaker
3I	Refrigerator-freezers with automatic defrost and with top mounted freezer with an automatic icemaker without through-the-door ice service
3I-BI	Built-in refrigerator-freezers with automatic defrost and with top-mounted freezer without an automatic icemaker
3A	All-refrigerators with automatic defrost
3A-BI	Built-in all-refrigerators with automatic defrost
4	Refrigerator-freezers with automatic defrost and side-mounted freezer without through-the-door ice service
4-BI	Built-in refrigerator-freezers with automatic defrost and with side-mounted freezers without automatic icemaker
4I	Refrigerator-freezers with automatic defrost and with side-mounted freezer with automatic icemaker without through-the-door ice service
4I-BI	Built-in refrigerator-freezers with automatic defrost and with side-mounted freezer with an automatic icemaker without through-the-door ice service
5	Refrigerator-freezers with automatic defrost and bottom-mounted freezer without through-the-door ice service
5A	Refrigerator-freezers with automatic defrost and bottom-mounted freezer with through-the-door ice service
5-BI	Built-in refrigerator-freezers with automatic defrost and with bottom-mounted freezer without automatic icemaker.
5I	Refrigerator-freezers with automatic defrost and with bottom-mounted freezer with automatic icemaker without through-the-door ice service
5I-BI	Built-in refrigerator-freezers with automatic defrost and with bottom-mounted freezer with automatic icemaker without through-the-door ice service
5A-BI	Built-in refrigerator-freezer—automatic defrost with bottom-mounted freezer with through-the-door ice service

Table 5 continued: Product categorisation for domestic refrigerating appliances in Canada and the USA

6	Refrigerator-freezers with automatic defrost and top-mounted freezer with through-the-door ice service
7	Refrigerator-freezers with automatic defrost and side-mounted freezer with through-the-door ice service
7-BI	Built-in refrigerator-freezers with automatic defrost and with side-mounted freezer with through-the-door ice service
11	Compact refrigerators and refrigerator-freezers with semi-automatic or manual defrost
11A	Compact all-refrigerators with manual defrost
12	Compact refrigerator-freezers with partial automatic defrost
13	Compact refrigerator freezers with automatic defrost and top-mounted freezer Compact all-refrigerators with automatic defrost
13I	Compact refrigerator-freezers with automatic defrost and with top-mounted freezer with automatic icemaker
13A	Compact all-refrigerators with automatic defrost
14	Compact refrigerator-freezers with automatic defrost and side-mounted freezer
14I	Compact refrigerator-freezers with automatic defrost and with side-mounted freezer with automatic icemaker.
15	Compact refrigerator-freezers with automatic defrost and bottom-mounted freezer
15I	Compact refrigerator-freezers with automatic defrost and with bottom-mounted freezer with automatic icemaker

Where:

- compact refrigerator/refrigerator-freezer/freezer means any refrigerator, refrigerator-freezer or freezer with a total refrigerated volume of less than 7.75 cubic feet (220 litres).

It is notable that the approach applied is to define a separate primary product category for each primary product feature e.g. for the appliance's compartment types, configuration of compartments, size (compact or not), defrost mechanism, built-in or freestanding, presence of icemaker or through-the-door ice service.

For domestic freezers the following 10 product categories are applied:

Table 6: Product categorisation for domestic freezers in Canada and the USA

Product type	
8	Upright freezers with manual defrost
9	Upright freezers with automatic defrost
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
10A	Chest freezers with automatic defrost system
16	Compact upright freezers with manual defrost
17	Compact upright freezers with automatic defrost
18	Compact chest freezers and all other compact freezers

Test procedure characteristics

The energy performance test method used in Canada (CAN/CSA-C300-15) is directly equivalent to the one used in the USA. Some aspects of the energy performance test method used in Canada/USA energy performance are aligned with IEC 62552 but there are significant differences, most notably:

- the steady state energy consumption test is conducted only at 32°C
- interior compartment temperatures are not aligned with those used in IEC
- adjusted volume is calculated at a 32°C ambient test temperature
- there is no explicit measurement of load processing energy, rather, the intent of the energy test procedure is to simulate typical room conditions (72 °F (22.2 °C)) with door openings, by testing at 90 °F (32.2 °C) without door openings.

China

China's regulations are applicable to household refrigerators with motor-driven compressor (including 500L and above), wine storage cabinets, and built-in refrigerating appliances. It is not applicable to refrigerators with a transparent door dedicated to display or those designed for other special purposes.

China differentiates 10 categories of domestic refrigerating appliances as follows:

Table 7: Product categorisation for domestic refrigerating appliances in China

Product category
1. Refrigerator without star compartment
2. Refrigerator with 1-star compartment
3. Refrigerator with 2-star compartment
4. Refrigerator with 3-star compartment
5. Refrigerator-freezer
6. Frozen food storage cabinet
7. Chest refrigerator-freezer
8. Chest freezer
9. Upright freezer
10. Wine storage cabinet

Within these categories:

- a chest refrigerator-freezer is defined as a cabinet in which food is accessed through the top door or lid, having at least one fresh-food storage compartment (soft freezer) suitable for storing fresh food, and at least having one compartment suitable for frozen fresh food or frozen food; for a combined model, the volume of the top-opening compartment shall account for more than 75% of the total volume
- an upright chest freezer is defined as Household refrigerating appliance which is divided into upper and lower parts, with the upper part being top opening (chest type), in which food is accessed through the top door or lid; and the lower part being upright or drawer type (upright type), in which food is accessed through the front door or the drawer.

EE metric weighting factors

In addition to these categories China applies the following feature weighting factors to the adjusted volume:

- 1.5 for compartments that use forced convection in frost-free refrigerating appliances, and 1.0 for other types of compartments
- correction factor of climate type, which is 1 if the refrigerator climate class is SN or N, 1.1 if the climate class is ST, and 1.2 if the climate class is T; for refrigerators with multiple climate types, the climate type with the highest correction factor is used to calculate the adjusted volume
- constant, 1.2 for built-in refrigerating appliances and 1.0 for others.

China also applies a base energy consumption correction factor of 50kWh/year for appliances with 4 doors or more.

Test procedure characteristics

China's energy performance test method is aligned to IEC 62552; China applies the following aspects in how this is implemented:

- the energy consumption at 16°C is weighted at 192 days out of 365 and that at 32°C at 173 days out of 365 to produce the total annual energy consumption (representative of 23.7°C)
- adjusted volume is calculated at a 23.7°C ambient test temperature
- ΔE load processing energy is included explicitly
- auxiliary energy is included explicitly.

European Economies

The regulations in European economies apply to electric mains-operated refrigerating appliances with a total volume of more than 10 litres and less than or equal to 1 500 litres.

They do not apply to:

(a) professional refrigerated storage cabinets and blast cabinets, with the exception of professional chest freezers

(b) refrigerating appliances with a direct sales function

(c) mobile refrigerating appliances

(d) appliances where the primary function is not the storage of foodstuffs through refrigeration.

With the recent change in regulations the European economies now only differentiate six categories of refrigerating appliances as follows:

Table 8: Product categorisation for refrigerating appliances in European economies

Product categories
dedicated low noise refrigerating appliances[3] with fresh food compartment(s)
low noise refrigerating appliances with transparent doors
other low noise refrigerating appliances, with the exception of low noise combi appliances with a frozen compartment
wine storage appliances with transparent doors
other wine storage appliances
all other refrigerating appliances, with the exception of low noise combi appliances with a frozen compartment[4]

By far the most common is the last category that includes the 10 primary categories that were formerly used and which treats refrigerators, refrigerator-freezers and freezers all within the same main category. The other five categories are much more specialised and have much smaller market shares.

EE metric weighting factors

In addition to these categories European economies apply the following feature compensation factors to the standard (base) energy consumption (where A_c (for auto-defrost) and B_c (for built-in) are specific to each compartment type and D (for no. of doors) applies to the total energy consumption):

[3] means a refrigerating appliance without vapour compression and with airborne acoustical noise emission lower than 27 A-weighted decibel referred to 1 pico watt (dB(A) re 1 pW)

[4] this is the most common product category

The values of the compensation factors per compartment type

<table>
<tr><th rowspan="2">Compartment type</th><th colspan="2">A_c</th><th colspan="2">B_c</th><th colspan="4">D</th></tr>
<tr><th>Manual defrost</th><th>Auto-defrost</th><th>Freestanding appliance</th><th>Built-in appliance</th><th>≤ 2 ([a])</th><th>3 ([a])</th><th>4 ([a])</th><th>> 4 ([a])</th></tr>
<tr><td>Pantry</td><td colspan="2" rowspan="5">1,00</td><td rowspan="10">1,00</td><td rowspan="4">1,02</td><td rowspan="10">1,00</td><td rowspan="10">1,02</td><td rowspan="10">1,035</td><td rowspan="10">1,05</td></tr>
<tr><td>Wine storage</td></tr>
<tr><td>Cellar</td></tr>
<tr><td>Fresh food</td></tr>
<tr><td>Chill</td><td>1,03</td></tr>
<tr><td>0-star & ice-making</td><td rowspan="5">1,00</td><td rowspan="5">1,10</td><td rowspan="5">1,05</td></tr>
<tr><td>1-star</td></tr>
<tr><td>2-star</td></tr>
<tr><td>3-star</td></tr>
<tr><td>Freezer (4-star)</td></tr>
</table>

([a]) number of external doors or compartments, whichever is lowest.

It is noteworthy that compared to the previous regulations:

- the auto-defrost factor has been reduced from 1.2 to 1.1
- the built-in factor used to be 1.1 but are now between 1.05 and 1.02
- there are no longer any climate class compensation factors
- compensation factors for the number of doors have been added.

Test procedure characteristics

European economies use a test method that is aligned to IEC 62552; they apply the following aspects in how this is implemented:

- the energy consumption is measured at 16°C and at 32°C and these values are weighted at 50% to produce the total value (representative of 25°C)
- adjusted volume is calculated at a 25°C ambient test temperature
- ΔE load processing energy is not included through an explicit energy measurement but by:
  - a) a choice of average ambient temperature of 25°C that overestimates the energy consumption that would be expected from an appliance operating at the most representative ambient temperature for Europe
  - b) an additional loading factor of 0.9 for all refrigeration appliances that are not freezers and 1 for freezers, where the measured energy consumption is divided by the loading factor
- auxiliary energy is included explicitly.

Japan

Japan's Top Runner regulations apply to electric refrigerators including ones combined with a freezer, except the following:

1) ones using thermoelectric elements

2) residential ones of absorption type and used mainly for storage of wine, or

3) ones other than residential ones as described below:

- cold air-forced convection types in which the lower limit of the rated storage temperature of the chiller is zero degrees or higher
- cold air-natural convection types
- ones whose rated internal volume is over 2,000 L
- ones other than those covered by JIS B 8630 (2009)
- ones that do not use 1,1,1,2,2-pentafluoroethane (HFC-125), 1,1,1-trifluoroethane (HFC-143a), or 1,1,1,2-tetrafluorethane (HFC-134a) as refrigerant
- ones for use while disconnected from a power source, comprising casters
- ones of horizontal type with an external height dimension of 650 mm or less (in a case of being integrated with a washstand, the height corresponding to that of the washstand shall be excluded)
- one of vertical type with an external height dimension of 2,050 mm or more
- ones having a water-cooled condenser
- ones having a structure comprising doors on both sides of the housing
- drawer refrigerators
- ones manufactured for an orderer in accordance with housing dimensions, compressor freezing capacity or insulation performance specifications defined based on the orderer's instructions, annual shipment volume of which is less than 50 units.

Japan differentiates three categories of domestic refrigerating appliances as follows (electric freezers are treated separately – see below):

Table 9: Product categorisation for domestic refrigerating appliances in Japan

Category			
Category name	Refrigerator type	Cooling type	Rated internal volume
a	Refrigerator and refrigerator-freezer	Cold air-natural convection type	—
b		Cold air-forced circulation type	Up to 375 liters
c			Over 375 liters

For electric freezers all types are in scope except the following:

- ones using thermoelectric elements
- ones for home-use and of absorption type, or
- ones other than those for home-use as described below:
  - ones whose rated internal volume is over 2,000 L
  - ones other than those covered by JIS B 8630 (2009)
  - ones that do not use 1,1,1,2,2-pentafluoroethane (HFC-125), 1,1,1-trifluoroethane (HFC-143a), or 1,1,1,2-tetrafluorethane (HFC-134a) as refrigerant
  - ones capable of maintaining a rated storage temperature of –30 degrees or less

- ones for use while disconnected from a power source, comprising casters
- ones of horizontal type with an external height dimension of 650 mm or less (in a case of being integrated with a washstand, the height corresponding to that of the washstand shall be excluded)
- one of vertical type with an external height dimension of 2,050 mm or more
- ones having a water-cooled condenser
- ones having a structure comprising doors on both sides of the housing
- ones intended to store foods exclusively for inspection
- drawer freezers
- ones manufactured for an orderer in accordance with housing dimensions, compressor freezing capacity or insulation performance specifications defined based on the orderer's instructions, annual shipment volume of which is less than 50 units.

For electric freezers the following categories are used:

Table 10: Product categorisation for electric freezers in Japan

Category		
Category name	Storage compartment	Cooling type
a	Freezer	Cold air–natural convection type
b		Cold air–forced circulation type

Unusually, compared to many other 4E economies – Japan's TR regulations makes no distinction between chest and upright freezers.

EE metric weighting factors

Beyond the product categorisation described above Japan applies no extra factors to take account of product features such as, whether the appliance is built-in or freestanding, the number of doors, transparent vs opaque doors, through-the-door ice dispensers, or the climate class.

Test procedure characteristics

Japan's energy performance test method is aligned to IEC 62552; Japan applies the following aspects in how this is implemented:

- the energy consumption is measured at 16°C and at 32°C and these values are weighted at 50% to produce the total value (representative of 25°C)
- adjusted volume is calculated at a 25°C ambient test temperature
- ΔE load processing energy is included through an explicit energy measurement but there is a slight deviation from the IEC method as the load processing and ice making are measured at the same time (rather than measuring them separately) which is intended to produce a figure that is similar to the previous JIS approach which used door openings
- auxiliary energy is included explicitly.

South Korea

The scope of South Korea's regulations are:

- household electric refrigerators and refrigerator-freezers with storage volume of up to 1,000L with a cooling system consuming less then 500W in electric power consumption as determined by KS C IEC 62552.

In addition, a separate regulation applies to Kimchi refrigerators as:

- household electric refrigerating appliances with a combined storage volume of 1,000L or less and Kimchi storage compartment with more than 50 percent of overall storage volume according to KS C 9321 (excluding business-specific products).

Aside from Kimchi refrigerators South Korea differentiates six categories of domestic refrigerating appliances as follows:

Table 11: Product categorisation for domestic refrigerating appliances in Korea

Product categories
Refrigerator only
Refrigerator-freezer with adjusted volume under 500L
Refrigerator-freezer whose adjusted volume is at least 500L and under 1,000L without an ice dispenser or homebar door
Refrigerator-freezer whose adjusted volume is at least 500L and under 1,000L with ice dispenser or homebar door
Refrigerator-freezer whose adjusted volume is at least 1,000L without ice dispenser or homebar door
Refrigerator-freezer whose adjusted volume is at least 1,000L with ice dispenser or homebar door

EE metric weighting factors

In addition to these categories Korea applies the following feature weighting factors to the adjusted volume:

- 1.2 for compartments that use forced convection in frost-free refrigerating appliances, and 1.0 for other types of compartments.

Korea applies a base energy consumption correction factor of:

- 31.2kWh/year for through-the-door icemakers used in refrigerator-freezers whose adjusted volume is at least 500L
- 0.264 kWh/year per cm of homebar door length for a fresh-food compartment
- 0.432 kWh/year per cm of homebar door length for a frozen-food compartment.

Test procedure characteristics

Korea's energy performance test method is aligned to IEC 62552; Korea applies the following aspects in how this is implemented:

- the energy consumption is measured at 16°C and at 32°C and these values are weighted at 50% to produce the total value(representative of 25°C)

- adjusted volume is calculated at a 25°C ambient test temperature
- ΔE load processing energy is included explicitly
- auxiliary energy is included explicitly.

5.2 Significance of differences in regulatory scope or product categorisation

There are only minor differences in overall scope of what falls under the 4E economy MEPS and labelling regulations for domestic refrigeration appliances. All include conventional refrigerators, refrigerator-freezers and freezers intended for domestic use. The main differences are:

- European economies include requirements for low noise refrigeration appliances e.g. those that would ordinarily be used for hotel minibar services
- European economies and China include requirements for dedicated wine storage appliances (Australia and New Zealand include wine storage if it is as a compartment type within an appliance having other compartment types) but others either exclude or do not mention these

Note, in both of the above cases the usage of the appliance may not be in a domestic setting

- Korea includes kimchi refrigerators
- European economies and China include requirements for appliances with transparent doors.

With regards to product categorisation there are significant differences; however, these may be slightly more superficial than they appear at first assessment as many of the distinctions are treated through the use of feature adjustment factors in economies that don't make as many formally distinct categories. The approach used in Canada and the USA is at one end of the spectrum in that overall 42 distinct product categories are used, each with their own MEPS formula, whereas that applied in the European economies is at the other as all 42 of the Canadian/US categories are essentially treated within a single product category in Europe. The new European approach represents a considerable consolidation from the previous European regulations which had 10 principal product categories. The approach now used in Europe has amended the energy performance formula so that each compartment type is treated as a separate term within it and adjustments are applied for the presence of features such as: frost-free, built-in design (which constricts design), a large number of doors (which affects anti-condensation heater losses), and load losses. This philosophy stems from the notion that the fundamental performance of a domestic refrigeration appliance is dependent on the efficiency of the refrigeration system and the thermal loads it has to process, which are a function of the internal design temperatures and ambient temperature the appliance operates at. These factors can be expressed and treated consistently for all vapour-compression cycle refrigeration devices while the impact of additional features can then be addressed by feature factors.

6. Comparison of domestic refrigeration appliance policy efficiency thresholds in 4E economies

This section presents the findings of policy benchmarking analysis for domestic refrigerator-freezers. This exercise has not been attempted for other types of domestic refrigeration appliances due to resource constraints and because refrigerator freezers dominate the 4E markets.

6.1 Benchmarking approach

The main factors that need to be addressed in the benchmarking process are:

- the difference in steady state ambient temperature and the effect this has on the efficiency of the refrigeration system
- the differences in thermal loads caused by different internal design temperatures and steady state ambient test temperatures
- the treatment of load processing
- the treatment of auxiliary energy loads.

The method applied here is the same as the benchmarking method used in the previous PEET studies but adapted to bring in the effect of load processing and to normalise energy consumption to the IEC 62552 test method when reported at 25°C.

6.2 Comparison of efficiency thresholds

In order to compare normalised regulatory efficiency thresholds two basic types of refrigerator-freezer are considered:

- direct cool (i.e. those with manual defrost of the freezer compartment)
- frost-free (i.e. those with auto-defrost of the fresh and freezer compartments)

Note, direct cool appliances include an auto-defrost mechanism to de-ice the evaporator used in the fresh food compartment.

For the direct-cool case three adjusted volumes cases (determined at 25°C ambient and with compartment temperatures in line with IEC 62552) are assessed for: 150, 300 and 450 litres of total adjusted volume.

For the frost-free case five adjusted volumes cases (determined at 25°C ambient and with compartment temperatures in line with IEC 62552) are assessed for: 150, 300 and 450, 750 and 1000 litres of total adjusted volume.

In both cases the configuration considered is for a free-standing top-mount (i.e. freezer on top) refrigerator freezer. Additionally, in both cases the appliance is not assumed to have any of the following characteristics:

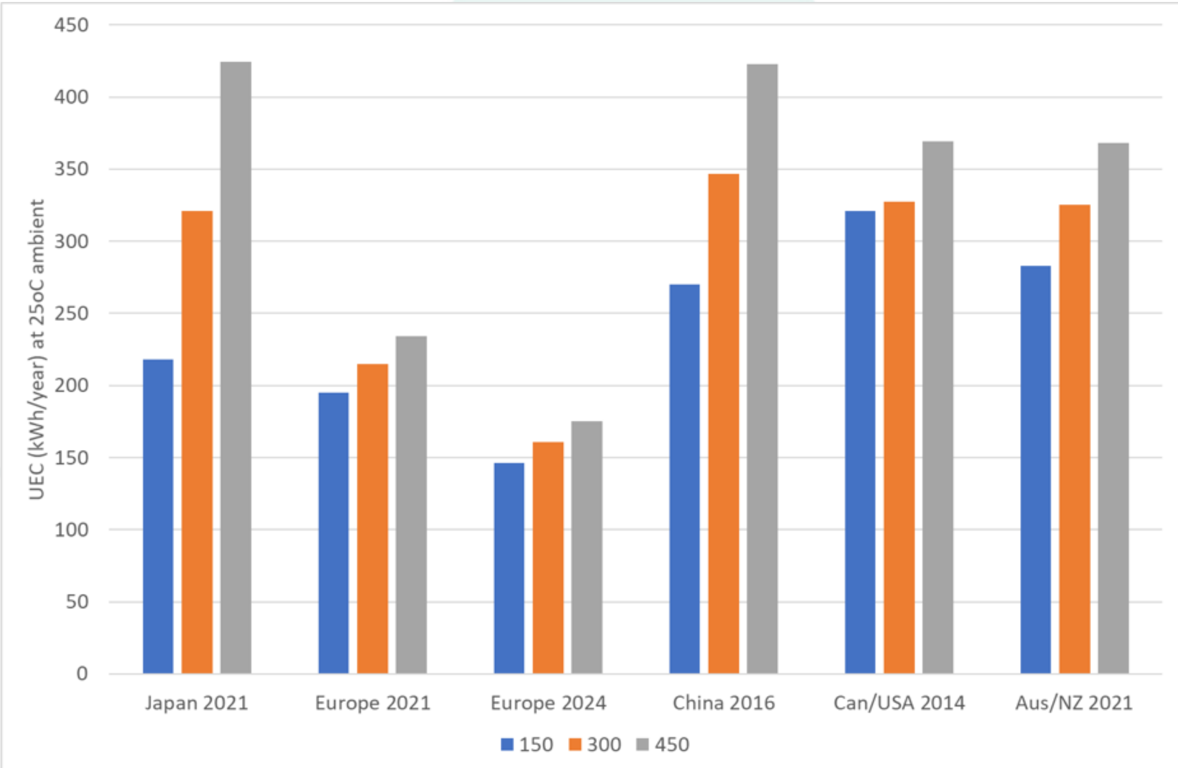
- through the door ice making
- ST or T climate class
- low noise (e.g. as defined in European regulations)
- transparent doors
- more than 2 doors.

It is understood that many other configurations could have been considered and compared but this set of features was chosen to be one of the overall most common types and to simply the process. The results of the comparisons are shown in the following sub-sections.

Direct cool (manual defrost) refrigerator-freezers

Figure 1 shows a comparison of the normalised MEPS/TR thresholds for direct-cool (i.e. manual defrost) refrigerator-freezer types with adjusted volumes at 150, 300 or 450 litres (when calculated at 25°C ambient and with IEC 62552 compartment temperatures). The results are for the case where the freezer compartment accounts for 43% of the total adjusted volume (which is representative of this type). The appliances are of a free-standing type with the freezer compartment on the top and have no additional features such as: through-the-door ice service, more than 2 external doors, tropical/sub-tropical climate classes that might affect the product category or feature bonuses applied.

Figure 1: Comparison of normalised direct cool domestic refrigerator-freezer MEPS/TR thresholds



From this the following observations can be made:

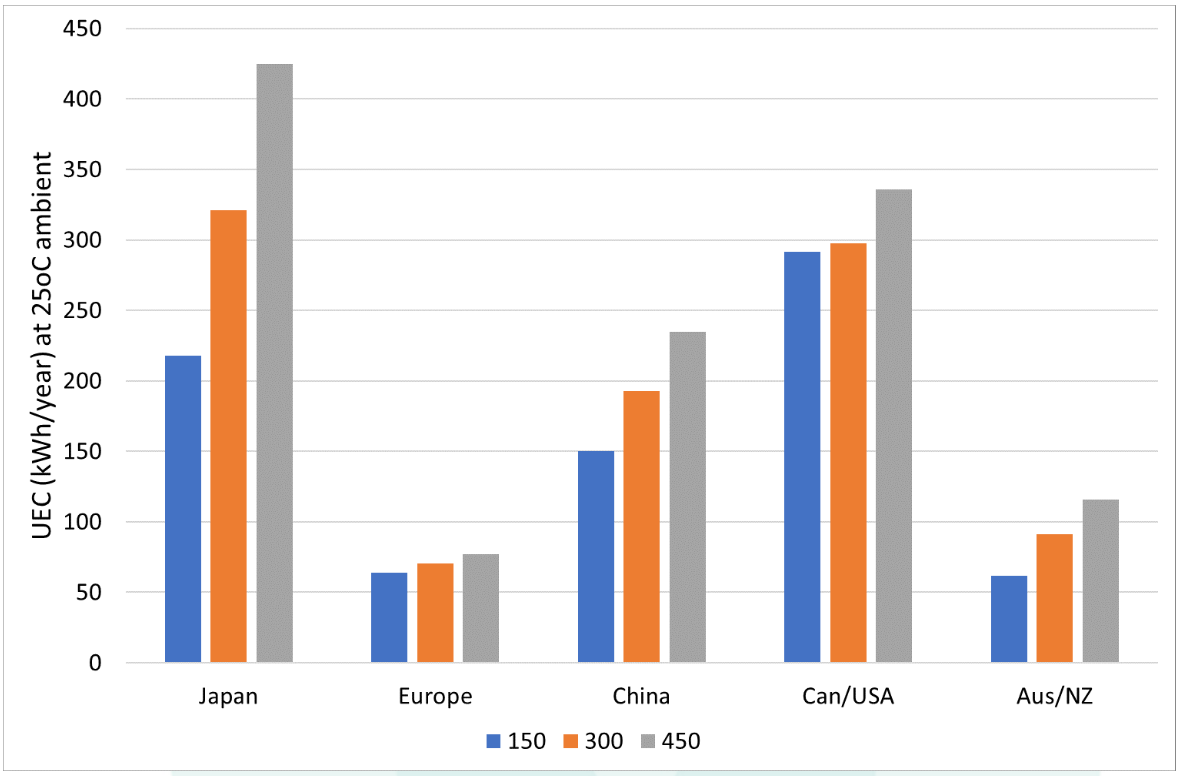
- Europe's MEPS are the most stringent existing MEPS although Japan's TR and Europe's MEPS are not too dissimilar for 150 litre AV appliances
- Europe's MEPS in 2024 are considerably more ambitious again than the current 2021 levels
- the stringency of the MEPS in Canada/USA and Australia/New Zealand are relatively similar
- Japan's TR thresholds have the steepest increase in permitted energy consumption as a function of adjusted volume
- China's MEPS are the least stringent for the 300 and 450 litre AV cases.

Figure 2 shows a comparison of the top energy labelling thresholds applied in each 4E economy, of which the following background is important:

- Japan's Energy Saving Label awards a maximum 5 stars when an appliance satisfies the current Top Runner threshold, thus the TR threshold is the same as the highest 5 star labelling threshold; however, it should be noted that the achievement ratio of the TR threshold is also reported so appliances that surpass the TR threshold will have their relative performance indicated but it is not reflected by additional stars
- Australia and New Zealand use a different efficiency metric to determine the energy label class to that used to determine MEPS compliance. The MEPS are rated at 32°C and are intended to align with the MEPS and methodology (with some deviations) as used in Canada and the USA. The labels are intended to give an overall energy consumption figure that is representative of the average indoor temperatures in Australian and New Zealand households which is 22°C. The efficiency metrics applied to determine label classes are different to those used to determine MEPS. The label applies star ratings (the more stars the more energy efficient) with a system that ranks products on a 1 to 10-star scale but also allows half stars. The highest efficiency label class is 10 stars
- Canada and the USA implement a voluntary Energy Star scheme for domestic refrigeration appliances where the eligibility threshold is 10% more efficient than the MEPS levels. Thus, the highest efficiency label threshold is Energy Star (10% better than the MEPS)
- European economies apply an A to G graded energy label; however, grade G is only applicable to less conventional appliance types (like low noise refrigerators or wine storage appliances) and Europe's MEPS are set at the F/G boundary for conventional vapour compression appliances. The highest efficiency label class is A (this follows a rescaling of the energy labelling that replaces the old G to A+++ scale)
- China's label is graded from class 1 (most efficient) to class 5 (least efficient). It uses dual efficiency metrics ("standard energy efficiency" and "total energy efficiency") for refrigerator freezers of which the standard energy efficiency grade 5 corresponds to the MEPS level; however, to attain a given label class the class is assessed under both metrics and the least efficient grade is applied (if there is a difference between the two). For all other domestic refrigeration appliance types the standard energy efficiency metric is used to determine compliance with MEPS and to determine energy label thresholds. The highest efficiency label class is 1.

Figure 2 shows a comparison of the highest efficiency label thresholds applied in each 4E economy for direct-cool refrigerator freezers.

Figure 2: Comparison of normalised direct cool domestic refrigerator-freezer top label class thresholds



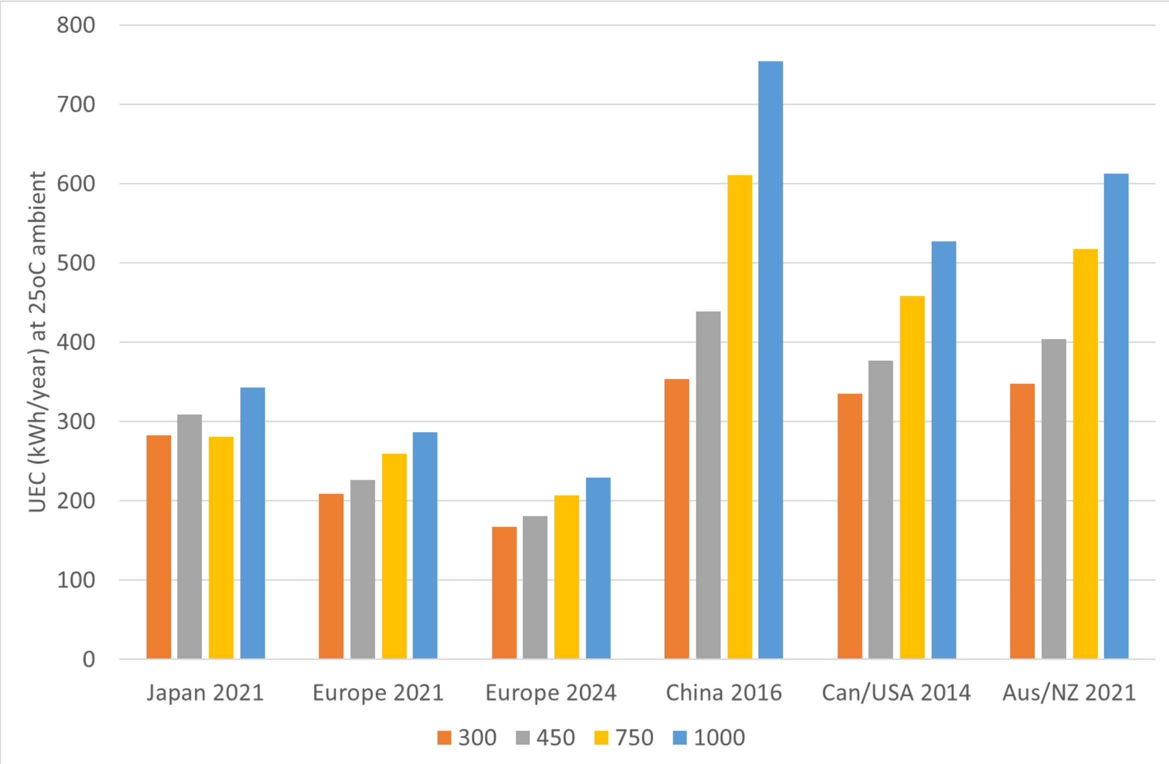
From this the following observations can be made:

- Europe's class A level is the most stringent for the 300 and 450 litre AV cases and about the same as Australia and New Zealand's 10 stars class at 150 litres AV
- Other highest efficiency labelling thresholds are less stringent than those used in Europe and Australia/New Zealand.

Frost-free (auto-defrost) refrigerator-freezers

Figure 3 shows a comparison of the normalised MEPS/TR thresholds for frost-free (i.e. fully auto defrost) refrigerator-freezer types with adjusted volumes at 150, 300, 450, 750 or 1000 litres (when calculated at 25°C ambient and with IEC 62552 compartment temperatures). The results are for the case where the freezer compartment accounts for 45% of the total adjusted volume (which is quite representative of this type across the 4E economies). The appliances are free-standing type and have no additional features such as: through-the-door ice service, more than 2 external doors, tropical/sub-tropical climate classes that might affect the product category or feature bonuses applied.

Figure 3: Comparison of normalised frost-free (indirect cool) domestic refrigerator-freezer MEPS/TR thresholds

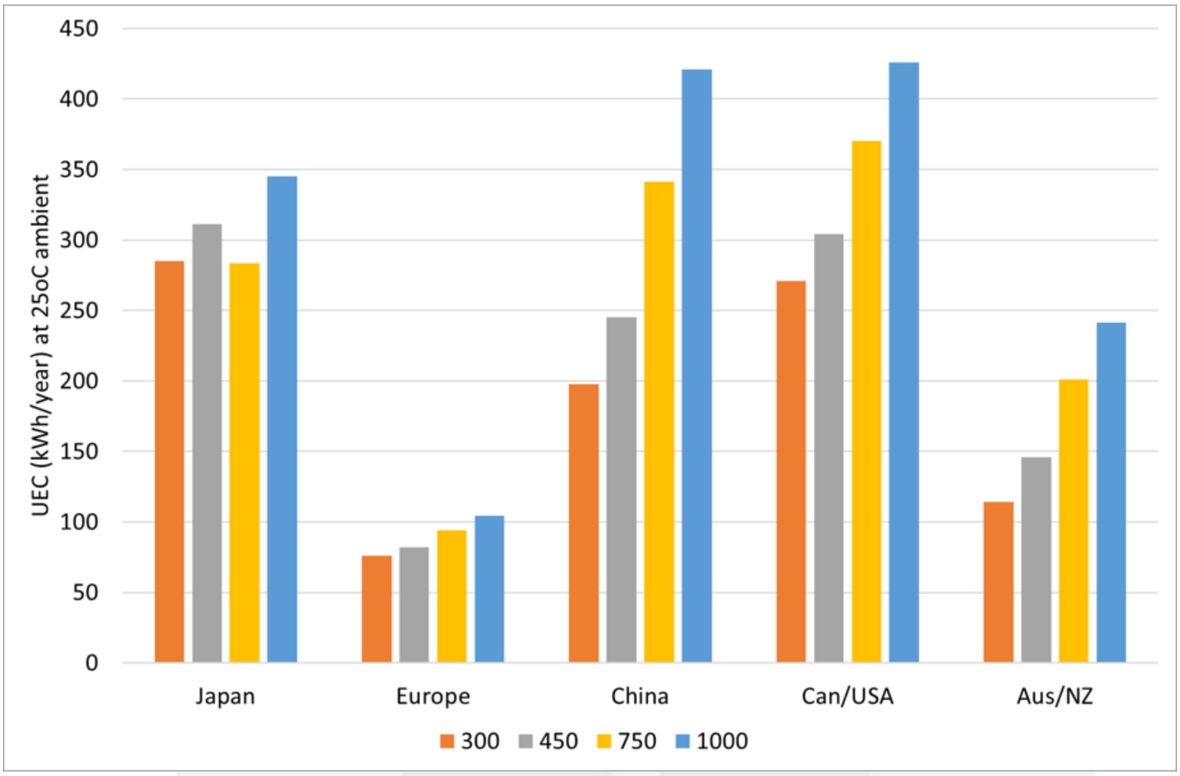


From this the following observations can be made:

- Europe's MEPS are the most stringent existing MEPS
- Japan's TR thresholds are the next most stringent
- Europe's MEPS in 2024 are considerably more ambitious again than the current 2021 levels
- the stringency of the MEPS in Canada/USA and Australia/New Zealand are relatively similar at 300 and 450 litres of AV but the Canadian/US MEPS are more stringent at higher AVs
- China's MEPS are the least stringent but more so at higher AV's than lower ones.

Figure 4 shows a comparison of the highest efficiency label thresholds applied in each 4E economy for frost-free refrigerator freezers.

Figure 4: Comparison of normalised frost-free (indirect cool) domestic refrigerator-freezer top label class thresholds



From this the following observations can be made:

- Europe's class A level is the most stringent in all cases
- Australia and New Zealand's 10 stars class is the next most stringent in all cases.

Appendix

A1. List of regulations and test standards

Australia	Greenhouse and Energy Minimum Standards (Household Refrigerating Appliances) Determination 2019 Test method: AS/NZS IEC 62552.1:2018, AS/NZS IEC 62552.2:2018, AS/NZS IEC 62552.3:2018 (commercial link not added) Efficiency criteria: AS/NZS 4474:2018 (commercial link not added)
New Zealand	EECA MEPS and labelling (Household Refrigerating Appliances) Test method: AS/NZS IEC 62552.1:2018, AS/NZS IEC 62552.2:2018, AS/NZS IEC 62552.3:2018 (commercial link not added) Efficiency criteria: AS/NZS 4474:2018 (commercial link not added)
Canada	Refrigerators and refrigerator-freezers MEPS and labelling requirements Freezers MEPS and labelling requirements Refrigerators and freezers test procedure CAN/CSA-C300-15
USA	Consumer refrigerators and freezers MEPS requirements Consumer refrigerators and freezers definition 42 U.S.C. 6291(16) Consumer refrigerators and freezers test standard: 10 CFR 430 Subpart B Appendix A to B Consumer refrigerators and freezers energy label: 16 CFR 305.14 Energy Star label: EStar V5.0
China	Domestic refrigeration appliances MEPS and energy efficiency grades: GB 12021-2015 Test standard: GB/T 8059-2016
EU	Domestic refrigeration appliances label: EU 2019/2016 Domestic refrigeration appliances (Ecodesign inc. MEPS): EU 2019/2019
UK Switzerland	See equivalent EU regulations
Japan	Refrigerator Top Runner: https://www.enecho.meti.go.jp/category/saving_and_new/saving/enterprise/equipment/toprunner/10_reizoko.html Freezer Top Runner: https://www.enecho.meti.go.jp/category/saving_and_new/saving/enterprise/equipment/toprunner/11_reitoko.html
Korea	Equipment efficiency regulations: 효율관리기자재_운용규정(산업통상자원부고시_제2020-225호)

A2. Standards development

The most widely used standard to measure domestic refrigeration appliance energy performance in 4E economies is IEC 62552 standard *Household refrigerating appliances - Characteristics and test methods*

This standard was first issued in 2007, had a major revision in 2015 and amended in 2020, the current version is the IEC 62552:2015+AMD1:2020. It is a major updated compared to the 2007 version of the standard. In particular, the energy consumption test has now two specified ambient temperatures (16°C and 32°C) and is carried out without test packages. IEC 62552-3:2015/AMD1:2020 *Household refrigerating appliances - Characteristics and test methods - Part 3: Energy consumption and volume*.[5]

Other characteristics of the IEC standard

Defrost energy

IEC62552-3 separately quantifies the incremental defrost and recovery energy and any associated temperature change during defrost. This can then be added mathematically to determine the daily energy consumption for any selected defrost interval. This value is separately measured at an ambient of 16°C and 32°C (if both temperatures are used).

The IEC method allows energy for longer or shorter defrost intervals to be estimated without any additional testing. Longer defrost intervals effectively allocate the fixed defrost and recovery energy over a longer defrost interval, reducing the impact of defrosting on overall energy consumption

Defrosting interval

The IEC test method has a measurement method for the determination of defrost interval for run time controllers or elapsed time controllers. For variable defrost controllers, a calculation approach is used based on a manufacturer declared value of maximum and minimum defrost interval at an ambient temperature of 32°C. The behaviour and qualification for these types of controllers are defined in IEC62552-3 Annex D. The defrost interval at an ambient temperature of 16°C is assumed to be twice the interval calculated for the parameters declared at 32°C. In order to get a representative energy consumption for an appliance during normal use, it is important that the defrost interval used to calculate energy consumption is reasonable.

Energy determination

IEC62552-3 has separate measurements of the steady state power at each control setting with a separate quantification of incremental defrost and recovery energy. The overall energy consumption is calculated as a function of the steady state power plus the additional energy associated with a defrost for the nominated defrost frequency.

The IEC standard does not specify the sequence of events and measurements, as the components of energy consumption are separately quantified and reported, this means that the results are highly reliable and accurate.

Triangulation and interpolation

Compared to previous standards IEC62552-3 provides more flexibility and more sophisticated numerical methods for interpolation, especially where there are more than two compartments. IEC also provides better safeguards and more flexibility in the data sets required for interpolation.

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[5] https://webstore.iec.ch/publication/21803

Volume determination

IEC62552-3 has a new approach for volume determination that is largely based on the US approach. This is a so called WYSIWIG approach, where all visible and usable volume is counted. Components that are required to make the product operate correctly must remain in place and are removed from the volume. Items that are not required to make the product work (e.g. bins and shelves) are removed.

Ambient controlled anti-condensation heaters

The IEC standard applies a temperature-humidity map specified at the regional level and the additional energy for ambient controlled anti-condensation heaters is calculated and added on to the measured energy.

Load processing efficiency

IEC 62552-3 (Annex G) is the first refrigerator energy performance standard to include this test. It measures the additional energy the appliance uses to remove a known quantity of heat (in the form of warm water) from the appliance. The intention is that this test directly assesses the ability of the appliance to process thermal loads due to food being placed in the appliance and air change loads from door opening and humidity ingress. The load processing energy is added to the other energy consumption components to determine the overall energy consumption.

Specific aspects in how IEC 6552 is applied in 4E economies

Australia and New Zealand

The AS/NZS IEC 62552 parts 1, 2 and 3 of 2018 are fully aligned to the IEC 62552 standard (2015 version).

China

China's standard GB/T 8059-2016 is aligned with the IEC 62552: 2015 test method.

GB 12021.2-2015 mentions that the latest edition of the IEC 62552 applies, consequently, it is currently based on IEC 62552-3:2015/AMD1:2020.

European economies

For the European market, ANNEX III of the Ecodesign regulation specifies the measurement methods. The EU regulation is mostly based on IEC 62552-3:2015/AMD1:2020 but clarifies some specific points. The European standardisation body (CENELEC) published the standard EN 62552:2020 to provide dedicated methods for measuring the energy performance according to the Ecodesign and labelling regulations. The main differences which impact testing the most are:

- The EN standard has an additional requirement/test for chill compartments.[6] If the refrigerating appliance doesn't fulfil this requirement, the chill compartment cannot be defined.
- The EN standard has an additional requirement for wine storage cabinets. According to the EN IEC 62552-2: 2020, during the storage test at 25°C, the relative humidity in the compartments must be measured and shall lie between 50-80%.
- During the freezing capacity test, the space to place light load is better defined in the EN than in the IEC standard and stacks that may be removed to make place for the light load is minimized.

[6] This is defined in EN IEC 62552-3: 2020 Annex ZA Chill compartment temperature control test

- The positions of the thermocouple sensor during the energy consumption test may differ slightly.
- Whilst according to the IEC and EN standards, the variable temperature compartment must be set to the most energy consuming condition, the regulation states that it must be set to the coldest position, excepted for a variable temperature compartment rated as a fresh food and/or chill compartment.[7]

In general, the test procedures used in the European economies and those used in other economies aligned to IEC 6552 have a high level of harmonisation. The few deviations are expected to have a very limited impact on the measured energy consumption in most cases. For wine storage cabinets and refrigerating appliance with chill compartments, the deviation of the test procedures has a larger impact.

Japan

Japan's JIS standard for refrigerators JIS C 9801 parts 1 to 3 of 2015 is aligned with the 2015 version of the IEC 62552 standard. A minor distinction is understood to be that the ΔE load processing energy is included through an explicit energy measurement but there is a slight deviation from the IEC method as the load processing and ice-making are measured at the same time (rather than measuring them separately) which is believed to be intended to produce a figure that is similar to the previous JIS approach which used door openings.

The JIS C 9801: 2015 standard supersedes the earlier 2006 version; however, the latter was applied in Top Runner determinations from the period of FY2010 to FY2020 and the former applied for the FY2021 Top Runner threshold, thus as far as the Top Runner requirements are concerned Japan adopted the IEC 62552 method with effect for the FY2021 Top Runner threshold.

Korea

Korea's KIS standard is understood to be fully aligned with IEC 62552 (2015 version).

Standards used in Canada and the USA

The USA and Canada used aligned energy performance test standards. The US standard is published by the DOE[8] whereas the Canadian standard is published by Canada Standards.

In the USA to determine that residential refrigerators and freezers that are currently manufactured or distributed into commerce are in compliance with DOE standards, manufacturers must follow the test procedure methods specified at 10 CFR 430, Subpart B, Appendix A and Appendix B.

In Canada the test standard applied is CAN/CSA-C300-15[9].

The main characteristics of these standards are that they test the energy performance of refrigeration appliances at a single ambient temperature of 32.2°C, whereas IEC 62552 measures steady state energy consumption at two ambient temperatures and interpolates between them.

The US and Canadian standards largely align with the IEC 62552 methods with regards to:

- how steady state energy consumption is measured at a single ambient temperature
- volume definition
- the method to measure compartment temperatures

[7] see Annex III 1(a) and Annex III 1(f)(1) of the Ecodesign regulation
[8] See: https://www.ecfr.gov/current/title-10/chapter-II/subchapter-D/part-430/subpart-B
[9] https://www.csagroup.org/store/product/CAN%25100CSA-C300-15/

- the method to determine defrost cycle energy use

but they differ with regard to:

- the compartment internal design temperatures
- the measurement of load processing (applied in IEC 62552 but not in the US/Canadian standards).

Pending amendments to the US test standard

In October 2021 the USDOE published a rulemaking on the amendment to the DOE test standard[10]. Under this rulemaking only minor changes are to be made to the standard which is due to come into effect in April 2022. The main change with impact on declared energy performance appears to be a revision of the through-the-door icemaker bonus from 84kWh/year to 28kWh/year; however, a summary of the changes is set out below.

In the process of considering the amendment to the test procedure the DOE assessed the possibility of aligning the test method to the IEC 62552 method. They produced an informative explanation of why they have not currently opted not to do so (see further below where the explanation is reprised in full). More details are available at the link provided in the footnote which includes the references cited.

[10] https://www.regulations.gov/document/EERE-2017-BT-TP-0004-0029

Summary of pending changes to the US test standard

Current DOE test procedure	Amended test procedure	Attribution
Incorporates by reference ("IBR") AHAM HRF-1-2008	Updates IBR to AHAM HRF-1-2019	Industry test method update.
Variation between definitions and corresponding test procedure provisions in industry standard	Definitions amended and established consistent with test procedure provisions in HRF-1-2019	IBR of HRF-1-2019.
Variation between testing provisions for testing anti-sweat heaters and equations to calculate annual energy use	Requires only the tests used for calculating annual energy use to be conducted	IBR of HRF-1-2019.
Specifies a temperature measurement interval of 4 minutes or less for most products	Specifies that the temperature and power supply measurement intervals shall not exceed 1 minute	IBR of HRF-1-2019; improves representativeness, repeatability, and reproducibility.
Does not define the terms "compartment" or "sub-compartment"	Defines terms consistent with HRF-1-2019	IBR of HRF-1-2019.
Does not explicitly specify thermocouple placement in certain product configurations	Provides additional thermocouple placement specifications	IBR of HRF-1-2019; improves representativeness, repeatability, and reproducibility.
Does not explicitly specify the setup for test chamber floors that have vents for airflow	Provides consistent specifications for test platform and floor requirements	IBR of HRF-1-2019.
Does not explicitly specify timing of required temperature range conditions	Specifies that conditions must be maintained for stabilization and test periods	Improves representativeness, repeatability, and reproducibility.
Requires a separate stabilization period and test period when conducting all energy tests	Allows test period to serve as stabilization period when conducting certain energy tests	IBR of HRF-1-2019.
Stabilization requirements may not be achievable by certain products with irregular compressor cycling or multiple compressors	Allows measuring average temperatures over multiple compressor cycles or for a given time period to determine stable operation	IBR of HRF-1-2019; addresses current waiver.
Includes energy use adder for automatic icemakers of 84 kWh/yr	Updates energy use adder for automatic icemakers to 28 kWh/yr	IBR of HRF-1-2019.
Tests connected features the same as certain other customer-accessible features, *i.e.*, set at the lowest energy usage position, except for demand response devices in the as-shipped position	Tests any connected products with the communication module on but not connected to a network	IBR of HRF-1-2019.
Inadvertently omits optional method for calculating average per-cycle energy consumption of refrigerators and refrigerator-freezers	Reinstates optional method and makes other non-substantive corrections	Correction.

DOE rationale of why the test method was not aligned with IEC 62552

DOE's test procedures for refrigeration products in Appendices A and B currently incorporate by reference the Association of Home Appliance Manufacturers ("AHAM") industry standard HRF-1, "Energy and Internal Volume of Refrigerating Appliances" ("HRF-1-2008"). DOE references HRF-1-2008 for definitions, installation and operating conditions, temperature measurements, and volume measurements. In August 2016, AHAM released an updated version of the HRF-1 standard, HRF-1-2016.

In the June 2017 RFI, DOE stated that, based on review of HRF-1-2016, the majority of the updates from the 2008 standard were clarifications or other revisions to harmonize with DOE's test procedures. 82 FR 29780, 29785. In the December 2019 NOPR, DOE proposed to incorporate by reference HRF-1-2016 into 10 CFR part 430, subpart A, and reference certain sections of the 2016 standard in appendix A and appendix B. DOE noted that updating the references to HRF-1-2016 would not substantively affect the existing test procedures in appendix A and appendix B. 84 FR 70842, 70847-70848. DOE also noted that AHAM had released a draft of an updated HRF-1 for public review and provided a link to the draft revision. 84 FR 70842, 70847. DOE requested feedback on its proposal and on whether DOE should incorporate an updated version of HRF-1 instead, should one become publicly available. 84 FR 70842, 70848.

In response to the December 2019 NOPR, AHAM supported incorporation by reference in its entirety of the new version of HRF-1, HRF-1-2019, stating that DOE had participated in the development of the standard and that the standard was also available for public review, allowing other stakeholders to provide feedback as well. (AHAM, No. 18, p. 2)

Whirlpool and Liebherr also recommended the incorporation of HRF-1-2019. (Whirlpool, No. 19, p. 1; Liebherr, No. 16, p. 1) Sub Zero commented that HRF-1-2019 is the most up-to-date and effective energy test procedure for household refrigeration equipment and recommended that it be adopted by reference by DOE. (Sub Zero, No. 17, p. 1-2)

DOE is also aware of another international test standard: International Electrotechnical Commission (“IEC”) Standard 62552, “Household refrigerating appliances—Characteristics and test methods” (“IEC 62552”). The latest publication of this test standard is IEC 62552:2015, which was published in three parts (IEC 62552-1:2015, IEC 62552-2:2015, and IEC 62552-3:2015) on February 13, 2015. (10) On November 30, 2020 IEC issued an amendment to this test standard, IEC 62552:2015/AMD1:2020. (11)

CEC encouraged DOE to incorporate by reference the three parts of IEC 62552, stating that the standard addresses all types of refrigerators, including those not driven by compressors, and that harmonizing with the international test procedure would reduce net test burden. (CEC, No. 20, p. 4)

Samsung recommended that DOE generally consider adopting global IEC test procedures in residential appliance test procedures in order to reduce regulatory burdens. Samsung referenced what it described as significant progress toward international modernization and harmonization of standards and test procedures in many industries, leading to improvements in efficiency. According to Samsung, DOE's adoption of IEC test procedures would allow companies to design international platforms and configurations for global markets, which Samsung asserted would reduce cost for manufacturers in design and testing and would result in improved efficiencies and broader consumer choices. (Samsung, No. 24, p. 3) The Joint Commenters referenced similar comments that Samsung provided in the December 2019 NOPR Public Meeting and also recommended that DOE evaluate the relevant IEC test procedures. (Joint Commenters, No. 22, p. 2) NEEA also recommended that DOE adopt a version of the IEC test procedure to harmonize refrigerator test procedures worldwide, which NEEA stated would reduce overall test burden on manufacturers. NEEA added that such harmonization would eliminate the need for manufacturers to optimize refrigerator performance to multiple test procedures. (NEEA, No. 26, p. 5)

In response to CEC's comment regarding applicability of IEC 62552 to non-compressor products, DOE's existing test procedure for MREFs in 10 CFR 430.23(ff) and appendix A already accounts for testing non-compressor products. (See 10 CFR 430.23(ff)(8)) Additionally, while HRF-1-2016 specifically limited scope to compressor-driven refrigerators, refrigerator-freezers, wine chillers, and freezers (See section 2 of HRF-1-2016), HRF-1-2019 does not limit scope to compressor products.

DOE recognizes that there may be a potential benefit to harmonizing among international test standards and regulations, including the potential for reduced burden on manufacturers. In the present case, the existing DOE test procedure, which uses an approach consistent with that in HRF-1-2019, has a long history of use in the United States market, is generally understood by industry, and the results are generally understood by consumers. The existing test procedure is also used as the basis for the Environmental Protection Agency's ENERGY STAR eligibility criteria for refrigerators, refrigerator-freezers, and freezers (12) and the Federal Trade Commission's ("FTC") EnergyGuide labels (13) for these products. DOE also notes that the current approach to the test procedure was generally supported for use by commenters representing manufacturers. (AHAM, No. 18, p. 2; Liebherr, No. 16, p. 1; Sub Zero, No. 17, pp. 1-2; Whirlpool, No. 19, p. 1)

For these reasons, DOE is generally maintaining the existing test approach in this final rule. As discussed in the following sections of this final rule, the test procedure amendments established in this final rule do not represent a significant change from the current test approach and, therefore, result in little or no additional burden on manufacturers. Additionally, DOE has determined that the existing test approach, including the amendments as discussed in this final rule, results in representative measures of energy use and is not unduly burdensome to conduct, as required under EPCA. (42 U.S.C. 6293(b)(3))

In addition to the comments described earlier in this section, many of the commenters supporting use of the IEC 62552 test method referred to the ambient conditions required in that test standard, including the requirement for testing at two ambient temperatures. As discussed in section III.B.1 of this document, DOE considered harmonizing with IEC 62552's ambient test conditions, including as part of an optional second ambient test condition; however, DOE concluded that the current single-ambient test approach is appropriate for determining representative energy consumption for refrigeration products.

DOE also reviewed the updates included in the latest HRF-1-2019 standard, as discussed in section III.B.2 of this document. Compared to the draft available for public review and referenced in the December 2019 NOPR, the published version of HRF-1-2019 includes only one substantive update, as discussed in section III.F of this final rule. After considering these updates, DOE is incorporating by reference HRF-1-2019 with additional changes as discussed further in this final rule.

1. Ambient Test Conditions

The DOE test procedures in appendices A and B simulate typical room conditions (72 °F (22.2 °C)) with door openings, by testing at 90 °F (32.2 °C) without door openings. 10 CFR 430.23(a)(7), 10 CFR 430.23(b)(7), and 10 CFR 430.23(ff)(7). The test procedures directly measure the energy consumed during steady-state operation and defrosts, if applicable. The additional thermal load and additional energy consumption of the refrigeration system at the elevated ambient temperature, compared to typical operating ambient conditions, represents the increase in energy consumption caused by thermal loads introduced during normal consumer use— e.g., from door openings and the loading of warm items into the refrigerated space. Additionally, the current test procedures incorporate usage adjustment factors to account for differences in these user-related thermal loads for different types of refrigeration products (i.e., chest freezers and MREFs are typically used less frequently than a primary refrigerator-freezer in a household).

DOE has provided principles of interpretation for its test procedures in 10 CFR 430.23(a)(7), 10 CFR 430.23(b)(7), and 10 CFR 430.23(ff)(7) to describe the intent of the test procedures and the requirements regarding component operation in the test condition versus typical room temperature operation. For example, energy consuming components that operate in typical room conditions (including as a result of door openings, or a function of humidity), and that are not excluded by the test procedure, must operate in an equivalent manner during energy testing under the test procedure, or be accounted for by all calculations as provided for in the test procedure. (See, for example, 10 CFR 430.23(a)(7)(i))

DOE first adopted the 90 °F ambient test condition in 1977 after conducting a public notice and comment proceeding to discuss the merits of a proposed test procedure that included the possibility of adopting the 90 °F ambient temperature condition or a higher one at 104 °F. (See 42 FR 46140, 46142 (September 14, 1977) (rejecting adoption of the 104 °F ambient test condition in favor of 90 °F)) DOE explained the basis for selecting this temperature condition in its proposal leading to that final rule by noting in part that the selected temperature is designed to compensate for door openings when they occur and a correction factor can be applied “when appropriate.” 42 FR 21584, 21586 (April 27, 1977). Further, industry's more recent efforts at revising and updating the test procedures for refrigeration have continued to consistently apply the 90 °F ambient condition. The currently incorporated by reference HRF-1-2008, the more recent HRF-1-2016, and most recent HRF-1-2019 all maintain the approach of a 90 °F ambient temperature.

In response to the December 2019 NOPR, DOE received a variety of comments regarding the test method set forth in IEC 62552, in particular with regard to the specification of two ambient test conditions (at approximately 90 °F and 60 °F) (14) by IEC 62552. The IEC 62552 method requires testing at these two ambient conditions with optional additional load processing efficiency tests (to account for a door opening and warm item insertion) and other auxiliary component efficiency tests. (15) The total energy consumption of a product is determined by a regional interpolation function of the 90 °F and 60 °F test results, load processing efficiency results, and auxiliary component efficiency results. The regional interpolation functions are not defined by IEC 62552—individual jurisdictions may adapt these interpolation weighting factors to result in representative household conditions for the specific jurisdiction.

In response to the December 2019 NOPR, AHAM opposed adopting the test method of IEC 62552 in the current DOE test procedure rulemaking. AHAM cited a study conducted in 1991 by Lawrence Berkeley National Laboratory that found agreement between the 90 °F test method required by the DOE test procedure and field use energy consumption. (16) AHAM stated that any effort to consider or adopt IEC 62552, specifically, the two ambient test conditions, would require extensive testing and take time to evaluate, which would be inappropriate at this time given DOE's statutory obligations to publish an amended test procedure. AHAM stated that it continues its efforts to harmonize HRF-1 with IEC 62552 and the DOE test procedures and commented that its task force will consider if any of the elements of the IEC 62552 test method should eventually be incorporated into HRF-1. AHAM supported an incorporation by reference of HRF-1-2019, which AHAM asserted balances representativeness with test burden, while also retaining high repeatability and reproducibility with the single 90 °F closed-door test point. (AHAM, No. 18, pp. 3-4) Sub Zero supported AHAM's comments and added that IEC 62552 over time has adopted more and more of the methods prescribed in HRF-1, and in the future, these test standards may become even more similar. (Sub Zero, No. 17, p. 2) Sub Zero additionally stated that the elevated-ambient, closed-door energy test prescribed in HRF-1-2019 has been shown to be an excellent proxy for determining actual field energy use while providing repeatability and reproducibility without imposing an unreasonable burden to conduct. (Sub Zero, No. 17, p. 1-2)

At the December 2019 NOPR Public Meeting, GEA stated that the 60 °F ambient test point used in IEC 62552 was developed specifically for products which, in low-temperature climates, would activate a heater in order to maintain refrigeration capacity, and that the 60 °F test is not needed to measure the average energy usage at 72 °F with door openings. GEA stated that applying an additional test point at 60 °F would not only double the testing time, but also would not be as repeatable or reproducible as the single ambient method in HRF-1. GEA further commented that single speed compressors and variable speed compressors alike would benefit from the lower ambient temperature. (GEA, Public Meeting Transcript, No. 11, pp. 54-57)

Several commenters recommended that DOE consider alignment with IEC 62552, stating that there are potential benefits associated with multiple ambient condition tests. The CA IOUs, CEC, NEEA, and the Joint Commenters commented that testing at a single ambient test point cannot differentiate energy-saving design options (e.g., variable speed compressors) present in refrigeration products currently on the market. (CA IOUs, No. 23, p. 1; CEC, No. 20, p. 3; NEEA, No. 26, p. 2; Joint Commenters, No. 22, p. 1) The CA IOUs and CEC also stated that the single condition leads to a focus on insulation rather than refrigeration efficiency. (CA IOUs, No. 23, p. 2; CEC, No. 20, p. 4) The CA IOUs, CEC, NEEA, and the Joint Commenters argued that the elevated ambient temperature does not represent normal use conditions. (CA IOUs, No. 23, p. 2; CEC, No. 20, p. 3; NEEA, No. 26, p. 2; Joint Commenters, No. 22, p. 1) The CA IOUs and CEC raised concerns regarding susceptibility to circumvention, stating that multiple test points discourage test circumvention strategies. (CA IOUs, No. 23, p. 2; CEC, No. 20, p. 4) The CA IOUs and CEC also argued that there is a high testing burden for manufacturers who supply products to international markets if individual jurisdictions each have different single-ambient test points. (CA IOUs, No. 23, p. 2; CEC, No. 20, p. 3) Specifically, the CA IOUs, NEEA, and the Joint Commenters commented that IEC 62552 allows jurisdictions to use the two ambient test points to interpolate to the appropriate regional ambient temperature, thus reducing overall test burden across jurisdictions with different climates. (CA IOUs, No. 23, p. 2; NEEA, No. 26, p. 2; Joint Commenters, No. 22, p. 2)

The Joint Commenters further commented and referred to previous comments on a request for information DOE published regarding the representativeness of DOE's test procedures and average use cycles of covered products. (17) The Joint Commenters stated that some variation in efficiency performance among models would be expected at more representative test conditions. The Joint Commenters stated that because most refrigerators and freezers are not placed in 90 °F rooms, the single elevated ambient test point may not be providing an accurate relative ranking of model efficiencies. Specifically, the Joint Commenters were concerned that two models that have the same energy consumption as measured by the current test procedure could potentially perform significantly differently at more representative conditions, and furthermore, that the current test procedure does not adequately reflect the benefits of variable speed compressors. The Joint Commenters commented that a refrigerator's compressor would cycle more often at an ambient temperature of 72 °F than at 90 °F and therefore, the benefits of variable speed compressors, which can reduce speed to cycle less frequently, would be greater at 72 °F. The Joint Commenters stated that a test procedure that relied on an ambient condition more representative of field conditions would provide more incentive for optimizing designs at these conditions and would supply better information to consumers. The Joint Commenters also mentioned that the load processing efficiency test in IEC 62552, which measures a unit's response to a single door opening and insertion of warm water bottles, can increase representativeness. (Joint Commenters, No. 22, pp. 1-2)

NEEA stated that test data of 100 refrigerators evaluated as part of the IEC 62552 development demonstrates that the ambient temperature has the greatest impact on refrigerator energy consumption, and technologies such as variable speed compressors have an energy savings potential of 10-30% for refrigerator-freezers due to reduced cycling losses from load-matching (i.e., responding to door openings and warm item insertion). NEEA commented that without the addition of a second ambient temperature test in DOE's test procedure, the reduced energy use associated with such energy saving technologies will not be recognized. NEEA stated that the current test procedure may even penalize the rated performance of energy efficient refrigerators in some cases due to rating equipment at near full compressor speed. NEEA also stated that testing at a single elevated ambient temperature with no user interaction does not reflect normal use and does not encourage manufacturers to optimize the performance of their products for a normal use condition. (NEEA, No. 26, p. 2)

NEEA presented data from testing six refrigerators using both the DOE (i.e., high ambient temperature) and IEC 62552 low-temperature ambient conditions. NEEA asserted that the data shows that refrigerators with variable speed compressors showed a relatively smaller increase in energy consumption from the low-temperature test to the high-temperature test. This data is reproduced in Table III.1. Based on this data, NEEA stated that DOE's single ambient test temperature obscures the energy saving benefit of variable speed technologies that would be of most benefit during normal use. (NEEA, No. 26, pp. 1-3)

NEEA referred to the Australian/New Zealand regulatory requirements for refrigerators and freezers (AS/NZS 4474:2018), which incorporate IEC 62552 without modifications but adapt the weighting factors for the 90 °F test result and the 60 °F test result for the purpose of providing a representative local energy use. NEEA stated that the IEC test method is specifically constructed in a manner to allow different countries and regions to add the different components together in a manner and weighting that best reflects local conditions while using only a single suite of test elements that remain harmonized throughout the world, and that weighting factors can be adapted for the typical conditions in the United States. (NEEA, No. 26, pp. 1-4)

Samsung commented in support of a test method with multiple ambient test conditions, specifically IEC 62552, stating that such a method would be more representative in capturing the energy savings benefits of innovative technologies such as variable speed compressors. Samsung stated that the current test procedure, with a single 90 °F ambient test point, was adequate at a time when most of the refrigerators in the market used single speed compressors, but that in the last ten years, variable speed compressors and adaptive control algorithms have allowed compressors to optimize performance for different load conditions as well as minimize temperature fluctuations for better food preservation. Samsung stated that the energy savings of such technologies would be realized under real-world variable-load conditions due to door openings, introduction of large food loads, seasonal temperature changes, and consumer day/night routines. (Samsung, No. 24, pp. 2-3)

Samsung acknowledged that testing in two ambient test conditions would result in an increase in the test burden, but Samsung stated that such burden is justified by the need for representativeness in order to accurately measure the efficiency benefits of new technologies. Samsung recommended that DOE could limit test burden by developing an optional single ambient test condition approach, as DOE has similarly done for the optional measurement or calculation of motor performance in the 2016 test procedure final rule for pumps. (18) (Samsung, No. 24, p. 3)

NEEA also commented in support of an approach in which manufacturers could elect to perform an optional second ambient condition test, noting that this approach would be an incremental approach to incentivize more efficient technologies while not increasing burden for those manufacturers choosing not to run the additional test. (NEEA, No. 26, p. 4)

At the December 2019 NOPR Public Meeting, ASAP commented that IEC 62552 has a strong international pedigree and recommended that DOE perform a side-by-side comparison of the IEC 62552 and the DOE test procedure. (ASAP, Public Meeting Transcript, No. 11, pp. 89-91) The CA IOUs also recommended that DOE conduct such a comparison to determine the representativeness of the single ambient test condition, and stated that the DOE test procedure should provide adequate differentiation of part-load compressor technologies. (CA IOUs, Public Meeting Transcript, No. 11, pp. 91-92)

DOE appreciates the comprehensive feedback from commenters regarding the ambient test condition issue. The primary concerns with the existing single ambient test condition approach were regarding representativeness (specifically for variable speed compressor products) and the potential for circumvention.

DOE recognizes the concern of using a single test condition to measure energy consumption of models with variable speed compressors. While variable speed compressors and single speed compressors may have similar performance at full-load conditions (i.e., full speed and compressor always on), variable speed compressors typically perform more efficiently than single speed compressors when operating at part-load conditions. Variable speed compressors may match the lower cooling demand by reducing speed rather than by cycling on and off, thereby avoiding losses that occur when the system cycles on and off. On March 29, 2021, DOE published a final rule to amend the test procedure for room air conditioners to, in part, provide for the testing of variable speed compressor products to better reflect their relative efficiency gains at lower outdoor temperatures compared to single speed compressor products (the “March 2021 Room AC Final Rule”). 86 FR 16446 (March 29, 2021). In the March 2021 Room AC Final Rule, DOE explained that the previous test procedure for room air conditioners measured performance while operating at full-load conditions (i.e., the compressor is operated continuously on), and as a result, the existing DOE test procedure for room air conditioners did not capture any inefficiencies due to cycling losses. Id at 86 FR 16452. DOE included a methodology for determining and applying a “performance adjustment factor” for variable speed room air conditioners to reflect the avoidance of cycling losses that would be experienced in a representative consumer installation (i.e., at part load conditions). 86 FR 16446, 16455-16460. However, the same is not true for the existing test procedures for refrigeration products: the existing 90 °F ambient test point does not impose a full-load test condition for all refrigeration products. As discussed previously in this section, the 90 °F test condition represents typical room conditions (72 °F (22.2 °C)) with door openings (i.e., typical operation rather than maximum thermal load operation). At the ambient test condition temperature of 90 °F, many refrigeration products exhibit compressor cycling, and thus the 90 °F condition typically already represents part-load conditions for single speed compressor products and variable speed compressor products alike. This is further supported by the existence of multiple provisions in HRF-1-2019 and IEC 62552 regarding cycling compressor systems (e.g., stabilization requirements and test period selection requirements). Given that most refrigeration products have compressors that cycle at this test condition, the single elevated ambient test method already captures inefficiencies due to cycling losses (and correspondingly, efficiencies for variable speed compressors avoiding cycling losses) for refrigeration products, which generally addresses the primary concerns that commenters raised regarding the test procedure not adequately capturing efficiency benefits of variable speed compressors.

As discussed, NEEA presented data from testing six refrigerators using two ambient test points of 32 °F and 16 °F (as set forth in IEC 62552), and this data is reproduced in Table III.1. Because the existing DOE test procedures use an ambient test condition of 90 °F (approximately 32 °C), DOE has calculated the performance differentials for these six refrigerators in terms of a percent decrease in energy use from 32 °C to 16 °C.

Table III.1—NEEA Ambient Test Condition Comparison

Unit	Compressor type	32 °C annual energy consumption(kWh/yr)	16 °C annual energy consumption(kWh/yr)	Percent decrease in energy use from 32 °C to 16 °C
B	Single Speed	536.50	243.43	55
C	Single Speed	607.19	281.61	54
F	Single Speed	563.55	291.21	48
Single Speed Mean				*52*
A	Variable Speed	625.41	327.61	48
D	Variable Speed	467.05	231.36	50
E	Variable Speed	451.43	229.32	49
Variable Speed Mean				*49*

NEEA's data indicate that the variable speed units exhibited a smaller decrease in energy use than single speed units when testing at 16 °C compared to 32 °C. Specifically, the average percent decrease in energy use (from 32 °C to 16 °C) was 52% for single speed compressor products but only 49% for variable speed compressor products in NEEA's dataset. This indicates that, on average, variable speed compressor products did not exhibit additional savings over single speed compressor products at lower ambient conditions.

In response to comments suggesting that DOE conduct additional investigative testing on a larger sample of single speed compressor products and similar variable speed compressor products, DOE tested 16 additional products using appendices A and B test procedures at ambient conditions of 90 °F and 60 °F to compare the resulting impacts on variable speed and single speed compressor products. DOE's investigative testing results are shown in Table III.2.

Table III.2—DOE Ambient Test Condition Comparison

Unit	Product class	Compressor type	Total adjusted volume (ft³)	90 °F annual energy consumption(kWh/yr)	60 °F annual energy consumption(kWh/yr)	Percent decrease in energy use from 90 °F to 60 °F
G	13A	Single Speed	4.4	229	76	67
H	3	Single Speed	11.9	312	152	51
I	3	Single Speed	21.9	392	189	52
J	3A	Single Speed	17.6	266	82	69
K	5A	Single Speed	27.7	682	402	41
L	5A	Single Speed	34.7	750	404	46
M	9	Single Speed	35.2	486	288	41
Single Speed Mean						*52*
N	13A	Variable Speed	5.2	239	63	74
O	3	Variable Speed	24.4	388	161	59
P	5	Variable Speed	13.2	306	157	49
Q	5A	Variable Speed	27.5	508	309	39
R	5A	Variable Speed	28.7	748	432	42
S	5A	Variable Speed	39.2	764	541	29
T	5A	Variable Speed	39.3	645	418	35
U	5A	Variable Speed	40.1	782	480	39
V	5-BI	Variable Speed	11.9	442	152	66
Variable Speed Mean						*48*
Standard Deviation for all Samples (G through V)						*13*

Similar to the test results from NEEA, DOE's test results showed no clear performance improvement for variable speed compressor products relative to single speed compressor products at the 60 °F test condition. Specifically, the average percent decrease in energy use (from 90 °F to 60 °F) was 52% for single speed compressor products but only 48% for variable speed compressor products in DOE's dataset, which closely matches the results from NEEA's dataset. This suggests that given the current state of compressor technology, introducing a second low temperature ambient test would have no significant impact on the relative measured energy use of variable speed compressor products compared to single speed compressor products. Therefore, adding a lower ambient temperature test for the purpose of differentiating the performance of variable speed compressors is not justified at this time.

In response to comments indicating that a single ambient test condition introduces the potential for circumvention, DOE provides principles of interpretation for its test procedures in 10 CFR 430.23(a)(7), 10 CFR 430.23(b)(7) and 10 CFR 430.23(ff)(7) to describe the intent of the test procedures and the requirements regarding component operation in the test condition versus typical room temperature operation. For example, energy consuming components that operate in typical room conditions (including as a result of door openings, or a function of humidity), and that are not excluded by the test procedure, must operate in an equivalent manner during energy testing under the test procedure, or be accounted for by all calculations as provided for in the test procedure. 10 CFR 430.23(a)(7)(i). Further, commenters did not provide an explanation for why a test conducted at the high temperature test condition (i.e., 90 °F) and a second low temperature condition (i.e., 60 °F) would be any more robust in preventing circumvention attempts.

On December 8, 2020 DOE published an early assessment review and request for information regarding energy conservation standards for miscellaneous refrigeration products (the “December 2020 MREFs RFI”). 85 FR 78964 (December 8, 2020). In response to the December 2020 MREFs RFI, the CA IOUs raised concerns about the appropriateness of the 90 °F ambient test condition for MREFs that utilize thermoelectric cooling rather than compressor cooling. The CA IOUs commented that, compared to other refrigeration products, MREFs have a lower cooling load and less frequent door openings. The CA IOUs suggested that alternative testing approaches would be more representative of an average use cycle for MREFs than the load factor adjustment in DOE's current test procedure, and these could also lead to more appropriately engineered solution so that consumers may realize improved real-world benefits. Specifically, the CA IOUs indicated that the adjustment factor of 0.55 in Appendix A may be appropriate for MREFs with compressor cooling, but that there was insufficient evidence presented by DOE that this same factor would be appropriate for MREFs with thermoelectric cooling. The CA IOUs noted that this could misrepresent and potentially limit the use of non-compressor cooling technologies (such as thermoelectric or magnetocaloric systems), which are capable of operating more efficiently at lower temperature differences between the cabinet interior and the ambient condition. The CA IOUs referenced data for coolers provided during the development of DOE's test procedure for MREFs. (19) (CA IOUs, December 2020 MREFs RFI, No. 5, pp. 3-4) (20)

In the development of the July 2016 Final Rule, DOE considered the data referenced in the CA IOUs comment and determined that one set of test requirements was appropriate for testing coolers in appendix A, regardless of refrigeration technology. 81 FR 46767, 46781-46782. DOE included the 90 °F ambient test temperature and 0.55 usage factor, as initially proposed for vapor-compression coolers, to establish consistent test requirements across all coolers, as this would ensure that all products offering the same consumer utility and function are rated on a consistent basis, thus providing consumers with a meaningful basis on which to compare product energy consumptions. 81 FR 46767, 46782. DOE also stated that manufacturers of products which are unable to maintain the standard 55 °F cooler compartment temperature when subject to a 90 °F ambient condition would be required to pursue a test procedure waiver to determine an appropriate energy use rating for these products that reflects actual energy use under normal consumer use. 81 FR 46767, 46781. As of this final rule, DOE has not received any petitions for waiver regarding non-compressor MREFs.

As such, the 0.55 usage factor applied to calculate energy consumption for MREFs accounts for the reduced cooling load and less frequent door openings for cooler compartments, which is a consistent reduction regardless of refrigeration technology. Furthermore, DOE notes that these provisions have not precluded the availability of thermoelectric coolers on the market and certified to DOE. In this final rule, DOE will maintain the existing approach for testing MREFs, including instructions for pursuing a test procedure waiver when appropriate.

For the aforementioned reasons, DOE is maintaining the single ambient test condition approach by incorporating by reference the most recent industry test procedure, HRF-1-2019.

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