Final Report by Electric Refrigerator Evaluation Standards Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy

The Electric Refrigerator Evaluation Standards Subcommittee had deliberations on judgment standards for the manufacturers or importers (hereinafter referred to as "manufacturers") concerning performance improvement of electric refrigerators (including electric freezers and refrigerator-freezers, hereinafter), and prepared an final summary report as below.

1. Evaluation of Current Standards

The weighted mean of energy consumption efficiency of electric refrigerators (including electric refrigerator-freezers, hereinafter) whose target year was fiscal 2004 was decreased to 290.3 kWh/year, which corresponds to improvement of 55.2% from the weighted mean of energy consumption efficiency (647.3kWh/year) (of products shipped prior to 1998) before introduction of the Top Runner Standard. In addition, the improvement was even better than the estimates (449.7 kWh/year) and the assumed improvement rate (30.5%), when the Top Runner Standard was then achieved.

In addition, the weighted mean of energy consumption efficiency of electric freezers was 369.7 kWh/year, which corresponds to improvement of 29.6% from the weighted mean of energy consumption efficiency (of products shipped in 1998) before introduction of the Top Runner Standard. In addition, the improvement was even better than the estimates (404.7 kWh/year) and the assumed improvement rate (22.9%), when the Top Runner Standard was then achieved.

With the above in mind, we can evaluate that as a result of efforts for energy conservation by manufacturers, energy saving has progressed and thus the current standards based on the Top Runner Program work effectively.

2. Target Scope [See Attachment 1]

This review shall apply to electric refrigerators stipulated as being covered by JISC9801:2006 Household Refrigerating Appliances---Characteristics and test methods.

3. Items to be judgment standards for manufacturers

(1) Target fiscal year [See Attachment 2]

It shall be the fiscal year 2010 .

(2) Target standard values [See Attachments 3 to 4]

With regard to electric refrigerators that manufacturers ship within Japan for the target fiscal year, a weighted average of the energy consumption efficiency (annual energy consumption) calculated in (3), by the volume of shipments for each manufacturer per category in the table below shall not exceed the target standard value.

Electric Refrigerators (Including Electric Refrigerator-freezers)

Category	Cooling Type	Rated Internal Volume	Number of Doors in Chiller Section	Calculation Formula of Target Standard Value
A	Natural convection type	—	—	E=0.844Vadj+155
B	Forced circulation type	300L or less	—	E=0.774Vadj+220
C		Over 300L	One door	E=0.302Vadj+343
D			Over one door	E=0.296Vadj+374

Electric Freezers

Category	Cooling Type	Rated Internal Volume	Number of Doors in Chiller Section	Calculation Formula of Target Standard Value
E	Natural convection type	—	—	E=0.844Vadj+155
F	Forced circulation type	300L or less	—	E=0.774Vadj+220
G		Over 300L		E=0.302Vadj+343

Notes (1) E: Energy consumption efficiency (kWh/year)

(2) Vadj: Adjusted internal volume (unit: L)

1) For a refrigerator-freezer and a freezer whose freezing compartment is of three-star type, Vadj shall be a numeric value obtained with the following formula:
Vadj= 2.20 x V (Rated internal volume of a freezing compartment) + V (Rated internal volume of other than a freezing compartment)
2.20 = (22.4 °C-(-18 °C))/(22.4 °C -4 °C) = 40.4/18.4

2) For a refrigerator-freezer and a freezer whose freezing compartment is of two-star type, Vadj shall be a numeric value obtained with the following formula:
Vadj= 1.87 x V (Rated internal volume of a freezing compartment) + V (Rated internal volume of other than a freezing compartment)
1.87 = (22.4 °C -(-12 °C))/(22.4 °C -4 °C) = 34.4/18.4

3) For a refrigerator-freezer and a freezer whose freezing compartment is of one-star type, Vadj shall be a numeric value obtained with the following formula:
Vadj= 1.54 x V (Rated internal volume of a freezing compartment) + V (Rated internal volume of other than a freezing compartment)
1.54 = (22.4 °C -(-6 °C))/(22.4°C -4 °C) = 28.4/18.4

(For Your Reference)

Three-star type : A freezing compartment whose average freezing load temperature of which is –18 °C or lower

Two-star type : A freezing compartment whose average freezing load temperature of which is –12 °C or lower

One-star type : A freezing compartment whose average freezing load temperature of which is –6 °C or lower

(3) Energy consumption efficiency measurement method [See Attachment 5]

The energy consumption efficiency of electric refrigerators shall be annual energy consumption, and a measurement method shall be the method specified in JISC9801: 2006 (for those with rated frequency of both 50 Hz and 60Hz, a larger value of those measured with 50Hz and 60 Hz shall be taken). For a refrigerator-freezer whose freezing compartment can be switched to cooling mode of a chiller, it shall be numeric values measured in respective modes, whichever is larger.

(4) Display items and others

Items to be displayed for electric refrigerators shall follow the provisions defined in the Household Good Quality Labeling Law, while items to be displayed for electric freezers shall follow the law concerning the Rational Use of Energy. Items concerning energy saving shall be as follows:

1) Display items shall be as follows:
   a) Product name and model name
   b) Rated internal volume
   c) Energy consumption efficiency
   d) Outside dimension
   e) Manufacturer's name

2) Compliance items
   The compliance items shall be as current specification.

4. Proposals for energy saving

(1) Actions of users

1) Through effective use of information such as "energy-saving labels", etc, users shall attempt to not only select an electric refrigerator with excellent energy consumption efficiency but also reduce energy by using an electric refrigerator appropriately and efficiently. (Retailers, manufacturers, and the government shall actively strive to offer information that contributes to such actions of users.)
2) In particular, users shall try to save energy by giving consideration to overloading of food, etc., or a place of installation of an electric refrigerator, etc.

(2) Actions of retailers

1) Retailers shall not only try to sell electric refrigerators with excellent energy consumption efficiency, but also offer appropriate information to users so that they can select electric refrigerators with excellent energy consumption efficiency. In addition, in using energy-saving labels, retailers shall carefully display the labels in a manner that users can easily understand and get no false impression, by, for example, showing conditions for calculating energy consumption efficiency.

(3) Actions of manufacturers

1) Manufactures shall promote technological development toward energy conservation of electric refrigerators and attempt to develop products with excellent energy consumption efficiency.
2) From the viewpoint of promoting the spread of electric refrigerators with excellent energy consumption efficiency, manufacturers shall attempt to provide appropriate information to encourage users to select electric refrigerators with excellent energy consumption efficiency, by displaying "energy-saving labels" in a catalogue, etc. In utilizing the energy-saving labels, manufacturers shall carefully display them in a manner that users can easily understand and get no false impression, by, for example, showing conditions for calculating energy consumption efficiency.
3) Manufacturers shall endeavor not to develop energy saving technologies suitable for a measuring method of energy consumption efficiency but to develop energy saving technologies suitable for the actual status of the usage of users.
4) Manufacturers shall strive to promptly establish a measurement method of energy consumption of electric refrigerators for commercial use.

(4) Actions of Government

1) From the viewpoint of promoting the spread of electric refrigerators with excellent energy consumption efficiency, the government shall attempt to take necessary action such as the spread and enlightenment activities, in order to promote actions of users and manufacturers. It shall also attempt to take such necessary action as spread or enlightenment activities for approach to energy conservation through a place of installation or a method of use of electric refrigerators, etc.
2) The government shall periodically and continuously check implementation of the display items by manufacturers and attempt at appropriate operation of the law so that information on energy consumption efficiency can be provided to users in correct and easily understandable manner.
3) The energy-saving standard based on the Top Runner Program is a very effective approach to energy saving of products. Therefore, the government shall make efforts to spread it not only domestically but also internationally, by taking appropriate opportunities.
4) The government shall continue to review propriety of addition of commercial electric refrigerators, as a target product of the Top Runner Standard.

Attachment 1

Target Scope

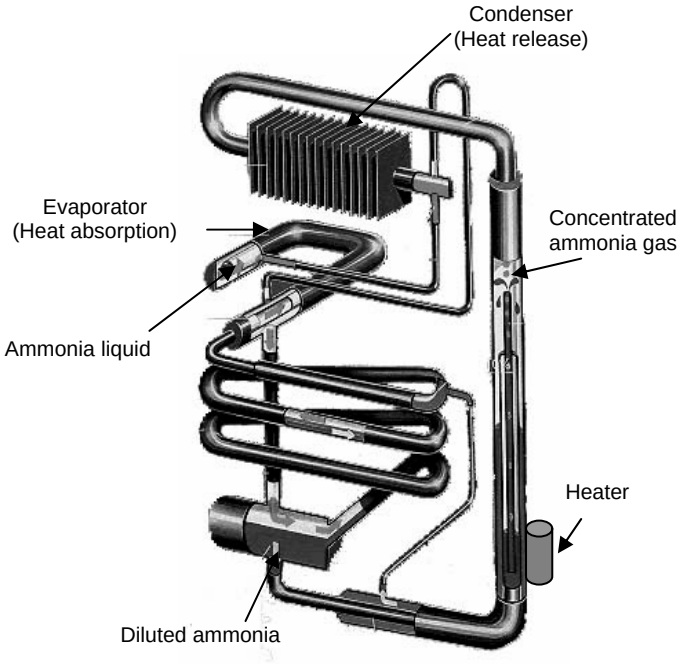
1. Electric Refrigerators

The present judgment standards, etc. shall apply to electric refrigerators specified as being covered by JISC9801.
In addition, the following shall be excluded.

1) Electric refrigerators of absorption type

They are used for specific purposes such as use in hotels, etc. Since there is no established measuring method of energy consumption efficiency of this kind and the production volume is extremely small, they shall be excluded.
*Volume of imports (in Fiscal 2004): Approximately 9,000 units

<<Mechanism of Absorption Type>>



Absorption type refrigerator that cools down when heated

- A heat source may be gas, electricity, or anything.
- A refrigerant is ammonia.
- An absorber is water.
- The mechanism is that heat absorption of ammonia liquefied in a condenser cools down the periphery when it vaporizes in an evaporator.

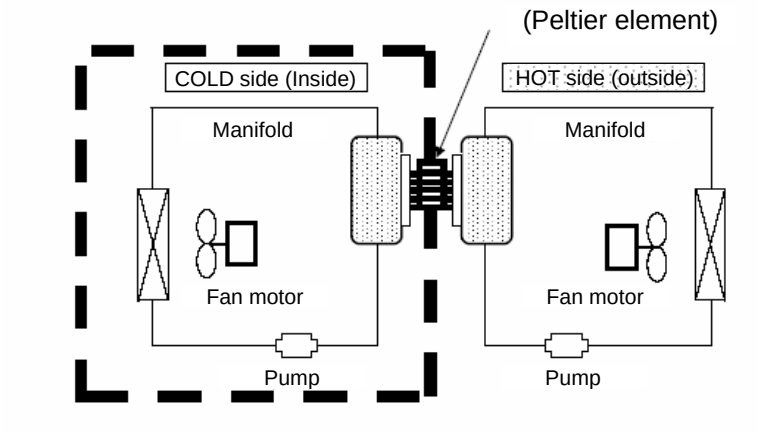
2) Electric refrigerators of Peltier method

They are used for specific purposes such as use in hotels, etc. Since there is no established measuring method of energy consumption efficiency of this kind and the production volume is extremely small, they shall be excluded.

*Domestic production (in Fiscal 2004): Approximately 13,000 units

<<Workings of Peltier Type>>

[Structure]



3) Vehicle-mounted electric refrigerators

Since there is no established measuring method of energy consumption efficiency and production volume is extremely small, they shall be excluded. Note that the following volume of domestic production is that of electric refrigerators and freezers.

*Domestic production (in Fiscal 2004): Approximately 5,000 units

4) Commercial Electric Refrigerators

Approximately 150,000 units of commercial electric refrigerators were manufactured in 2004 (according to statistics published by Japan Refrigeration and Air Conditioning Industry Association). However, they are typical products with small productions as well as large variations; therefore, they are often made-to-order and applied to various purposes. Due to such circumstances, at the current moment, no measuring method such as measurement/computation of energy consumption has been established. Nevertheless, since discussion on the measuring method has been under way in Japan Refrigeration and Air Conditioning Industry Association, we shall separately consider the possibility of including them as a target product as soon as a measuring method is developed.

2. Electric Freezers

The present judgment standards, etc. shall apply to electric freezers specified as being covered by JISC9801. The followings shall be excluded.

1) Vehicle-Mounted Electric Freezers

Since there is no established measuring method of energy consumption efficiency and production volume is extremely small, they shall be excluded. Note that the following volume of domestic production is that of electric refrigerators and freezers.

*Domestic production (in the fiscal year 2004): Approximately 5,000 units

2) Commercial Electric Freezers

Approximately 30,000 units of commercial electric freezers were manufactured in the fiscal year 2004 (according to statistics published by the Japan Refrigeration and Air Conditioning Industry Association). However, they are typical products with small productions as well as large variations; therefore, they are often made-to-order and applied to various purposes. Due to such circumstances, at the current moment, no measuring method such as measurement/computation of energy consumption has been established. Nevertheless, since discussion on the measuring method has been under way in Japan Refrigeration and Air Conditioning Industry Association, we shall separately consider the possibility of including them as a target product as soon as a measuring method is developed.

Attachment 2

Target Fiscal Year of Electric Refrigerators, etc.

1. In general, a considerable improvement in energy consumption efficiency of electric refrigerators is made when a model change takes place, and a typical development period of new products of electric refrigerators is approximately 2 to 3 years. For this reason, consideration should be given so that manufacturers can take about 1 or 2 opportunities of bringing out new models before the next target fiscal year.
   With the above in mind, it is appropriate to set the next target fiscal year of electric refrigerators to the fiscal year 2010.

2. In addition, it is expected that the improvement rate of energy consumption efficiency in the target fiscal year will be approximately 21.0% for electric refrigerators and approximately 12.7% for electric freezers, based on the assumption that there will be no change from current volume of shipments and composition of each category (results of the fiscal year 2005).

<Overview of Estimation: Electric Refrigerators>

(1) Energy consumption efficiency calculated from values of actual achievements of electric refrigerators shipped in the fiscal year 2005:
Approximately 572 kWh/year

(2) Energy consumption efficiency estimated from the target standard value of electric refrigerators to be shipped in the target fiscal year:
Approximately 452 kWh/year

(3) Improvement rate of energy consumption efficiency

$$\frac{(572-452)}{572}\times 100 = \text{Approximately 21.0 \%}$$

<Overview of Estimation: Electric Freezers>

(1) Energy consumption efficiency calculated from values of actual achievements of electric freezers shipped in the fiscal 2005:
Approximately 482 kWh/year

(2) Energy consumption efficiency estimated from the target standard value of electric freezers to be shipped in the target fiscal year:
Approximately 421 kWh/year

(3) Improvement rate of energy consumption efficiency

$$\frac{(482-421)}{482}\times 100 = \text{Approximately 12.7 \%}$$

Attachment 3

Classification of Electric Refrigerators

1. Basic Idea

Under the current criteria, electric refrigerators are classified based on the following:
1) Classification by storage
2) Classification by cooling type
3) Classification by use of specified technology (inverter technology and vacuum insulation material)

The electric refrigerators shall be classified as shown below:

Table 1: Current Classification of Electric Refrigerators

Storage	Cooling Type	Use of Specified Technology
Electric Refrigerators	Cold air-natural convection type	−
	Cold air-forced circulation type	−
Refrigerator-Freezers	Cold air-natural convection type	−
	Cold air-forced circulation type	Using specified technology
		Without specified technology

Electric freezers shall be classified as shown below:

Table 2: Current Classification of Electric Freezers

Storage	Cooling Type	Use of Specified Technology
Freezers	Cold air-natural convection type	−
	Cold air-forced circulation type	−

Under the new standard, classification shall be made, considering the following:
1) A distinction shall be made between refrigerators (including refrigerator-freezers) and freezers, because they have a different storage configuration and are also considered being different in Japan Standard Commodity Classification (JSCC) (revised in June 1990, Ministry of Internal Affairs and Communications).
2) As a measuring method of energy consumption efficiency specified in JISC 9801 partly differs, classification shall be made for cooling type.
3) In recent years, in order to improve energy saving performance, inverter technology and vacuum insulation materials have been widely introduced. Classification shall be made, taking this into consideration.

4) As various devices such as layout of a freezing compartment and a vegetable drawer, number of chiller doors, and etc. have been made in view of consumers' needs, and thus configurations of electric refrigerators have become diversified, classification of them shall also be considered.

2. Specific Classification Method

(1) Classification by Storage

A distinction shall be made between refrigerators and freezers, because they have a different storage configuration and are also considered being different in Japan Standard Commodity Classification (JSCC) (revised in June 1990, Ministry of Internal Affairs and Communications).

(2) Classification by Cooling Type

A measuring method of energy consumption efficiency of electric refrigerators is specified in JIS 9801. However, electric refrigerators of natural convection type and those of forced circulation type have different measurement conditions such as regarding opening/closing of doors, etc. Thus, it is not possible to simply compare their respective energy consumption efficiency, and they shall be separated.

(3) Classification by Rated Internal Volume

Under the current classification, electric refrigerators are classified by use of specified technology (inverter technology and vacuum insulation material). However, as for electric refrigerators having rated internal volume of over 300L, many of them have incorporated the specified technology to improve energy saving performance. As a result, it is no longer exceptional.

Nevertheless, the specified technology has not been introduced to electric refrigerators having rated internal volume of 300L or smaller still yet, because increased price will accompany. For instance, an attempt to introduce the inverter technology into an electric refrigerator having rated internal volume of 300L or smaller would result in a price increase of about 17,000 yen (according to the survey by the Japan Electrical Manufacturers' Association). Then, the possibility is high that the increased price cannot be recovered by means of lowering the running cost.

Therefore, possible effect of the introduction of the specified technology taken into consideration, classification by rated internal volume of electric refrigerators shall be made with the rated internal volume of 300L as a border, while no classification by presence/absence of the specified technology shall be made.

<<For your reference>>

A price increase of 17,000 yen can be converted into energy consumption, as follows:

17,000 (yen) ÷ 22 (yen/kWh) = 772.7 (kWh)

Assuming that electric refrigerators will be used for 10 years, we have to cut down annual energy consumption by approximately 77.3 kWh. If energy saving effect to be realized by using the inverter technology is 12%, payback can be only achieved with electric refrigerators consuming approximately 650 kWh/year or more.

This means that payback would not be possible with top models among electric refrigerators having rated internal volume of 300L or lower (approximately 550 kWh/year).

Basic idea about establishment of judgment standards of manufacturers, etc. (Excerpt)
Principle 5: In the case in which any existing products may become expensive due to a high-level energy saving technology and in which the possibility is extremely high that a price increase accompanying introduction of said energy saving technology cannot be recovered by lowering running cost in a certain period taking utilization of the product into account, a distinct class may be set for the products, as necessary.

(4) Classification by the Number of Doors in a Chiller Section

To secure space for opening a door, production of electric refrigerators having chiller door configuration of "2-door for a chiller section (Figure 2, so-called side-by-side door or French door)" has increased, in addition to ones of "1-door for a chiller section (Figure 1)". For large electric refrigerators, in particular, this tendency is more common because area of a chiller door is larger. In electric refrigerators having rated internal volume of 401L or greater, over half of approximately 1.564 million units of shipped refrigerators, i.e., approximately 870 thousands units have 2 chiller doors (surveyed by the Japan Electrical Manufacturers' Association, 2005).

However, those with 2 chiller doors consume more power approximately 30 kWh/year than those with 1 chiller door. It is because the former have a dew formation prevention heater mounted in the center of the doors (See page 24).

Thus, in order not to hinder consumers' needs, classification by door configuration of a chiller section shall be established.

Figure 1 Single Door (for a chiller section)

Figure 2 Double Door (for a chiller section)

3. Setting of Basic Classification Proposal

As shown in the list below, a proposal for basic classifications shall be set:

Table 3: Proposed Classification of Electric Refrigerators

Category	Storage	Cooling Type	Rated Internal Volume	Number of Doors in Chiller Section	Production Volume* (Composition Ratio)
A	Refrigerators (including refrigerator-freezers)	Cold air-natural convection type	—	—	291,318 units (6.8%)
B		Cold air-forced circulation type	300L or lower	—	1,332,260 units (31.3%)
C			Over 300 L	1 door	1,613,081 units (37.9%)
D				2 doors or more	864,486 units (20.3%)
E	Freezers	Cold air-natural convection type	—	—	31,687 units (0.7%)
F		Cold air-forced circulation type	300L or lower	—	120,988 units (2.8%)
G			Over 300 L	—	0 unit

*Production volume in fiscal 2005 (surveyed by The Japan Electrical Manufacturers' Association)

(Reference)

Effects of Internal Temperature Compensating Heater

For electric refrigerators of forced circulation type and having rated internal volume of 300 L or greater, in order to respond to consumers' needs, those models called as, for instance, a bottom freezer type, center-mounted crisper type, vertical vegetable compartment type, etc. are supplied on the market. Although it is difficult to define them categorically, we divide them into one type whose crisper abuts on a freezer on one side and another type whose crisper abuts on a freezer on two sides. In 2005, the former accounts for 65% of the total shipments, while the latter accounts for 35%.

As shown in Figure 1 and Figure 2, the models whose crisper abuts on a freezer on two sides are characterized in that temperature is being regulated by means of a heater such as heating wire, etc., because they are more susceptible to a freezer than those having a crisper abutting on a freezer on one side, and thus tend to be cooled over necessary. In term of annual energy consumption, the former consumes about 70 kWh/year over the latter, as shown in Figure 3.

We decided not to establish a category by internal temperature compensating heater, however, for the following reasons. It is difficult to define them categorically, because a number of configurations are assumed depending on how they abut, i.e., whether only a part of a side of a crisper abuts or a whole side abuts. In addition, installation of an internal temperature compensating heater varies in individual models, depending on layout of a crisper, freezer, ice compartment, switching compartment. In addition, we believe that classifying all these models in one same category would promote improvement in installation of an internal temperature compensating heater, thereby encouraging further reduction of energy consumption.

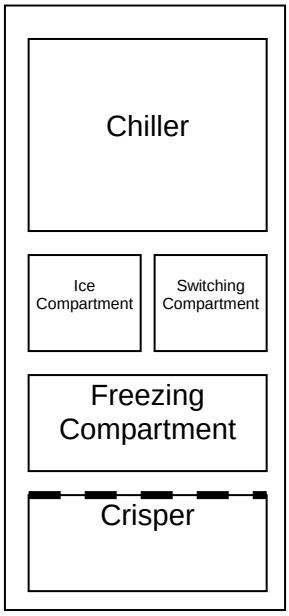


Figure 1

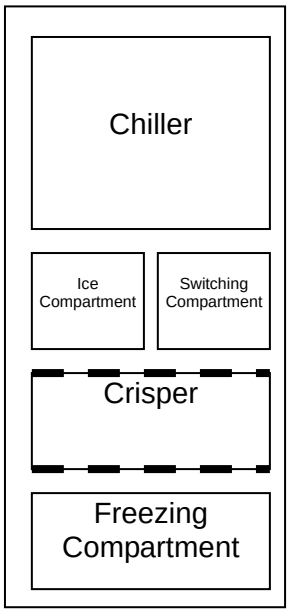


Figure 2

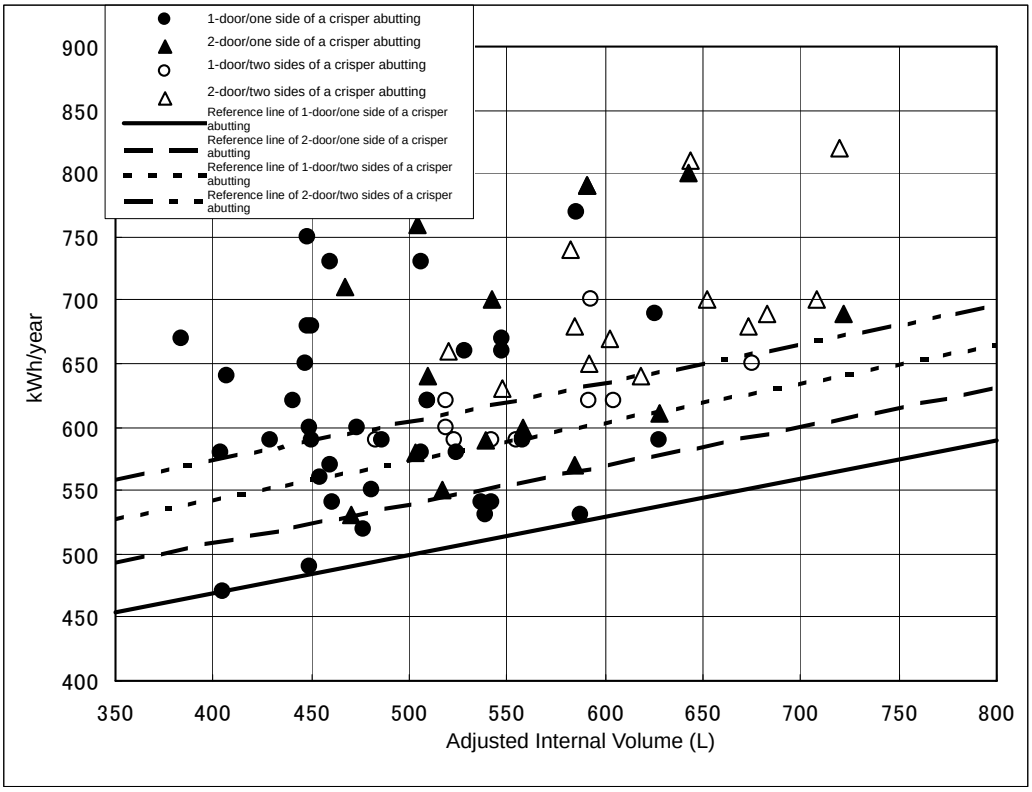


Figure 3: Differences in Annual Energy Consumption Depending on Number of Sides that Heater Abut on

Attachment 4

Target Standard Values of Electric Refrigerators

1. Idea on Setting Target Standard Values

(1) Basic Idea

We shall set target standard values based on the idea of Top Runner Program. The specific policy shall be as follows:

1) A target standard value shall be set for every appropriately defined category.
2) For any category for which possible improvement of efficiency is anticipated because of future technology advancement, a target standard value shall allow for the improvement wherever possible.
3) Target standard values shall not be inconsistent among categories.

(2) Possible Improvement of Energy consumption efficiency Attributed to Future Technology Advancement

Possible improvement in energy consumption efficiency is assumed, as shown below:

Table 1: Possible Improvement in Energy Consumption Efficiency

Category	Elements of Improved Efficiency	Possible Improvement
A, E	・Improved efficiency of a compressor, improvement of heat insulation characteristics/wall thickness, nonuse of CFC (10%)	10%
B, F	・Improved efficiency of a compressor (3%)	3%
C, G	・Improved efficiency of a compressor (4%) ・A difference of approximately 70 kWh/year depending on installation status of an internal temperature compensating heater	1%
D	・Improved efficiency of a compressor, optimization of calorific power of a heater of dew condensation prevention type (6%) ・A difference of approximately 70 kWh/year depending on installation status of an internal temperature compensating heater	3%

2. Specific Calculation Formula of a Target Standard Value

As energy consumption efficiency correlates to adjusted internal volume (*), a calculation formula of a target standard value of electric refrigerators, etc. shall be expressed by a linear function expression with energy consumption efficiency and adjusted internal volume as variables. In principle, the specific calculation formula shall be developed for each category according to the following procedure:

The target products shall be categorized by every 50 L of adjusted internal volume, and the highest energy consumption efficiencies in each category shall be defined as top values. Then, a group of the top values shall be subject to simple regression, in order to determine a slope. After that, an intercept shall be determined so that none of the top values lies below the line with the determined slope. Thus, a calculation formula of a target standard value shall be set.

In addition, since energy consumption efficiency of electric refrigerators and electric freezers can be corrected by adjusted internal volume, these of the same type shall have the same target standard value.

* Electric refrigerators are composed of a chiller and a freezer, etc., and every product of refrigerators and freezers has a different capacity ratio between a chiller and a freezer. In order to compare them under the same conditions, we decided to use adjusted internal volume that is corrected with external temperature and internal temperature of the products.

Table 2: Target Standard Value Calculation Formula of Electric Refrigerators (including Electric Refrigerator-Freezers)

Category	Cooling Type	Rated Internal Volume	Number of Doors in Chiller Section	Target Standard Value Calculation Formula
A	Cold air-natural convection type	—	—	E=0.844Vadj+155
B	Cold air-forced circulation type	300L or less	—	E=0.774Vadj+220
C		Over 300L	One	E=0.302Vadj+343
D			2 or more	E=0.296Vadj+374

Table 3: Target Standard Value Calculation Formula of Electric Freezers

Category	Cooling Type	Rated Internal Volume	Door of Chiller	Target Standard Value Calculation Formula
E	Cold air-natural convection type	—	—	E=0.844Vadj+155
F	Cold air-forced circulation type	300L or less	—	E=0.774Vadj+220
G		Over 300L		E=0.302Vadj+343

Notes 1: E: Energy consumption efficiency (kWh/year)

2: Vadj: Adjusted internal volume (unit: L)

1) For a refrigerator-freezer and a freezer whose freezing compartment is of three-star type, Vadj shall be a numeric value obtained with the following formula:
Vadj= 2.20 x V (Rated internal volume of a freezing compartment) + V (Rated internal volume of other than a freezing compartment)
The coefficient of 2.20 is determined by the following calculation, considering respective differences among the external temperature of 22.4°C, the internal temperature of a freezer of -18°C, and that of a refrigerator of 4°C.
2.20 = (22.4°C-(-18 °C))/(22.4 °C -4 °C) = 40.4/18.4

2) For a refrigerator-freezer and a freezer whose freezing compartment is of two-star type, Vadj shall be a numeric value obtained with the following formula:
Vadj= 1.87 x V (Rated internal volume of a freezing compartment) + V (Rated internal volume of other than a freezing compartment)
The coefficient of 1.87 is determined by the following calculation, considering

respective differences among the external temperature of 22.4°C, the internal temperature of a freezer of -12°C, and that of a refrigerator of 4°C.
1.87 = (22.4 °C -(-12 °C))/(22.4 °C -4 °C) = 34.4/18.4

3) For a refrigerator-freezer and a freezer whose freezing compartment is of one-star type, Vadj shall be a numeric value obtained with the following formula:
Vadj= 1.54 x V (Rated internal volume of a freezing compartment) + V (Rated internal volume of other than a freezing compartment)
The coefficient of 1.54 is determined by the following calculation, considering respective differences among the external temperature of 22.4°C, the internal temperature of a freezer of -6°C, and that of a refrigerator of 4°C.
1.54 = (22.4 °C -(-6 °C))/(22.4°C -4 °C) = 28.4/18.4

(For Your Reference)

Three-star type :	A freezing compartment whose average freezing load temperature of which is –18 °C or lower
Two-star type :	A freezing compartment whose average freezing load temperature of which is –12 °C or lower
One-star type :	A freezing compartment whose average freezing load temperature of which is –6 °C or lower

(Reference 1)

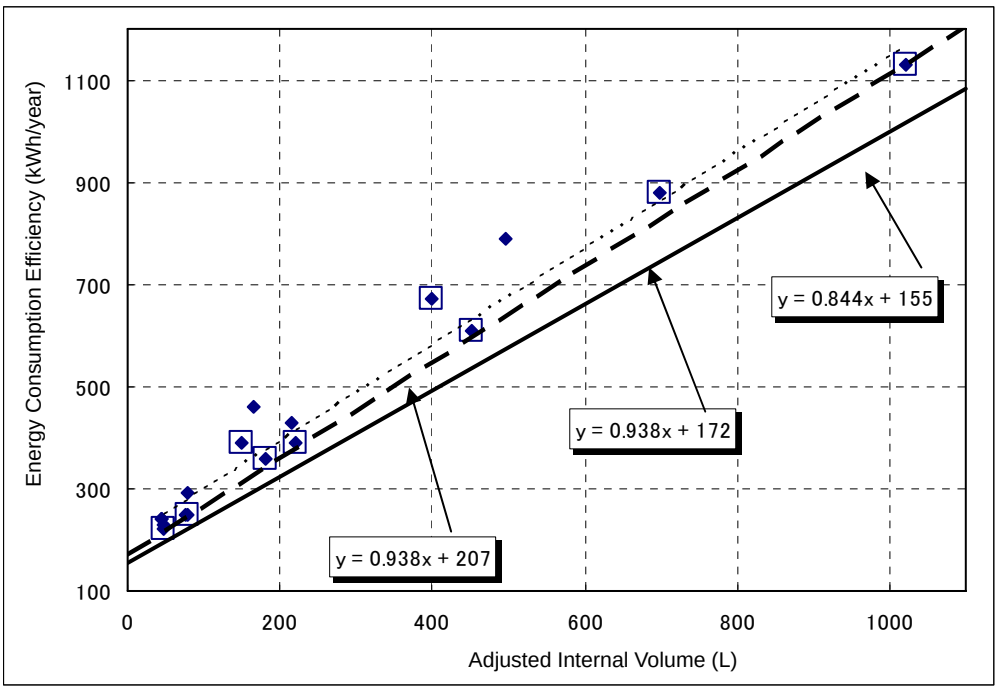


Figure 1: Target Standard Value Calculation Formula (Category A and E)

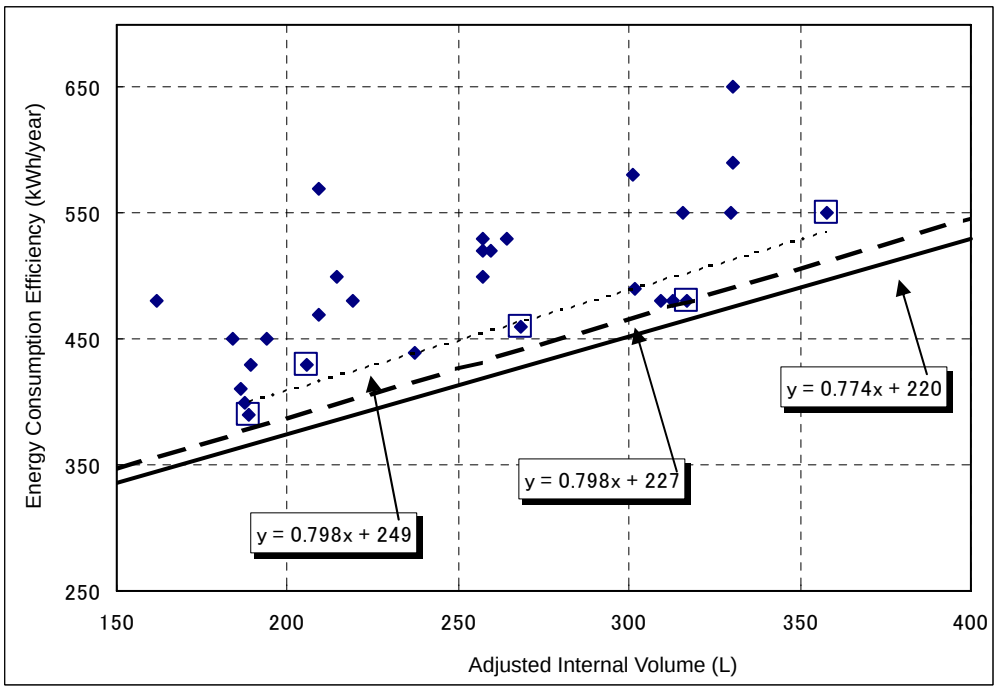


Figure 2: Target Standard Value Calculation Formula (Category B and F)

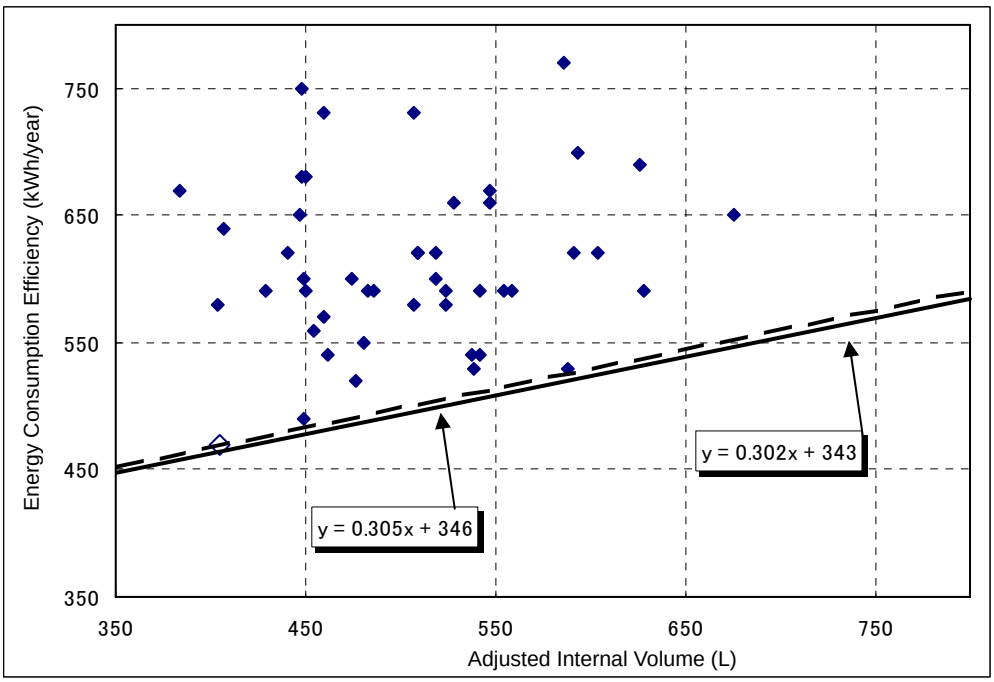


Figure 3: Target Standard Value Calculation Formula (Category C and G)

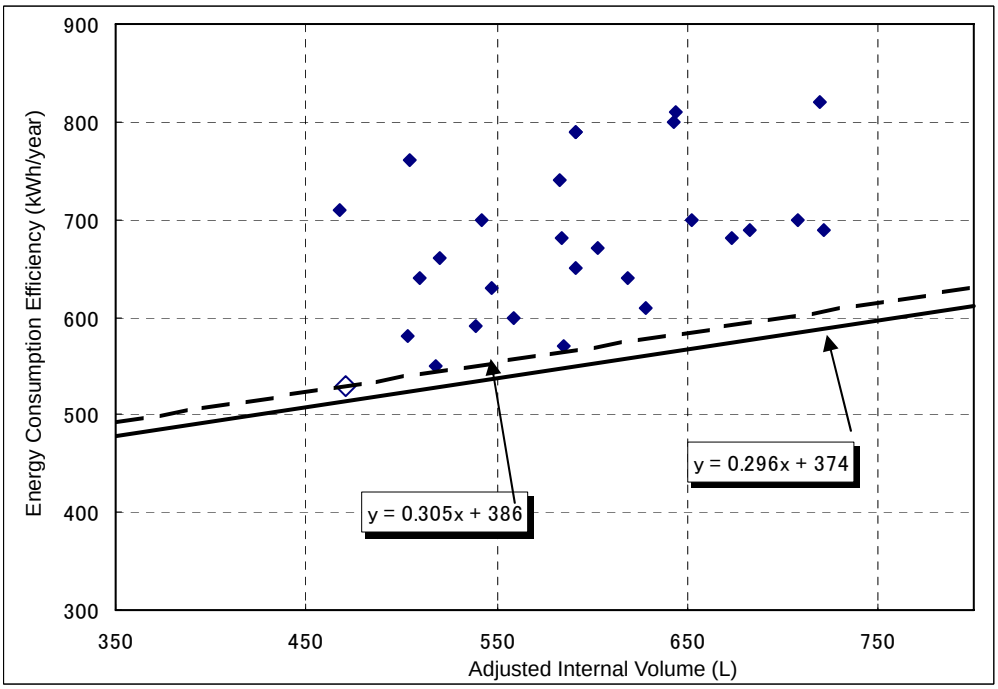


Figure 4: Target Standard Value Calculation Formula (Category D)

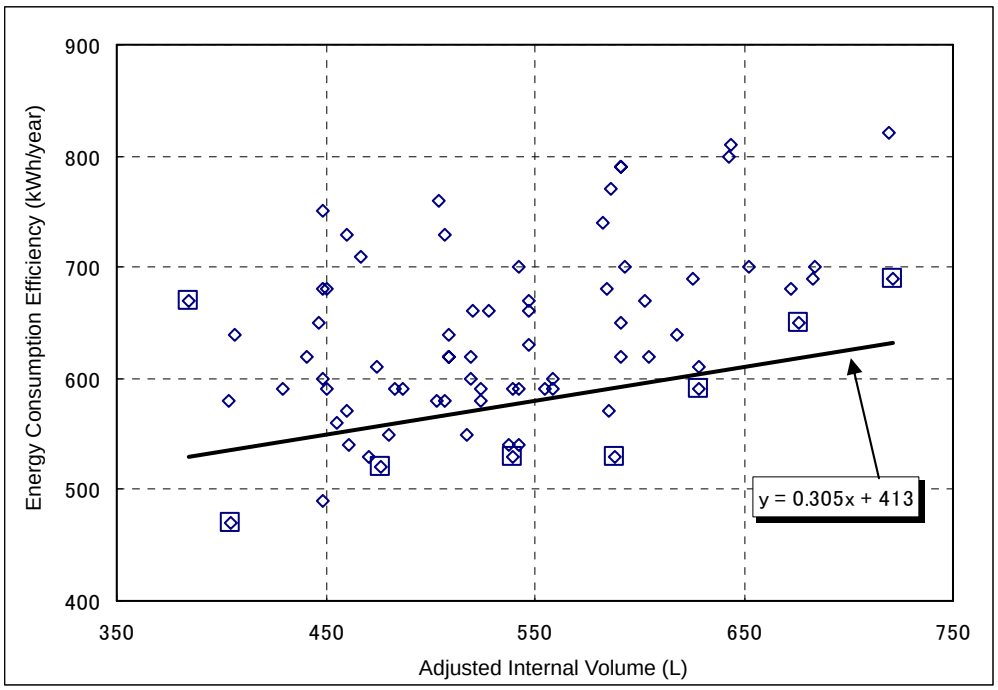


Figure 5: Calculation of Slope for Category C, D and G

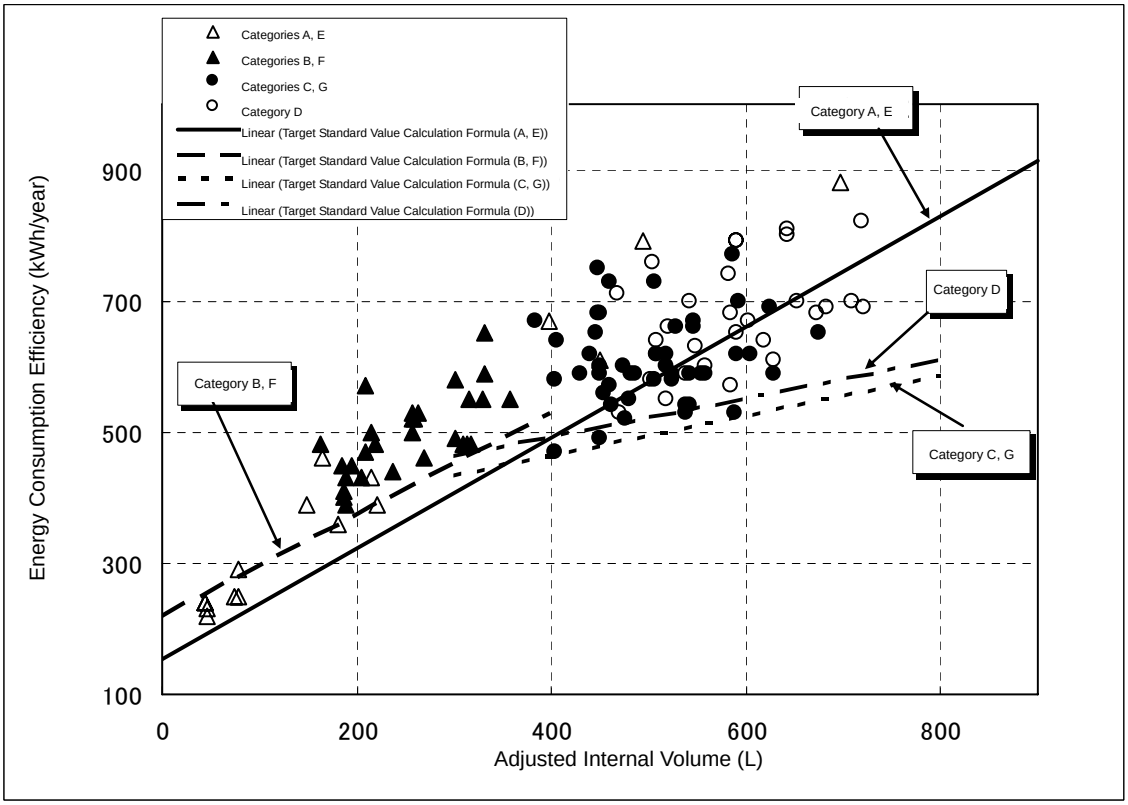


Figure 6: Target Standard Value Calculation Formula (Overall)

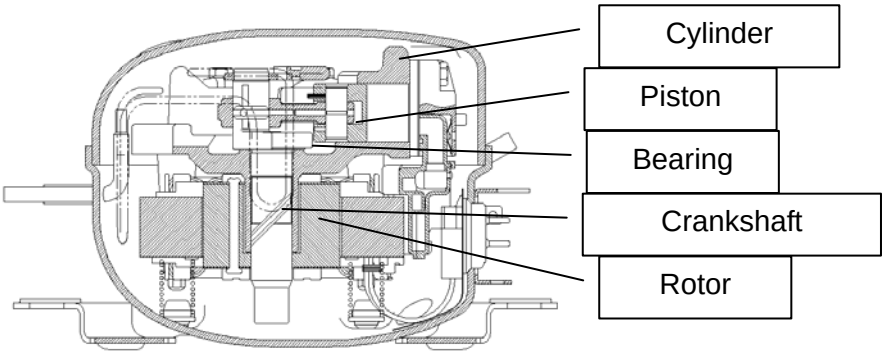
(Reference 2)

Examples of Major Techniques for Improving Efficiency of Electric Refrigerators

(1) Compressor

[Reduction of Mechanical Loss]

For mechanical loss, it is effective to take a measure to reduce loss mainly in a sliding unit of a bearing/crankshaft as well as in a sliding unit between a piston/cylinder of a compressing unit, whereby an attempt to maximally reduce a sliding area is made and a motor input value is reduced, while reliability is secured. For a piston, in particular, a new surface treatment is adopted in attempt to reduce sliding loss.



[Reduction of Intake/Discharge Loss]

Compression efficiency is improved by tuning valves or an intake muffler so that a refrigerant is sucked and discharged smoothly.

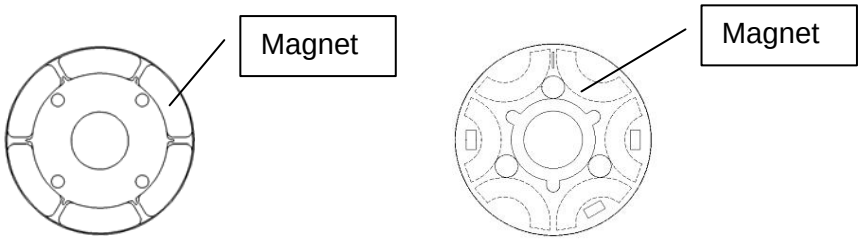
[Rotation at Slower Speed]

To implement slower rotation and thereby reduce input substantially, a fueling mechanism of a crankshaft is improved, and thus rotation is slowed down.

(2) Motor for Compressor

[Shape of Rotor Magnet]

Through the use of an improved IPM motor that has better motor efficiency than a conventionally used SPM motor, a change to a lighter motor with higher efficiency is implemented.



SPM Motor IPM Motor

[Improvement of Winding]

One of measures to improve the motor efficiency is to increase the ratio of winding to widen coil section area by rolling more motor windings in a limited motor space. It reduces resistance of motor winding and thus copper loss is also reduced.Increased ratio of winding is implemented through design improvement of adopting salient-pole concentrated winding method in which winding is directly rolled around a stator.

In addition, in order to improve motor efficiency during slow rotating operation, which has an effect on energy saving of refrigerators, tuning of length of winding and cross section has been

attempted

[Magnetic Steel Sheet with Low Iron Loss]

As motor iron loss, there are hysteresis loss and eddy current loss. Currently, to reduce the eddy current loss, silicon steel sheet with low iron loss is now adopted and thinning thereof is attempted.

(3) Insulation Technology

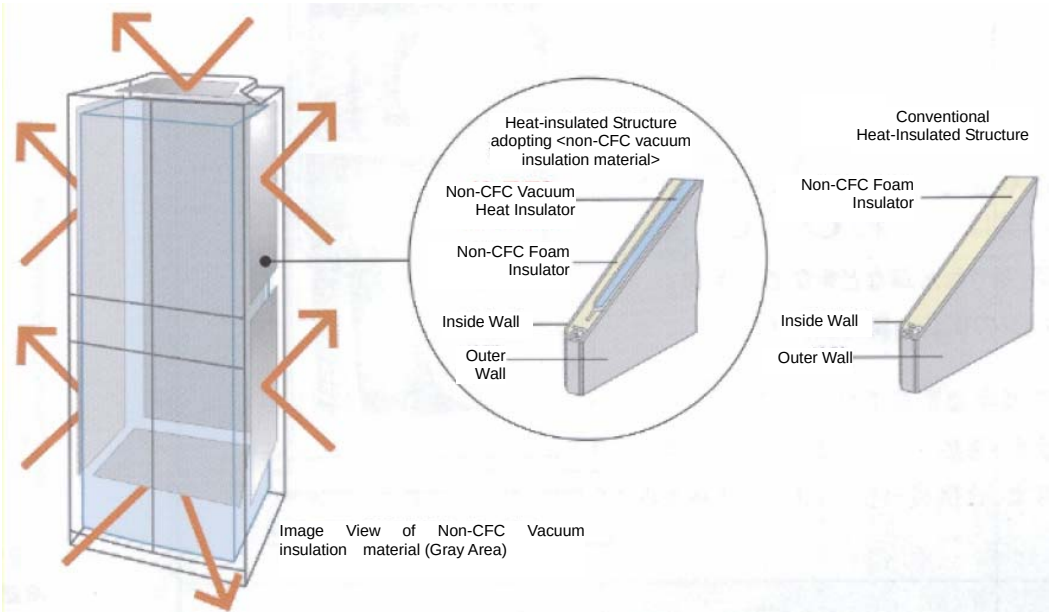
Gas thermal conductivity of a foaming agent is the biggest factor to determine insulation efficiency of polyurethane heat insulator. It has been changed as shown in the following list, because global environment-protection measures (reduction of ozone depletion substances and global warming substances) need to be prioritized.

Period of Use	1970	1990 – 2003	1994 –
Name of Foaming Agent	CFC-11	HCFC-141b	Cyclopentane
Boiling Point (°C)	24	32	49
Gas Thermal Conductivity (W/mK)	0.011	0.013	0.018
ODP (Ozone Depletion Potential)	1.0	0.11	0
GWP (Global Warming Potential)	1.0	0.25	＜0.01

The gas thermal conductivity of foaming agent used as shown in the above table has worsened. In addition, elevation of boiling point of foaming agent gas has prompted deterioration of thermal conductivity by liquefaction during cooling.

Improvement of gas thermal conductivity of cyclopentane has now reached a limit. Consequently, improvement of power consumption has been attempted through enhancement and extended use of vacuum insulation material.

By adopting a heat insulation system combined conventional urethane with vacuum insulation material, which has 10 times higher insulative property than the former, for heat insulation between outer wall and inner box of a refrigerator, about 25% reduction of heat loss has been achieved.



For a vacuum insulation material, improvement of insulative property is under way through enhancement of degree of vacuum and reduction of influence of heat bridge (heat wraparound) by changing aluminum evaporation coating of outer shell from all-surface to single-surface.

(4) Adoption of Natural Refrigerant

In order to reduce GWP, a rapid shift of a refrigerant from HFC-134a to R600a, natural refrigerant (isobutane), is taking place. Although R600a is a flammable refrigerant and thus needs careful handling, it is expected to improve cycle efficiency by about 7%.

Characteristics of Refrigerants

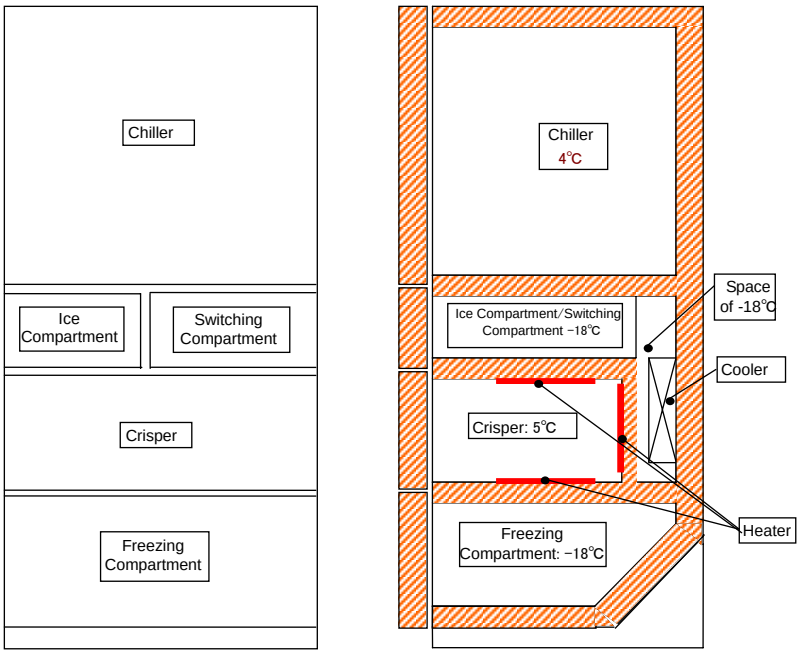
Refrigerant	HFC-134a	R600a
ODP (Ozone Depletion Potential)	0	0
GWP (Global Warming Potential)	1300 (As C02=1)	3 (As C02=1)
Freezing capacity	100 (Reference)	Approx. 57 (low)
Theoretical COP (%)	100 (Reference)	Approx. 107 (Good)
Classification of burning quality	Noncombustible gas	Combustible gas (lower limit 1.8 vol%, upper limit 8.4 vol%)

(5) Optimization of Cold Air Trunk

Conventionally, for optimization (simulation) designing by thermo-fluid analysis, only a partial analysis was made. However, higher performance of PC and software has now enabled large-scale calculation, thereby optimum designing for the whole has been implemented.

(6) Internal Temperature Compensating Heater

For a temperature compensating heater in a crisper, an attempt to reduce heater capacity is made by optimal control of heater energization ratio depending on outside temperature and internal temperature, etc., and by improved insulative property of compartment wall by means of reexamining its thickness between a crisper and a freezer and adopting high efficient urethane as a heat insulator, etc.



Front View　　Sectional Side Elevation

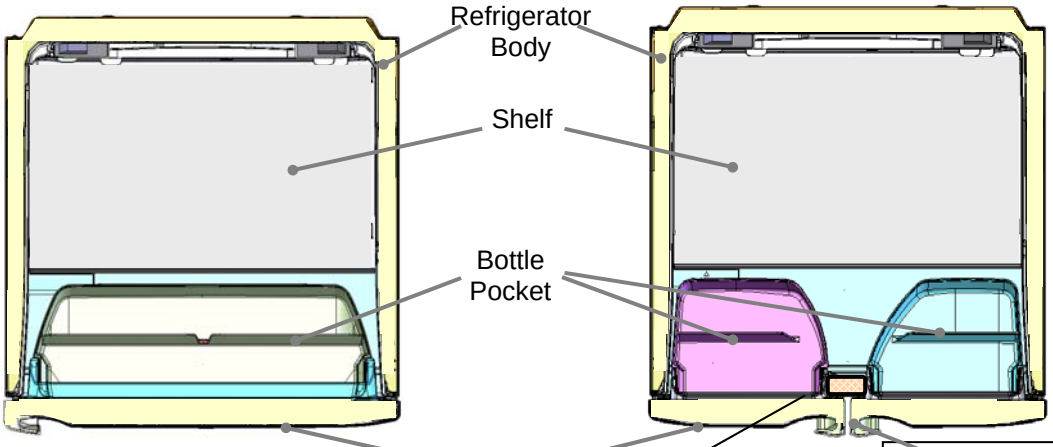
(7) Dew Formation Prevention Heater

As illustrated below, in an electric refrigerator of “side-by-side door” type, “a partition for preventing leak of cold air” is placed between the two doors for the purpose of curbing spill of the cold air. However, outside surface of a refrigerator may be cooled due to temperature within the refrigerator (thermal conduction), and, in some cases, dew may be formed on the partition surface, depending on environmental conditions such as temperature/humidity, etc of a place where a refrigerator is installed. Hence, as a measure to prevent such dew formation, a heater is arranged inside the partition (See the figure below), thereby controlling thermal conduction of the heater according to the environment where a refrigerator is installed and its operating conditions.

Consequently, refrigerators of double door type may contribute to a higher electric bill than those of single door type, depending on status of use. In a case that a partition is secured to the body of a refrigerator, when it is opened, the partition limits the usable space, and its usability will be worsened. Thus, the structure where the partition is attached to a door and moves along with the door when it is opened has now become prevalent (See the figure below).

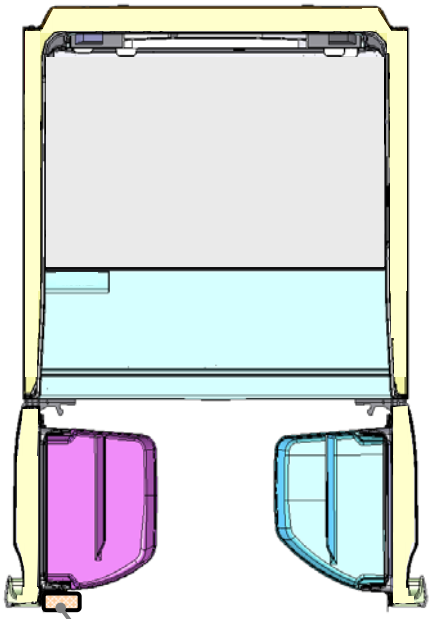
By incorporating a part of a heat radiator of a freezing cycle inside a partition and thus generating heat, such a partition secured to a refrigerator body could prevent dew formation without using an electric heater. In case of a movable partition, however, it is difficult to incorporate a heat radiator inside. Thus, in the present circumstances, there is no technique to prevent dew formation that can substitute for installation of an electric heater.

However, it is necessary to address reduction of power consumption through optimization of electric conduction ratio of a heater or improvement of insulative property of a partition.

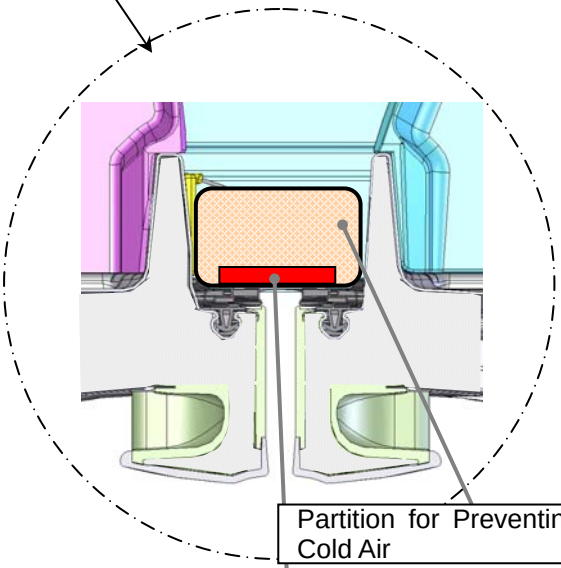


"Single Swing" Type

"Side-by-Side" Type



When doors of a side-by-side type are opened



Enlarged View of Periphery of the Partition

Attachment 5

Energy Consumption Efficiency of Electric Refrigerators and Measurement Method

1. Basic Idea

In the case of electric refrigerators, when they were designated as top runner target products in 2000, as a realistic index of energy consumption efficiency, "annual energy consumption" measured by the method specified in JISC9801:1999 was adopted.

However, the measurement method specified in JISC9801: 1999 reflects a situation far from actual status of use because of difference in setting of internal temperature controller and in heater operation due to effects from installation requirements and ambient temperatures, etc. Therefore, JISC9801:1999 was reviewed, and JISC9801:2006 was promulgated on May 1, 2006. Since JISC9801:2006 is a measurement method close to actual status of use, it is considered reasonable to adopt JIS9801:2006.

2. Specific Energy Consumption Efficiency and Measurement Method

The energy consumption efficiency for electric refrigerators shall be annual energy consumption (for ones supporting both rated frequency of 50 Hz and 60Hz, a numeric value measured with respective frequencies, whichever is larger), and a measurement method shall be the method specified in JISC9801: 2006. For a refrigerator-freezer that is a freezer capable of switching to cooling mode equivalent of a chiller, it shall be a numeric value measured in respective modes, whichever is larger.

(Reference)

Major Revisions to JISC9801

1. Ambient Temperature of a Refrigerator when Measuring Power Consumption

The survey about kitchens of general household in 8 prefectures across the country (i.e., a total of 23 kitchens in condominium buildings and stand-alone buildings in Hokkaido, Miyagi, Tokyo, Osaka, Okinawa, etc.) was conducted. Based on the survey results, such as annual average room temperature, the conventional one-point measurement (25°C±1°C) was changed to two-point measurement (30°C±1°C (summer) and 15°C±1°C (winter)). If measurement takes place at 2 points, namely 15°C and 30°C, the function that does not work at the conventional one-point temperature setting (25°C) (e.g. a temperature compensating heater to be used for prevention of freezing in a crisper) does operate, and thus power consumption will be closer to actual status of use.

2. Other Conditions during Measurement of Energy Consumption

To measure power consumption in the condition closer to actual state of use, plastic bottles containing water shall be placed according to respective volumes of a chiller and a freezing compartment, and such optional functions as automatic ice making or deodorizing shall be run.

3. Installation Condition (Distance to Wall) of a Refrigerator when Measuring Power Consumption

The refrigerator installation environment in approximately 1,300 general households across the country was surveyed. Based on the result, a distance between wall and a refrigerator during the measurement was changed from 30 cm, the numeric value in the conventional standard, to 5 cm that is closer to the actual status. This could make power consumption be closer to the actual status in which effect of heat to be reflected back from the wall is considered.

4. Internal Temperature Setting of a Chiller during Measurement of Power Consumption

The internal temperature setting was changed from the conventional 5°C to 4°C, according to actual status.

5. Number of Opening/Closing of Chiller Door during Measurement of Power Consumption

Based on results of monitoring surveys, number of opening/closing of chiller door was changed to conventional 25 times to 35 times.

<<Browsing of JISC9801:2006>>

For JISC9801:2006, refer to Home Page of Japanese Industrial Standards Committee (http://www.jisc.go.jp/).

Attachment 6

Electric Refrigerator Evaluation Standards Subcommittee
Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy
Background of Holding

First Subcommittee Meeting (September 28, 2005)
- Disclosure of Electric Refrigerator Evaluation Standards Subcommittee
- Achievements of electric refrigerators
- Current situation of commercial electric refrigerators
- Current situation of home electric refrigerators
- Scope of electric refrigerators to be covered
- Energy consumption efficiency and measurement method

Second Subcommittee Meeting (January 24, 2006)
- Energy consumption efficiency and measurement method of electric refrigerators
- Idea on revision of classification of electric refrigerators

Third Subcommittee Meeting (May 9, 2006)
- Consecutive changes in annual energy consumption in actual use
- Classification of electric refrigerators for setting targets
- Target standard value and target fiscal year of electric refrigerators
- Others

Fourth Subcommittee (May 25, 2006)
- Interim summary report

Interim summary report was open for public comments during the period from May 27, 2006 through June 27, 2006; however, no particular comment was received. Thus, it became the final summary report.

Attachment 7

Electric Refrigerator Evaluation Standards Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee for Natural Resources and Energy
List of Members

Chairman Koichi WATANABE, Emeritus Professor, Keio University

Members Kenji AMANO, Project General Manager, Medical Equipment/Reliability Test Department, Safe Electromagnetic Center, Japan Quality Assurance Organization

Hiroyuki UEMURA, Vice-Chairman, Electric Refrigerator Environment-responsive Committee, Japan Electrical Manufacturers' Association (since the 3rd meeting)

Katsuhiko KADOGUCHI, Head of Heat Utilization Group, Technology Research Dept., National Institute of Advanced Industrial Science and Technology

Akihito KANAI, Assistant Vice-President of Planning Department and Assistant General Manager of Development Division, Japan Consumers' Association

Hiroyuki KUDOU, General Manager of Technology, Energy Conservation Center, Japan

Yoshiro SHIBATA, Chief Scientist, Jukankyo Research Institute, Inc.

Kikuko TATSUMI, Director/Environment Committee member of NIPPON ASSOCIATIOIN OF CONSUMER SPECIALISTS

Kiyohide HATA Chairman, Electric Refrigerator Technology Ad-hoc Committee, Japan Electrical Manufacturers' Association (since the 3rd meeting)

Eiji TOBIHARA, Professor specialized in environmental studies, Graduate School of Frontier Science, University of Tokyo

Yoichi HORI, Professor, Institute of Industrial Science, University of Tokyo

Reference 1

Consecutive Changes in Annual Energy Consumption in Actual Use

1. Background

With this revision of JISC9801, annual energy consumption measured by the conventional measurement method widely changed.

Hence, in order to verify whether actual efficiency was improved by introducing the top runner program, it was decided to check a transition in annual energy consumption since introduction of the top runner program, with a new measurement method.

Note that previously shipped items were checked by estimates (specific models (center-mounted-crisper type of 450L class)) because their production had been stopped.

2. Transition of Annual Energy Consumption in Actual Use

The estimates of annual energy consumption of each year according to the new measurement method were studied (Fiscal 1998=100). It certainly decreased every year, which means that introduction of the Top Runner Program steadily improved efficiency.

For the annual energy consumption per unit adjusted internal volume, improvement of efficiency has also steadily progressed.

(For your reference: method of estimating annual energy consumption)

Since power consumption has been routinely measured at 30℃ and 15℃ as a part of performance test, estimation was made based on the data.

However, measurement conditions of the performance test do not include opening/closing of doors, etc, the past annual energy consumption was estimated by using a coefficient which is a difference between annual energy consumption by the new JIS9801 in 2005 and that by the performance test in 2005.

In addition, for the purpose of maintaining consistency, data of a manufacturer that has been manufacturing electric refrigerators of a specific model (450L class/ center-mounted-crisper type) since 1998 was used.

Fiscal Year	98	99	00	01	02	03	04	05
Annual energy consumption in actual use (Estimates) (Index: Fiscal 1998=0)	100	95	91	89	86	82	79	67
Annual energy consumption per unit adjusted internal volume (kWh/year L)	1.9	1.8	1.7	1.7	1.6	1.5	1.4	1.2

(Reference)

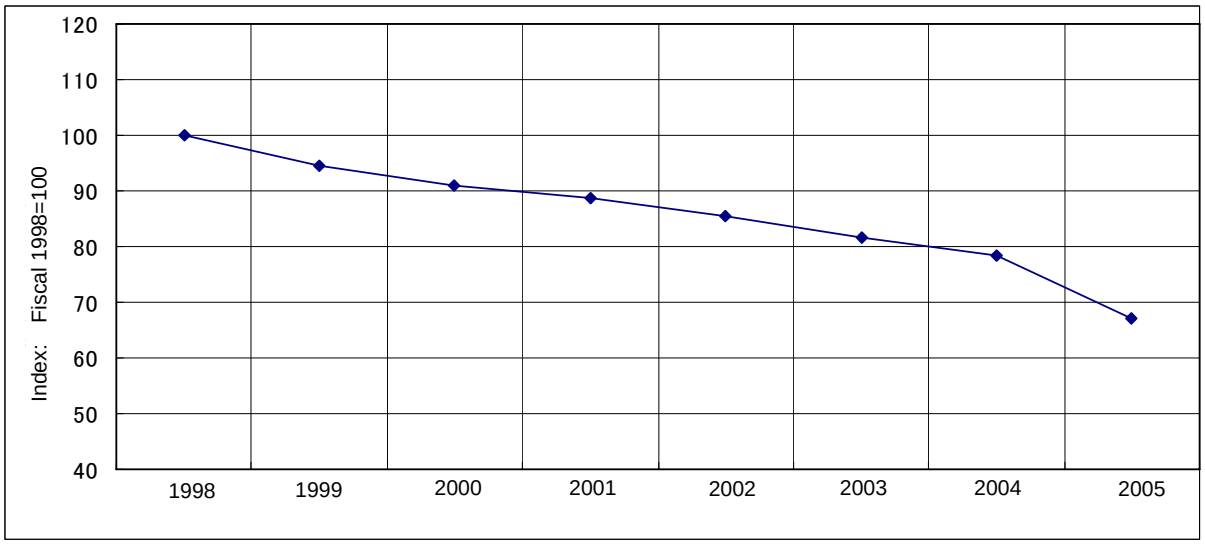


Figure 1: Transition in Annual Energy Consumption in Actual Use (Estimates)

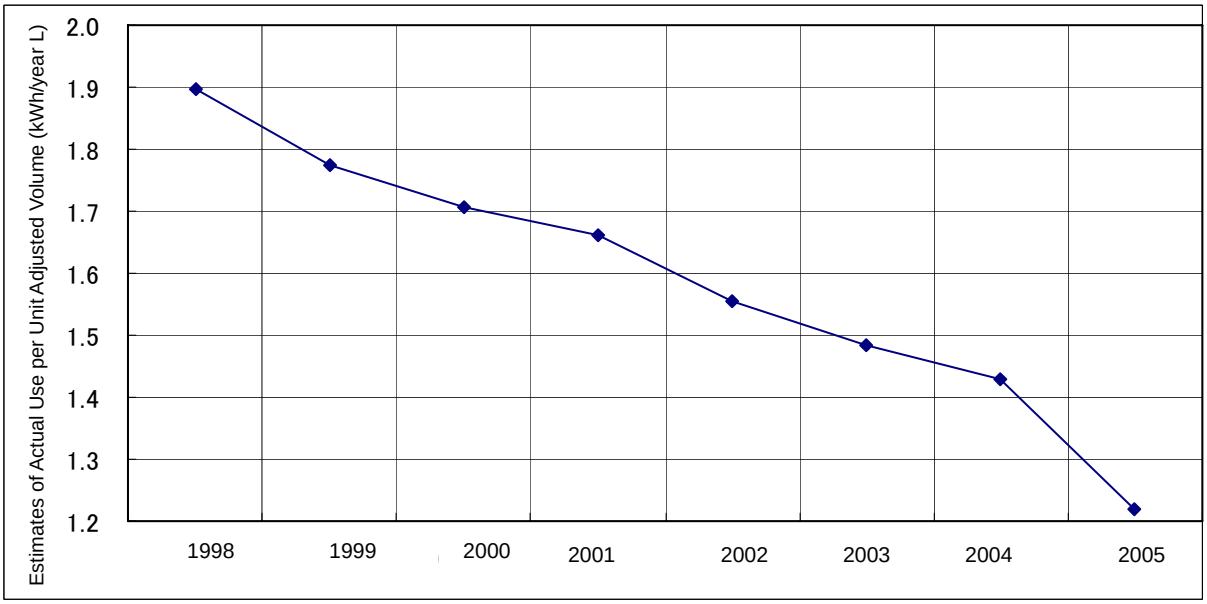


Figure 2: Transition in Annual Energy Consumption per Unit Adjusted Internal Volume (Estimates)

Reference 2

Method of Measuring Energy Consumption of Commercial Electric Refrigerators

1. Proceedings

The Japan Refrigeration and Air Conditioning Industry Association (JRAIA) conducted a survey on a measurement method of energy consumption of products and use environment in a member company. Based on the survey result, JRAIA developed an energy consumption trial computation model of commercial electric refrigerators and carried out proving tests. Then, JRAIA summarized measurement results and standardized a method of measuring energy consumption of commercial electric refrigerators (industry standard JRA4032).

2. Issues

Although a measurement method exists as an industry standard, measurement data often has substantial variations. Thus, it is necessary to verify its repeatability. In addition, since it has been confirmed that a measurement method specified in the measurement method of household electric refrigerators (JISC9801) which was used as reference employs a condition far from actual status of use, any method capable of measuring energy consumption closer to actual usage shall also be considered.

To be specific, JRAIA shall review on scope setting of devices that measure energy consumption with the same measurement method, verification of repeatability of measured data, and evaluation of energy consumed by optional equipment that was excluded from the measurement.

3. Future Schedule

For a measurement method of energy consumption of commercial electric refrigerators, JRAIA shall survey market status, verify measurement data, etc., and then review the industry standard within 2006.

Based on this, JIS standardization of the measurement method and addition of the product to the Top Runner's targets shall be examined.

Reference 3

Current Status of Household Electric Refrigerators and Household Electric Freezers

1. Market Trend of Household Electric Refrigerators and Freezers

1-1 Domestic Demand (Production Volume, Amount, Import/Export Volume)

In Japan, small refrigerators (90 litters) for home use were first released in 1952. Since then, refrigerators have become dramatically widespread as household requisites while internal volume has been increasing and functionality has been improving along with enrichment of dietary life. Until 1975, every home had at least one refrigerator, and thus currently replacement is a main demand.

On the one hand, production at overseas factory has increased recently, while domestic production is on downward trend.

Table 1: Domestic Demand of Electric Refrigerators

(Calendar Year, Unit: 1000 units, 1.0 million yen)

	1975	1980	1985	1990	1995	2000	2001	2002	2003	2004
Volume of domestic production (A)	3,474	4,282	5,354	5,048	5,013	4,224	3,875	3,317	2,859	3,020
Amount of domestic production	212,641	349,196	435,140	457,673	492,904	435,071	412,276	324,926	280,743	315,649
Import Volume (B)	76	60	10	356	717	1,463	1,769	1,923	1,827	2,008
Export Volume (C)	332	696	1,905	444	262	208	75	64	68	69
Domestic Demand (A+B-C)	3,218	3,646	3,459	4,960	5,468	5,479	5,569	5,176	4,618	4,959

Source: Domestic production & amount: current survey of industrial production by Ministry of Economy, Trade and Industry
Import/export volume: customs statistics by Ministry of Finance

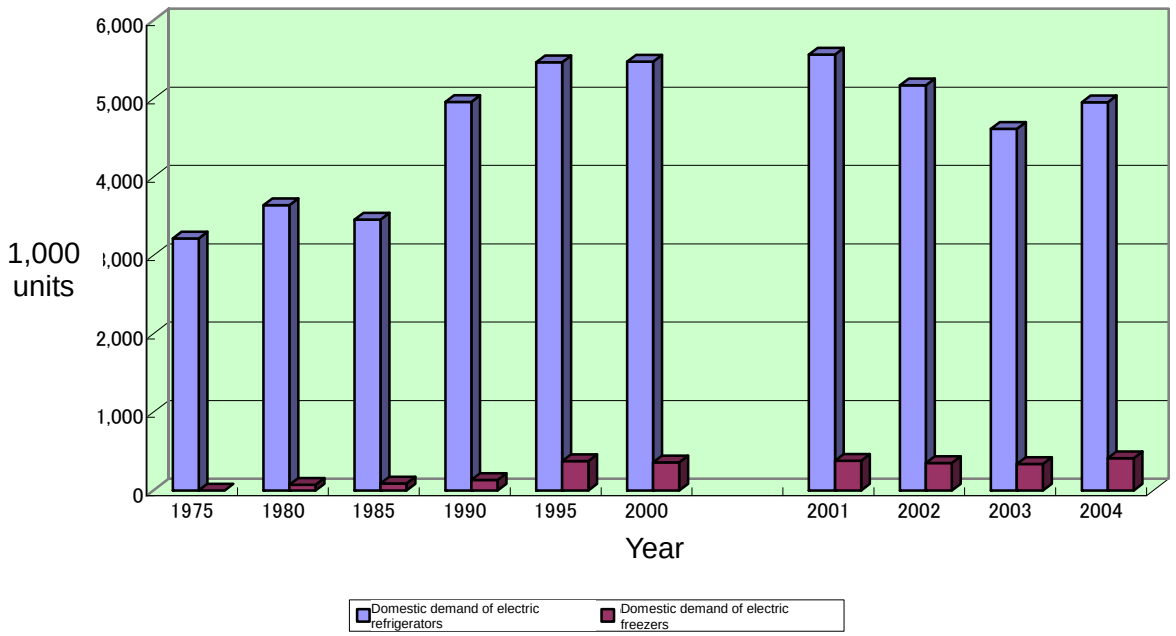
Table 2: Domestic Demand of Electric Freezers

(Calendar Year, Unit: 1000 units, 1.0 million yen)

	1975	1980	1985	1990	1995	2000	2001	2002	2003	2004
Volume of domestic production (A)	111	109	102	111	207	134	123	82	71	47
Amount of domestic production	4,707	6,802	7,576	9,745	19,540	16,382	17,052	13,863	13,163	12,803
Import Volume (B)	-	4	1	26	172	230	261	276	273	373
Export Volume (C)	-	40	13	3	3	6	5	7	7	8
Domestic Demand (A+B-C)	-	73	90	134	376	358	379	351	337	412

Source: Domestic production & amount: current survey of industrial production by Ministry of Economy, Trade and Industry
Import/export volume: customs statistics by Ministry of Finance

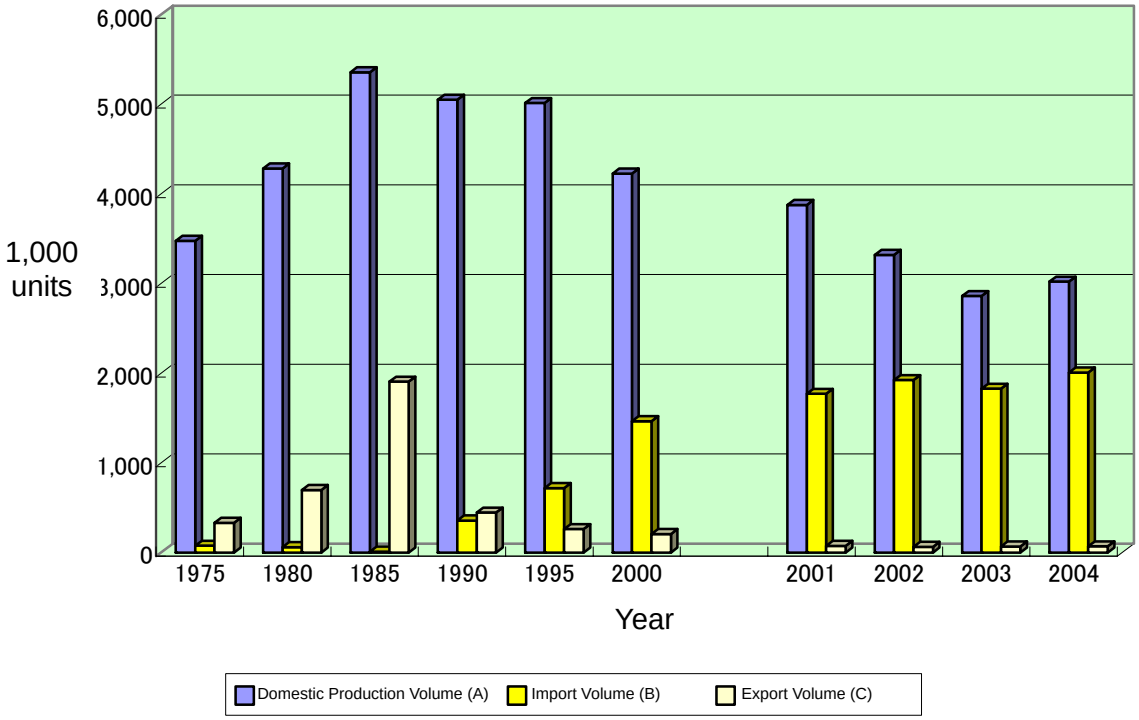
Figure 1: Domestic Demands of Electric Refrigerators and Electric Freezers



Demand for electric freezers is even below 10% of that of electric refrigerators, and accounts for approximately 8.3% of demand of electric refrigerators in 2004. It is considered that the increased demand in 1990 is a result from increased demand for larger refrigerators due to Heisei (bubble) boom since 1987.

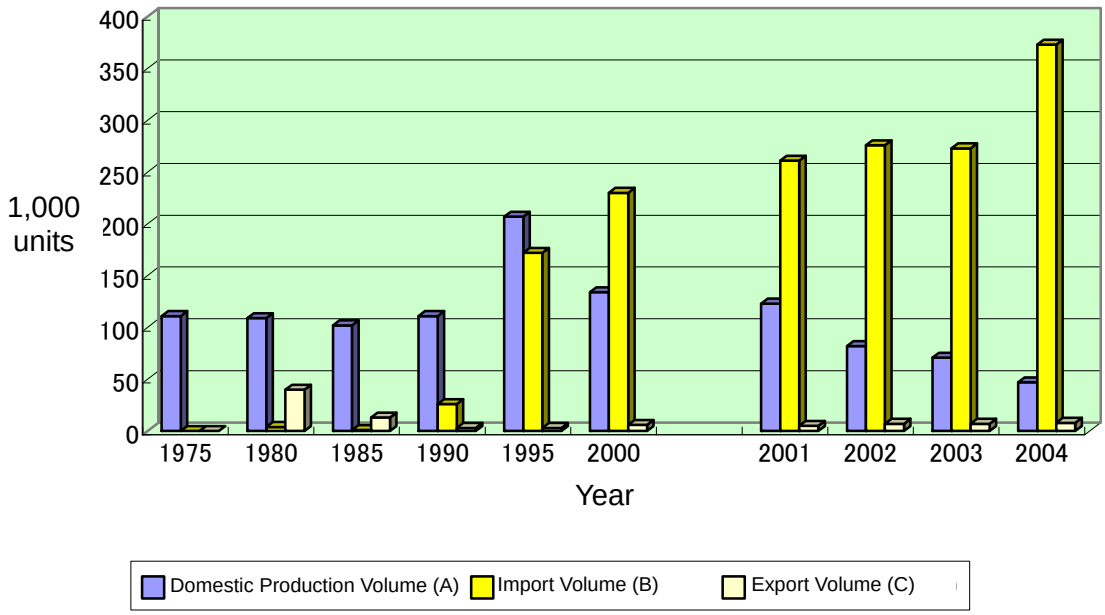
The table below shows the transition of domestic production and import/export volumes of electric refrigerators

Figure 2: Transition of Domestic Production and Import/Export Volumes of Electric Refrigerators



Although domestic production and export increased till 1985, export has decreased since then, due to strong-yen recession. In 2004, volume ended in just under 70,000 units.

Figure3: Transition in Domestic Production of and Import/Export of Electric Refrigerators



For electric freezers as well, import has been increasing since 1995, while domestic production has declined. In 2004, proportion of domestic production to import is 12%.

1-2 Transition in Volume of Shipment of Electric Refrigerators by Internal Volume

According to the survey of Japan Electrical Manufacturers' Association, transition by capacity is as shown in the figure, and a "shift to large volume" of refrigerators has become noticeable since 1990. The data in 2004 has shown that large refrigerators having internal volume of 300L or more have a majority of the total shipment. In recent years, super-large refrigerators of 401L or more accounts for 36%.

On the one hand, small refrigerators of 140L or less have still deep-rooted popularity of 30% level among students and unmarried households.

Figure 4: Transition in Domestic Shipment by Capacity of Electric Refrigerators

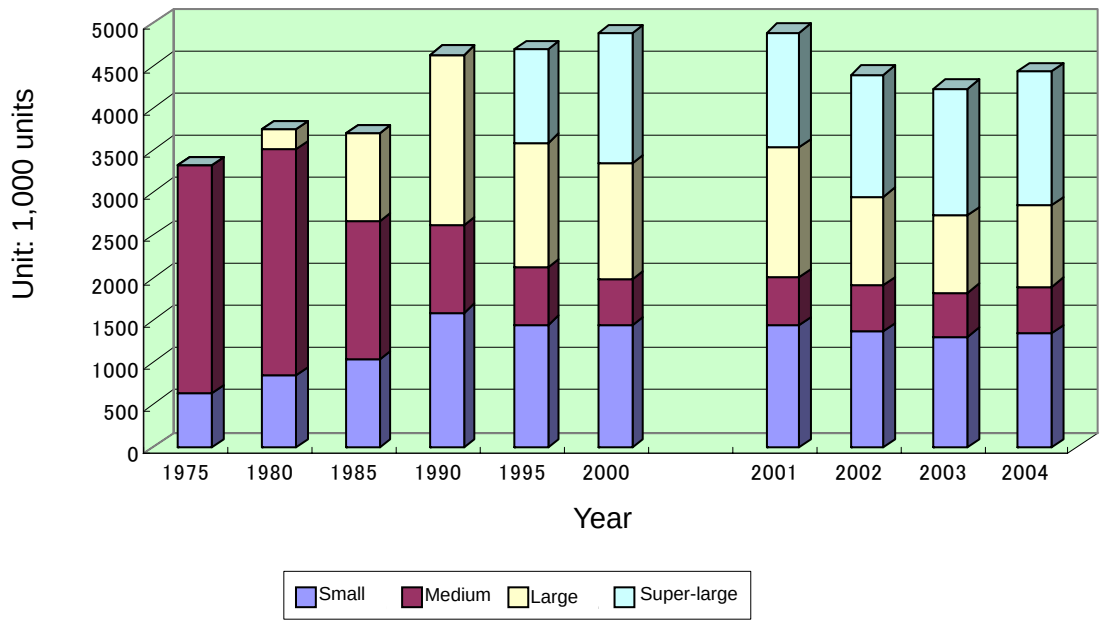


Table 3: Transition in Shipment by Capacity and Composition Ratio of Electric Refrigerators

(Unit: 1,000 units)

	1975	1980	1985	1990	1995	2000	2001	2002	2003	2004
Small	635 (19%)	847 (23%)	1,037 (28%)	1,596 (34%)	1,449 (31%)	1,432 (29%)	1,433 (29%)	1,372 (31%)	1,311 (31%)	1,338 (30%)
Medium	2,697 (81%)	2,661 (71%)	1,634 (44%)	1,018 (22%)	679 (14%)	553 (11%)	570 (12%)	543 (12%)	521 (12%)	565 (13%)
Large	0	234 (6%)	1,029 (28%)	2,018 (44%)	1,468 (31%)	1,369 (28%)	1,530 (31%)	1,044 (24%)	903 (21%)	955 (22%)
Super-large	-	-	-	-	1,098 (23%)	1,531 (31%)	1,356 (28%)	1,440 (33%)	1,497 (35%)	1,575 (36%)
Total	3,332	3,742	3,700	4,631	4,693	4,885	4,888	4,399	4,233	4,433

(Notes) 1. Refrigerators of 140L or less are classified as small, those of 141 to 300L as medium, those of 301 to 400L as large (super-large refrigerators before 1990 were addressed as large), and those of 401L or more as super-large.
2. The percentage in parentheses represents the composition ratio of each year.
3. Since this statistics show volume of shipment among member companies of the Japan Electrical Manufacturers' Association, they differ from the numeric values shown in Table 1.

Source: Independent statistics by the Japan Electrical Manufacturers' Association

1-3 Domestic Major Manufacturers

They include SANYO Electric Co., Ltd., Sharp Corporation, Toshiba Consumer Marketing Corporation, Hitachi Appliances, Inc., Matsushita Electric Industrial Co., Ltd., Mitsubishi Electric Corporation, and so on.

1-4 Import Manufacturers

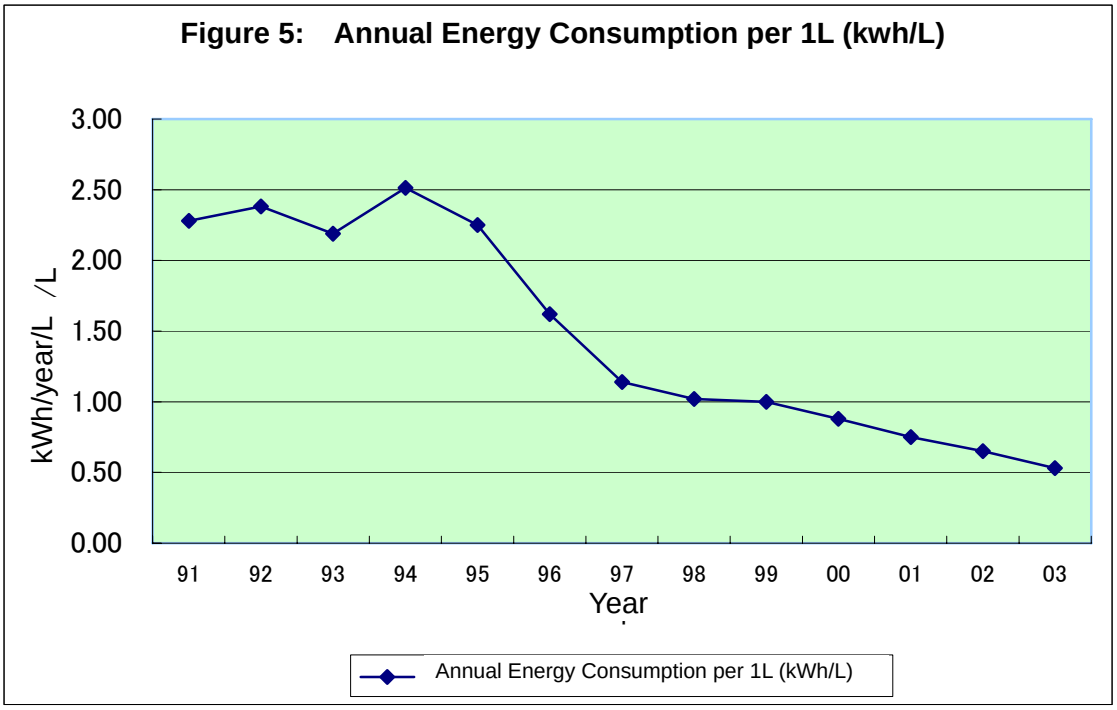
They include M&M (China), LG Electronics (South Korea), Electrolux (Sweden), Samsung Electronics (South Korea), GE (United States), Daewoo (South Korea), Haier (China), Whirlpool (United States), and so on.

2. Energy Saving Measures for Household Refrigerators

2-1 Transition of Energy Saving Technologies for Refrigerators

Development of energy saving technologies undertaken by every manufacturer has substantially reduced power consumption of refrigerators. Temporary rise in power consumption in 1993 and 1994 was attributed to effects of changes in refrigerant and heat insulator foaming agent responding to abolition of specified CFC.

Figure 5: Annual Energy Consumption per 1L (kwh/L)



Source: Japan Electrical Manufacturers' Association

Note: Although the method of measuring energy consumption was changed in 1993 and 1999 (because JIS was revised), correction was made with a coefficient which is a difference in data caused by difference in measurement method.

2-2 Improvement of Energy-Saving Technologies

In Japan, energy-saving technologies for refrigerators have reduced energy consumption through accumulation of three basic technologies. The table below summarizes a relationship among major basic energy-saving technologies.

Table 4: Major Basic Energy-Saving Technologies

Basic Technology Element	Technology Item	Specific Cases
Cooling Technology	Efficiency of compressors	Motor efficiency, compression efficiency, adoption of isobutane as a refrigerant, etc.
	Improved condensation efficiency	Mounting location of a condenser, shape/heat release area, etc.
	Optimization of cold air trunk	Review and improvement of cold air flow
Insulation Technology	high-efficiency of insulation material	Expansion of area in which a vacuum insulation material is used, etc
	Improvement of heat-insulated structure	Insulation effect of door gaskets (shape)
Control Technology	Optimization of heater control	Heat quantity control of various types of temperature compensating heaters
	Optimization of cooling circuit	Improved heat loss due to a stopped compressor
	Reduced torque at startup	Low consumption during stable operation
	Inverter technology	Improved efficiency of cooling cycle

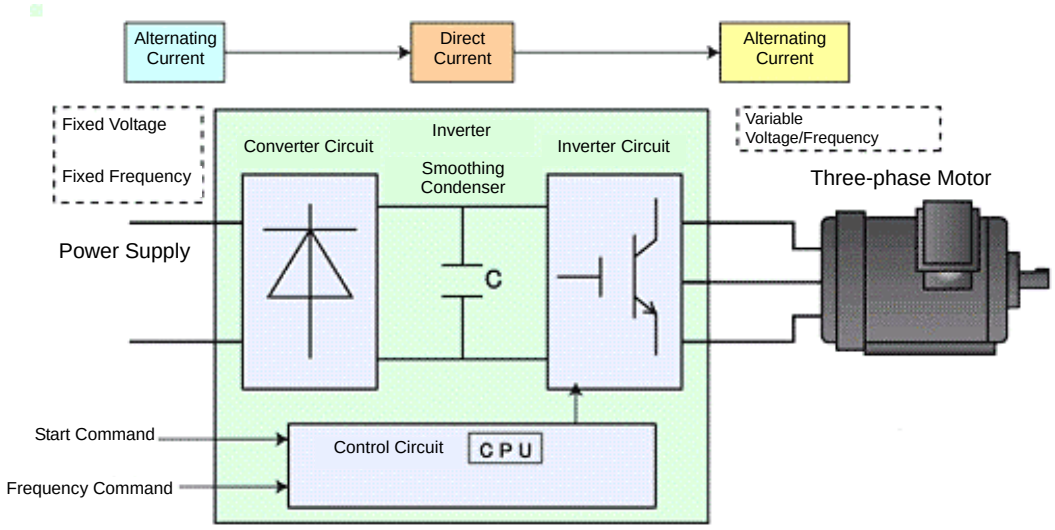
In addition, these technologies have facilitated reduction of power consumption of household refrigerators.

Typical technologies for reduction of power consumption of refrigerators include the following:

(1) Improved efficiency of a compressor (Improvement of motor efficiency)

A change to a highly-functional motor that drives a compressor has increased motor efficiency and slowed down rotation of a compressor, thereby saving energy.

Figure 6: Circuit Example



(2) Adoption of Natural Refrigerant

Toward reducing the Global Warming Potential (GWP), as for a refrigerant, replacing CFC's substitutes by a natural refrigerant, namely Isobutane, is now taking place. Isobutane is capable of improving cycle efficiency by approximately 7%.

Table 5: Refrigerant Characteristics

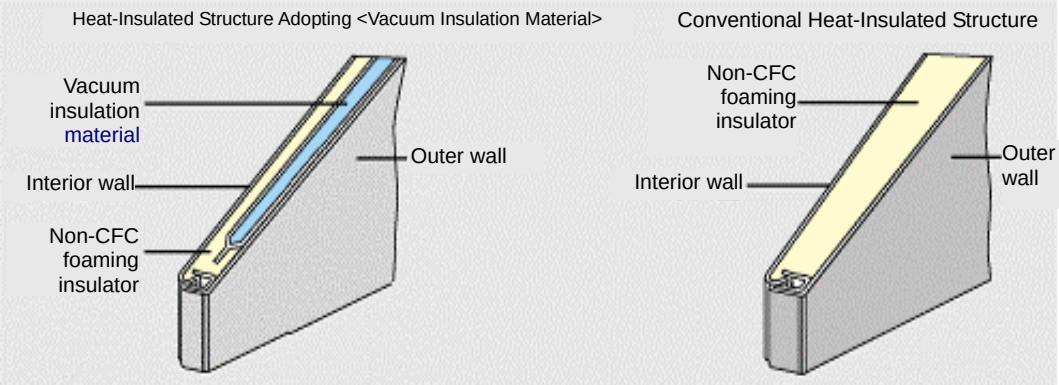
Refrigerants	CFC's Substitutes	Isobutane
ODP (Ozone Depletion Potential)	0	0
GWP (Global Warming Potential)	1300 (as CO2=1)	3 (as CO2=1)
Theoretical COP (%)	100 (Baseline)	Approx. 107 (Good)

A switch to the natural refrigerant has almost completed in large models of 300L or more, and its application has been expanding to a wide range of models including small ones.

(3) Vacuum insulation material

Adoption of a combined heat insulation system of a vacuum insulation material having high insulation efficiency and a conventional urethane insulator enables a substantial increase in heat insulation performance.

Figure 7: Thermal Insulation Structure Using Vacuum Insulation Material



However, high manufacturing cost of vacuum insulation materials has now limited its use mainly to large refrigerators of 400L or more.

2-3 Differences of Method for Measuring Energy Consumption between International Standard (ISO) and JIS Standard

A method for measuring energy consumption of electric refrigerators was set as a JIS standard (JIS C 9607) in 1979. Then in 1993, in order to ensure international compliance and repeatability, ISO standard was adopted. In 1999, JISC9801 was subjected to partial revision due to changes in use environment and in configuration of refrigerators (shift to multiple doors), and it has been used up to the present date.

As for the international standard, it adopts a measurement method which evaluates products' performance (cooling capability) and emphasizes its repeatability in particular.

Table 6: Transition in JIS and Its Comparison with International Standard

	JISC9607 (Law A)	JISC9607 (Law B)	JISC9801	ISO8561 Standard
History of revisions	Established in 1979	Established in 1993	Established in 1999	Established in 1995
Ambient Temperature	15C° (265 days) 30C° (100 days)	25C°	25C°	25C°
Humidity	75%±5%	45%～85%	70%±5%	45%～75%
Installation Condition	A refrigerator shall be installed with the back face abutting on wall and the sides being 30 cm away from wall.	Same as left	Same as left	Same as left
Measurement Condition	Nothing should be stored in a chiller and a freezing compartment.	Nothing should be stored in a chiller. Load should be given to a freezing compartment.	Nothing should be stored in a chiller and a freezing compartment.	Nothing should be stored in a chiller. Load should be given to a freezing compartment.
Conditioning of Products	○Chiller : 3C°±0.5C° ○Freezing compartment: -18C°±0.5C°	○Chiller 5C° or lower ○Freezing compartment -18C° or lower	Same as left	Same as left
Opening/Closing of Door	○Chiller: 50 times/day ○Freezing compartment: 15 times/day	No opening/closing of door	○Chiller: 25 times/day ○Freezing compartment: 8 times/day	No opening/closing of door
Additional Functions (such as ice maker)	Switch off a heater for prevention of dew formation and others.	Switch off a heater for prevention of dew formation.	Switch off a heater for prevention of dew formation and others.	Switch off a heater for prevention of dew formation.

Reference 4

Overview of Commercial Refrigerators, Commercial Freezers and Commercial Refrigerator-Freezers

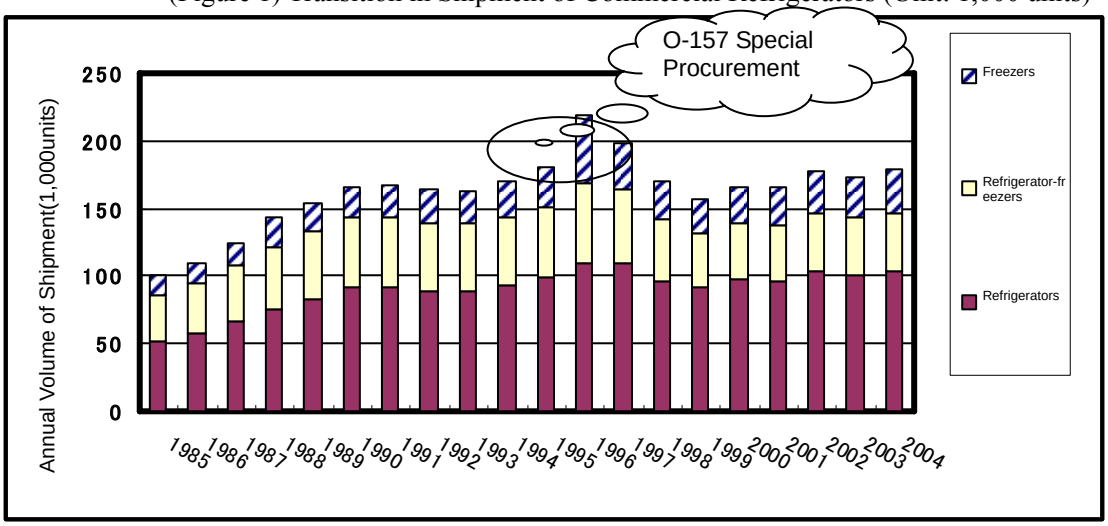
1. What are commercial refrigerators, commercial freezers and commercial refrigerator-freezers?
   (1) In Japan Standard Commodity Classification (Bureau of Statistics, Ministry of International Affairs and Communications), commercial refrigerators, commercial freezers and commercial refrigerator-freezers (hereinafter referred to as "commercial refrigerators") shall be defined as listed in Table 1.
   (2) Refrigerators and refrigerator-freezers are classified into those for home use and for commercial use.
   (For your reference) Household refrigerators are positioned as "household electric/electronic machinery and appliances" (Standard Commodity Classification: 60.51).

(Table 1) Medium Category 56 – Cooling Machine Applied Products and Equipment

Category No.	Product Item Name
56 3	Refrigerator-freezer equipment
56 31	Refrigerator-freezer, refrigerator and freezer
56 311	Refrigerator-freezer
56 3112	Commercial refrigerator-freezer
56 312	Refrigerator
56 3122	Commercial refrigerator
56 313	Freezers
56 3131	Horizontal type freezers
56 3132	Vertical type freezers

2. Production Scale
   ○ According to the industry statistics (Figure 1) of the Japan Refrigeration and Air Conditioning Industry Association, actual production of 2004 is approximately 180,000 units.

(Figure 1) Transition in Shipment of Commercial Refrigerators (Unit: 1,000 units)



Source: Japan Refrigeration and Air Conditioning Industry Association

1) Major manufacturers

Hoshizaki Electric Co., Ltd., Fukushima Industries Corp., SANYO Electric Co., Ltd., Daiwa Industries, Ltd., Hitachi Air Conditioning System, Toshiba Carrier Corporation, Matsushita Electric Industrial Co., Ltd., Orion Machinery

2) In the 1980s, with development of the restaurant industry, shipment of commercial refrigerators increased rapidly.
3) There was special demand due to O-157 in 1996.
4) The number of chains of convenience stores has grown since 1990, and about 170,000 to 180,000 units are shipped every year.

3. Applications

(1) They are mainly installed in hotels and restaurants (various types of restaurant industry), at offices or schools/hospitals (various types of mass feeding), and at the back of supermarket or convenience stores to store items (See Exhibit 1).

(2) Users' demands for commercial refrigerators differ from those for household refrigerators. Size, specification and performance of household refrigerators cannot respond to the followings.

1) Accelerated cooling speed

Notes1. As opening and closing of a door are quite often, the function to rapidly cool down internal elevated temperature is needed.

2. The function to rapidly cool down a hot object until set temperature is needed.

2) Enhanced thermal insulating properties

The function to maintain internal temperature at set degree even in a kitchen, etc., where ambient temperature is high is needed.

(3) Approximately 60% of the shipment volume is made-to-order items, which are individually designed and manufactured according to a customer's requests. The remaining 40% are combinations of about 400 kinds of mother dice and options. They are typical products in small quantities and of various types.

(4) Mainly, food distributors and process manufacturers select configuration and performance depending on an application. Typical configurations of a product are as shown in Exhibit 2. The followings are typical examples:

(Example 1) Although insulation performance may become poorer, a door shall be made of glass so as to easily understand the internal condition, thereby improving working efficiency of a worker.

(Example 2) Doors are installed on both front and back side of a refrigerator in order to have items go through the refrigerator in one way.

(Example 3) A compressor to be mounted is selected depending on frequency of opening/closing and items to be stored, and then cooling capability is set accordingly.

(Exhibit 1)

Applications of Commercial Refrigerators

	Business Category	Application and Purpose	Property of Equipment
Feeding Service	Schools	To preserve foodstuff/food to taste for diet	Front and rear door opening/closing type, cart-in type
	Hospitals		
	Welfare institutions		
	Feeding service center		
Safety	Healthcare center	To preserve food to taste for diet	
Transportation	Door-to-door delivery/postal service	To preserve delivered food	Vehicle-mounted type
Agriculture	Producers	To preserve mold and products	
	Productive cooperations	To preserve harvestry	
Fishery	Market	To maintain chilling freshness/frozen storage	To be housed in a dedicated container.
Food processing	Bread making	To keep and mature dough	Constant temperature-high humidity type
	Confectionery production		
	Noodle making	To preserve/mature noodles	
	Meat processing factories	To preserve/mature raw ingredients/processed items	
	Vegetable processing factories	To preserve foodstuff/To preserve processed items and seasoning agent	
Restaurant Business	Hotels Restaurants Wedding centers Funeral halls Event halls Golf courses	To preserve foodstuff/processed items	Glass door type Hotel bread housing type Constant temperature-high humidity type Center pillar-less type Sandwich type Drawer type Type with rapid freezing capability feature Drain water evaporation type
	Restaurants at passenger boats		
	Railroad restaurants		
	Buckwheat/wheat noodle shops	To preserve noodle ingredients/foodstuff.	
	Ramen shops		
	Steak houses	To preserve foodstuff such as meat, vegetables, etc.	
	Hamburger shops		Sandwich type
	Sushi restaurants	To preserve sushi items	
Lease	Hospitals, elder care facilities	To let a room with rent	Chiller locker type
Sales	Stock rooms in the back of convenience stores	To preserve foodstuff/preserve goods/to preserve delivered food	
	Stock rooms in the back of supermarkets		
	Food section of department stores		

(Exhibit 2)

Product Configuration

1) Vertical Type

- This type is used in a kitchen in restaurants, coffee shops, ice cream shops, supermarkets, general cafeteria, and feeding facilities, etc.

Figure a. Vertical Type (Range of Effective Internal Volume: 300 to 1,800L)

(Features)

- Having larger internal volume per lot area than the horizontal type, the vertical type is used in a kitchen in a hotel, feeding facilities, etc. installation area of which is limited. A cooling unit is mounted at the top.
- There are a number of demands for glass doors to maintain the visibility of stored items inside a refrigerator.

Product in the photograph:

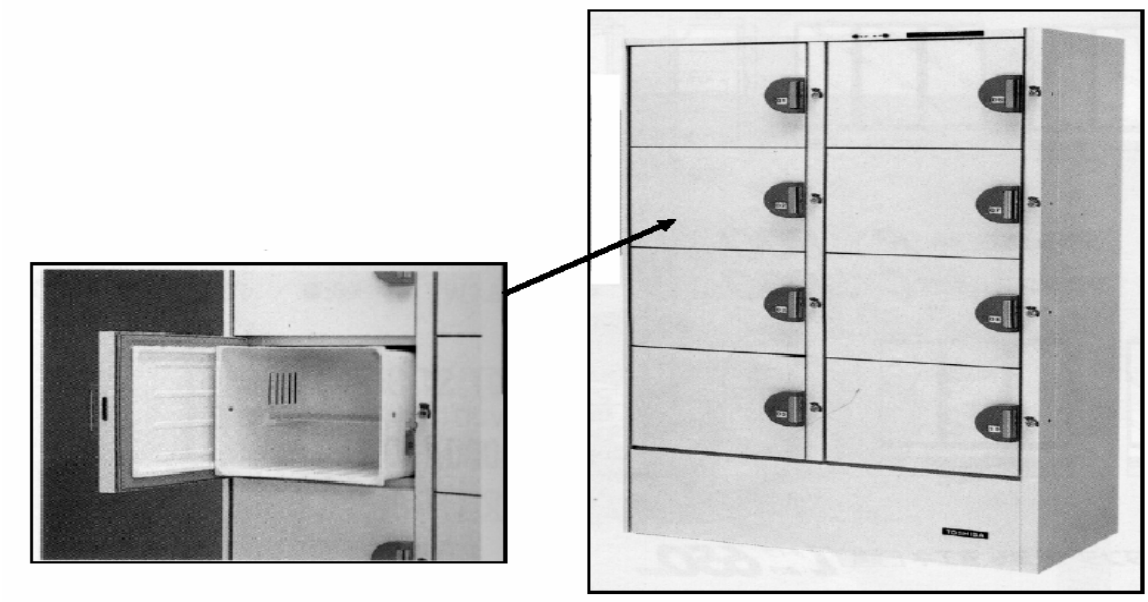
Effective Internal Volume 1,042 L

Power Consumption 370 W

Figure b. Locker Type (Range of Effective Internal Volume: 216 to 288 L)

(Features)

- A condensing unit is mounted at the bottom. The single unit controls temperatures of all compartments.
- As each compartment is independent and thus each door of every compartment can be opened or closed independently, this type has better energy efficiency than other refrigerators having the same capacity.



Product in photograph:

Effective Internal Volume: 36L x 8 compartments (288L)

Power consumption 370W

2) Double-Sided Door Type

(Features)

- It has the same structure as the vertical type.
- In hotels, fast food restaurants, etc., doors are installed on both front and back sides to improve working efficiency. Food can be put in or taken out from both sides.

Figure c. Pass-through Type (Range of Effective Internal Volume: 523 to 1,800L)

Product in photograph:

Effective internal volume 1,730 L

Power consumption 1,055 W

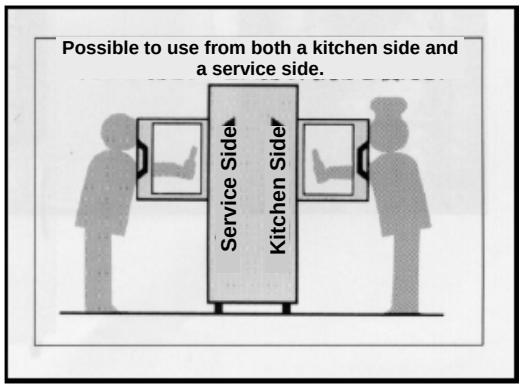
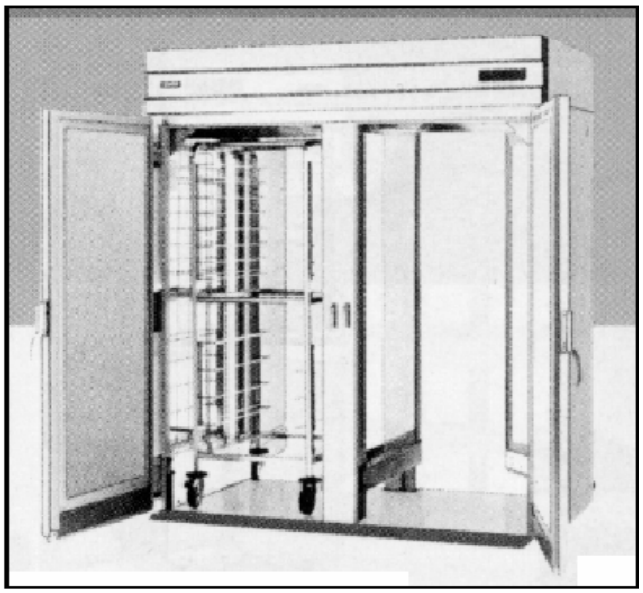


Figure d. Cart-in Type (Width of Effective Internal Volume: 1,000 to 2,500 L)

- It has the same structure as the vertical type.
- Items can be preserved while kept on a cart.



Product in photograph:

Effective internal volume 2,413 L

Power consumption 736 W

3) Horizontal Type

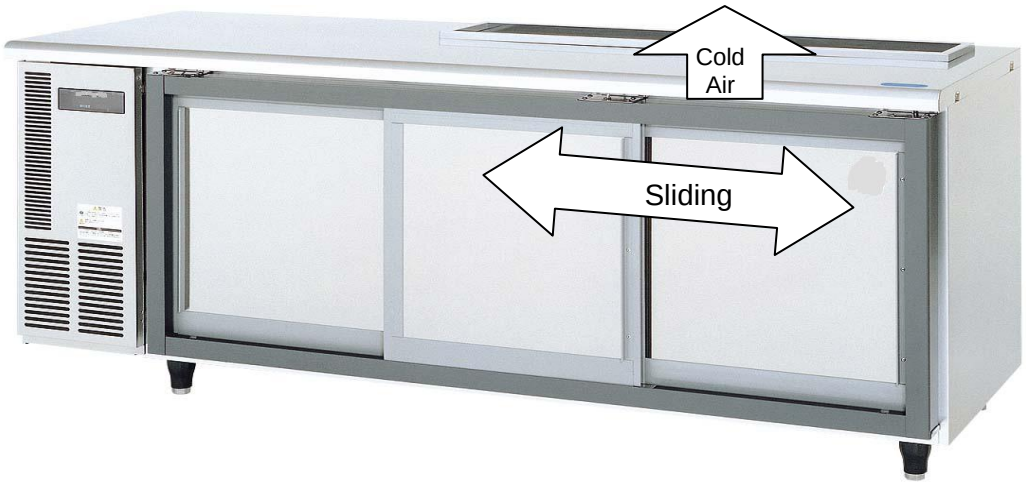
- A cooling unit is mounted on the side.
- The product shall be approximately 800 mm high and a working table is provided on a top face. Thus, internal volume per lot area cannot be increased. The working table shall be used for various cooking tasks and temporary storage of cooked food.

Figure e: Horizontal Type (Range of Effective Internal Volume: 74 to 700L)

Product in photograph: Effective internal volume 332 L
Power consumption 220 W

Figure f. Sandwich Table (Range of Effective Internal Volume: 240 to 520L)

- Rectangle holes are provided on a top board and foodstuff containers are fitted in the rectangle holes and sealed. Containers are chilled by cold air inside, and thus foodstuff is kept fresh.



Product in photograph: Effective internal volume 426 L Power consumption 266 W

4) Other Examples

- A cooling unit, refrigerant piping, etc. are provided for chilling and freezing in parallel, and different temperature zones are controlled in one device.

Figure g. Refrigerator-freezers (Range of Effective Internal Volume: 330 to 1,800L)

Product in photograph: Effective Internal Volume 1,524 L

Power consumption 740W

Figure h. Constant-temperature high-humidity storage (Range of Effective Internal Volume: 290 to 1,500L)

- The internal structure of a refrigerator is composed of dual boxes wherein cold air flows therebetween, and indirect cooling is conducted. A convective flow inside a refrigerator is thereby controlled, a face of foodstuff is prevented from drying, and high humidity is maintained.
- Because of indirect cooling, there is a little difference between temperature of internal air and interior wall face temperature, and thus moisture inside a refrigerator cannot easily form dews, and humidity is maintained. In addition, as foodstuff is not subject to wind, it does not dry easily.

Product in photograph: Effective internal volume 818 L
Power consumption 410 W

(Figure i.) Option　Example of Order-to-made Selection