Standards and Labeling Policy for Deep Freezers

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Glossary

AEc	Annual Energy consumption
AQSIQ	Administration of Quality Supervision Inspection and Quarantine of China
CAGR	Compound annual growth rate
CO_2	Carbon Dioxide
DOE	Department of Energy
EEI	Energy Efficiency Index
EU	European union
EUEB	European Union Eco Labeling Board
FTC	Federal trade commission
HFC	Hydrofluorocarbons
HCFC	Hydro chlorofluorocarbons
IS	Indian Standards
MEP	Minimum Energy Performance
NDRC	National Development and Reform
OEM	Original equipment manufacturer
PUF	Polyurethane foam
SAEc	Standard Annual Energy consumption

01 Deep freezers

Deep-freezing is a technique in which food items are cooled rapidly (a few minutes to an hour) by exposing them to intense temperatures from -30°C to -50°C, until the product core temperature reaches -18°C. The temperature range in a deep freezer usually varies from 0 to -18°C, hence deep freezers are generally used for frozen products.

Definition

Deep freezers are electrical equipment in which food products are frozen to increase their shelf life. The typical examples of foods which are stored in deep freezers are ice cream, frozen meats (fish, poultry, livestock), frozen ingredients, some frozen processed commodities.

The temperature requirements and technology employed for cooling vary as per the nature and perishability of the product. The broad categorization of products as per their temperature requirement is shown in Table 1.

Table 1: Food classification basis temperature

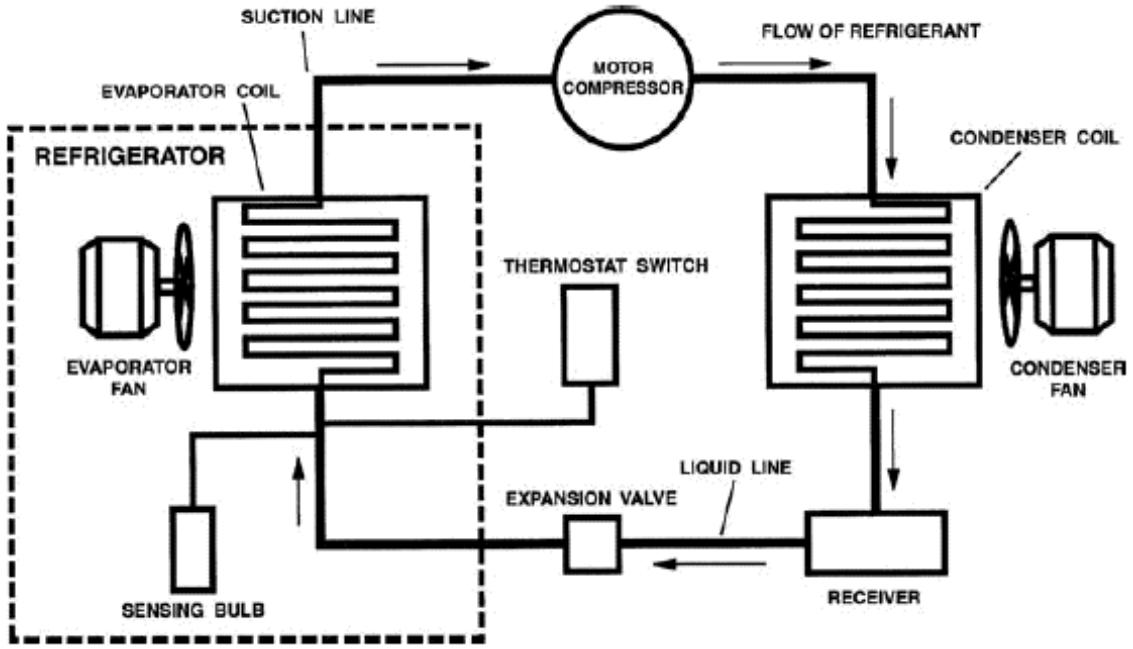
Temperature requirements	Products
Frozen (< -18°C)	Ice cream, frozen meats (fish, poultry, livestock), frozen ingredients, some frozen processed commodities.
Chilled (0-10°C)	Fresh fruits & vegetables, fresh meats, milk, butter, confectionary, some pharmaceuticals.
Mild chilled (10-20°C)	Fresh fruits & vegetables, chocolates, seeds and some milk products
Normal (>20°C)	Whole onion, dehydrated foods, pickle, jams, oils and extracts

Operating principle

The deep freezers work on the principle of vapor compression. The vapor compression uses a circulating liquid refrigerant as the medium which absorbs heat from one place and subsequently reject it elsewhere. Key functional components of a deep freezer include condenser coil, evaporator coil, compressor vessel, expansion valve and electric fan.

During the vapor compression cycle, the refrigerant generally undergoes through 4 stages i.e. compression, condensation, throttling and evaporation through various *thermodynamic* state changes. The refrigerant absorbs the heat inside the freezer when it flows through the evaporator coils. Because of the heat absorbed by the saturated low-pressure refrigerant, a state change of refrigerant occurs as per the thermodynamic laws leading to production of freezing temperatures outside the coil. This air blowing with the help of an electric fan results in a mist of cold air throughout the volume of the freezer compartment. The refrigerant then passes into the compressor. The compressor converts the low-pressure gas into a pressurized liquid that enters the condenser coil. A state change of refrigerant again happens as per the thermodynamic laws, which produces heat behind the freezer that is funnel away by an electric fan. The refrigerant, acts as the transfer medium, absorbing and rejecting heat, with the expansion valve regulating the amount and thermodynamic state of the refrigerant. The operating principle a deep freezer is depicted in the Figure 1.

Figure 1: Working Principle of a Deep Freezer



Application

Deep freezers have a variety of applications, such as:

- Retail and hospitality
- Food and beverage processing
- Cold storage and warehouses
- Labs, Hospitals, Pharmas

Classification

There are various types of deep freezers available in the Indian market. They can be classified based on their capacity, type and application.

Capacity

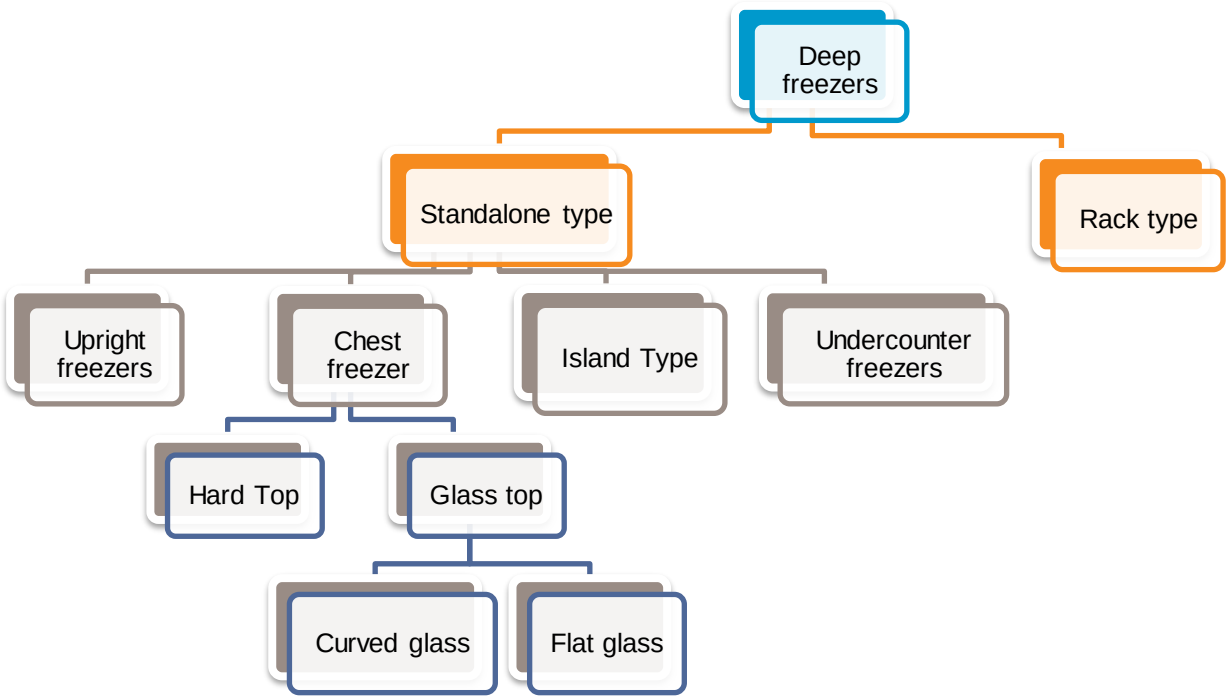
Deep freezers come in various capacities ranging from 50 to 1000 liters. Based on their capacity, they are broadly divided into 4 segments-

- 200L and below
- 200L to 300 L
- 300L to 500L
- 500L and above

Type

The deep freezers are broadly classified into two categories i.e., stand alone and rack type with further sub-categorizations as depicted in Figure 2.

Figure 2: Classification based on type



The choice of deep freezer for an application depends on the capacity, design, application, cost, place of installation etc.

Standalone freezers

Standalone systems are plug and play units with the evaporator, condenser, compressor and expansion valve housed in a compact single assembly. They come in various sizes ranging from 50 to 1000 liters. Standalone freezers can be categorized into the following sub types-

1. **Upright deep freezers**

As the name suggests these are vertical in shape and have access from the front. These are not as prevalent in the market as their chest type counterparts.

Figure 3: Upright type freezer

2. Chest freezer

These are horizontal in shape with access from the top. They are the most common type of freezers in the Indian market and are further classified into the following categories:

- **Hardtop**

These deep freezers have a door, which is the same material as the body. These could be single door, double door or triple door (which are rare). In the case of double door, there could be two separate compartments having different temperature settings depending upon the user convenience and need.

Figure 5 Double door hard top

Figure 4 Single door hard top

- **Glass Top**

  The door in this type of freezers is made up of hard glass with a sliding mechanism enabling the customers to view the products without opening the door. These are of two type's i.e. flat glass and curved glass.

Figure 6: Curved glass deep freezer

Figure 7: Flat glass deep freezer

3. Island type

These are generally found in super markets and very large convenience stores. These are used for displaying large amounts of frozen food especially meats, fish and seafood allowing customers to browse through the products at display. They come in large capacities and generally have multiple compressors and heat exchangers. They are not very popular in the Indian market.

Figure 8: Island type freezer

4. Under Counter

Under counter freezers are like chest freezers but are often built with aluminum interior walls and stainless-steel floors. The main purpose of an under counter deep freezer is to provide quick access to products through multiple drawers and doors. Most of the under counter freezers conform to the industry standard of 0.90 m, which allows them to roll underneath 0.91 m high countertops. These are mostly used by chefs for keeping the cooked food fresh as per different temperature requirement of the food

Figure 9: Under counter freezer

Comparison of Chest V/s Upright deep freezers

Both kinds of freezers have their pros and cons, but it really comes down to space and personal preference while selecting them. Some of the pros and cons are listed below:

Table 2: Chest type and upright type comparison

S. No.	Parameters	Description
1	Space requirements	Upright freezers require less floor area as compared to chest freezers. For example, a 0.62 cubic meters chest freezer uses a rectangular floor space of 0.60 m by 1.82 m while the upright type would require 0.76 m by 0.76 m
2	Temperature consistency	Consistency of temperature is more in chest freezers
3	Ergonomics	Upright freezers are more ergonomic than chest type. They are easy to arrange and convenient for the customers as they have more shelves, bins and dividers
4	Cost	Chest type freezers are cheaper than their upright counterparts
5	Holding time	Holding time for chest freezers is more than upright type, which means that in case of electricity failure or a burn out the chest type can maintain the temperature for longer period
6	Defrost	Upright type generally come with a self-defrost function, which is not available in chest type

Major market players

The deep freezer market in India presents a mixed scenario with variety of players from all across the world. Predominantly deep freezer market is import driven, but some big players such as Voltas, Blue star, Godrej, Rockwell and Western have their manufacturing facilities in India (although significant number of their models are still imported). Other players such as Cell frost, Elanpro, Kieis, Lloyd, and Haier completely import their units from China, USA. Key players in the deep freezer market are listed below:

Supply chain analysis

Majority of deep freezer are imported as a complete unit, while some original equipment manufacturers (OEMs) have local manufacturing facilities as well. The OEMs which have local manufacturing facilities fabricate some components such as heat exchangers, body etc. in house while other components like compressors and PUF insulation expanding chemical are imported. The main components of a deep freezer and their sourcing is as follows–

Compressor

- The major compressor manufacturers are Danfoss, Highly, Copeland, Emersion, LG. These are completely imported from China.

Refrigerant

- Most compressors work on R-134a, R-290 and R-600a refrigerant. R-290 and R-600a are imported, whereas R-134a is also manufactured in India.

Heat Exchanger

- There are 2 heat exchangers in a deep freezer i.e. evaporator and condenser. The heat exchangers are made up of copper tubes. OEM's with local manufacturing, manufacture heat exchangers in-house or procure from local vendors.

Body

- The outer body of a deep freezer is generally made up of Cold rolled cooling (CRC) or CRCA (Cold Rolled Cooling Annealing) and painted with powder coating. The inner body is made of SS/ Aluminum foil and plastic moulded sheet.

Insulation

- Polyurethane rigid foam (PUF) insulation is provided between the two layers. The PUF insulation not only maintains the temperature in the freezer in case of burn out but also cuts the energy cost significantly. The insulation expanding agent is imported. Body and insulation are manufactured in house or procured locally by the OEM's that have local manufacturing.

Market Characteristics

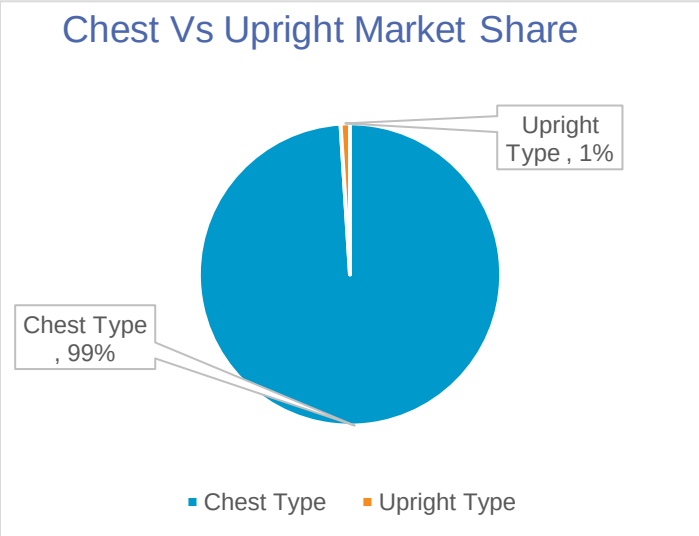
Market size

A two-pronged approach was used to arrive at the total market size, understand the product segmentation and validate the results, which included

- Detailed survey questionnaire (as listed in Annexure A.1)
- One on one interaction with major deep freezer manufacturers

As per the market data received from various manufacturers, the total market size for deep freezers (of organized sector for Chest type and Upright type segment) for **FY 17-18 is about 5- 6 lakh units.** The market has more than doubled in last 3 years (with a CAGR ~ 28%) and is expected to continue to grow at a higher CAGR. The chest type freezers constitute about **99% of the** market share, leaving 1% for the upright type.

Figure 10 Market share Chest Vs Upright type



Import / Export Data

As per Ministry of trade and commerce data, 3.72 lakh deep freezer (chest and upright) units were imported, which means the indigenous manufacture was approximately 2 lakh units. The export component for deep freezers is miniscule; only 1690 units were exported in FY' 17-18.

Since the deep freezer market is mostly import driven, a comprehensive analysis on Import/Export data for FY'15-16 has been carried out to understand the market trends. The import/export data for each month has been sorted using Harmonized system (HS) codes from one of the online providers of commercial and import/export information known as Zauba corp. Zauba crop is a popular source for Import/export data and a lot of businesses use Zauba corp data for Management Information Systems (MIS) and other purposes. To cross check the authenticity of the data, the total import quantity for FY'15-16 from Zauba was validated against the ministry of commerce and Industry data of Government of India, the variation in annual import quantity number was less than 3%. Further, the results of analysis conducted on the monthly data have been validated from various manufacturers to rule out any erroneous trends.

The figure below illustrates the major countries of import and export for FY' 15-16:

Imports
FY 2015-16 (Total units imported 1.79 lacs)

China - 99.7 %
Turkey, Denmark, USA, ~ 0.3%

Exports
FY 2015-16 (Total units exported: 70)

Oman, Qatar, UAE, Maldives, Nepal,

Annual imports

Almost all the import for deep freezers is from China, a miniscule share is also imported from Turkey, Denmark and USA. The graphs below depict the growth in Import of deep freezers over last three years. Since 2015, the deep freezer imports have grown over 100 % in both quantity and value.

Figure 11 Annual Import Trend

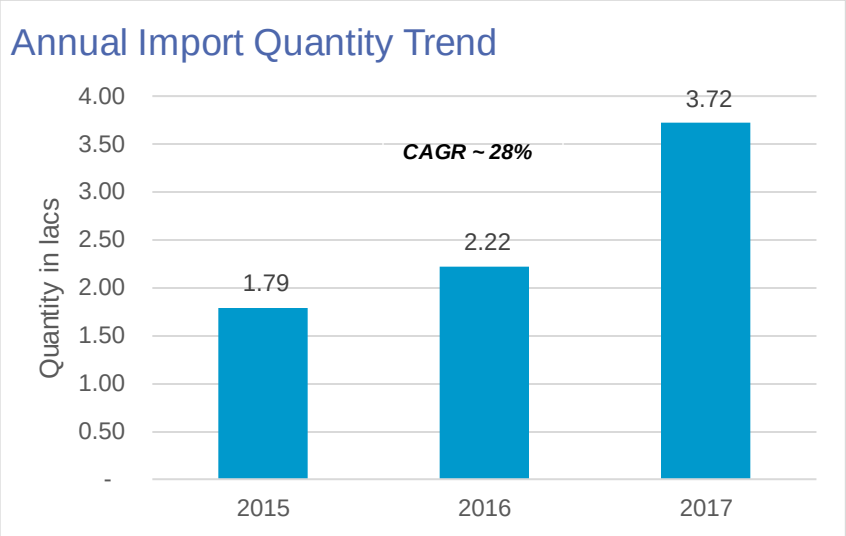


Figure 12 depicts the monthly variation in import quantities throughout the year. The trend indicates that imports start to pick up December onwards and peaks in the month of February, after which it starts declining. Capacity ranges of 200L – 300L and 300L – 500L constitute 66% of the import as shown in Figure 13.

Figure 12: Monthly import trend for different capacity segments

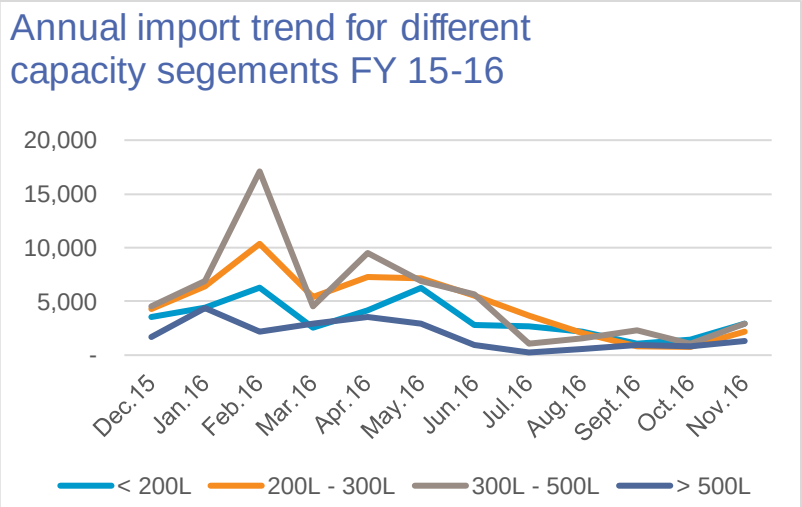
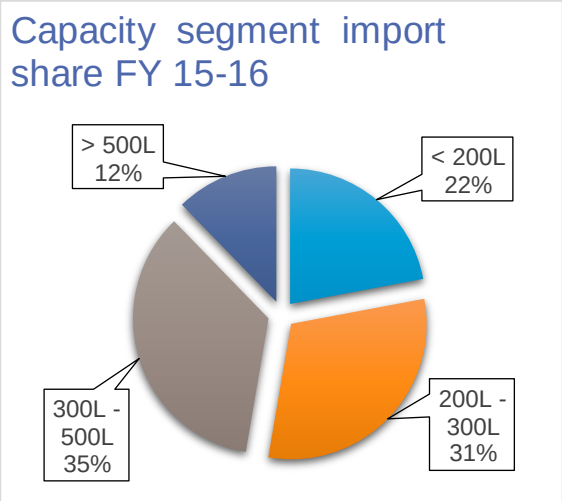


Figure 13: Capacity segment import share



Key Findings

- As per the estimates received from various manufacturers, the total market size for deep freezers (chest type and upright freezers) is around 5-6 lakhs out of which 3.72 lakh units are imported.
- The 200L – 300L and 300L - 500L capacity segments for chest freezer or top access type dominate the market share.
- The market share of Upright type or front access freezers compared with the chest type or front access type is miniscule (around < 1%)
- The market size for deep freezers has more than doubled in last 3 years (with a CAGR ~ 28%) and it expected to grow at a steep CAGR.

03 Deep freezer labeling programs in other countries

The section reviews international labeling programs adopted in leading economies across the world.

European Union

European Union is comprised of 28 countries, all of which have to comply by harmonized regulations including those pertaining to energy efficiency requirements and labeling. Although the countries under EU have their individual labeling programs also, but the Directive for Mandatory Energy Labeling of Household Appliances (Directive 92/75/EEC) made comparative labeling compulsory in all member countries. A common labeling program for refrigerators and freezers came into effect in 1995.

Review of EU freezer rating methodology

The EU labeling program covers refrigerated appliances mentioned in Table 3.

Table 3: Equipment covered under EU labeling program

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

Energy Efficiency Index (EEI)

The EU standard and labeling program specifies Energy Efficiency Index (EEI) as a measure of performance for their comparative label. The EEI is calculated by comparing the actual energy consumption of the appliance with a reference/standard value.

The EEI is calculated using the following formula

$$EEI = \frac{AEc}{SAEc} \text{ X } 100$$

Where:

- AEc is the Annual Energy consumption in kWh/year
- SAEc is the Standard Annual Energy consumption in kWh/year
- AEc = E (Energy consumption in 24 Hours) X 365

SAEc = (Veq X M) + N + CH

Veq is the equivalent Volume and the calculation methodology for it is explained later.

CH is an adjustment factor for refrigerated appliances and its value is equal to

- 50 kWh/year for refrigerating appliances with a chill compartment of least 15 litres volume
- Otherwise, CH is equal to 0 kWh/year.
- M and N are constants whose values have been derived using statistical techniques such as regression

Table 4: M and N constant values for EEI calculation EU

Constants	Values	Conditions
M	0.472	Chest freezers
	0.539	Upright Freezers
N	286	Chest freezers
	315	Upright Freezers

Veq - Equivalent volume calculation

$$V_{eq} = (\sum_{C=1}^{n} Vc\ X\ \frac{25 - Tc}{20}\ X\ FF)\ X\ CC\ X\ \ BI$$

- n is the number of compartments;
- Vc is the storage volume of the compartment(s);
- Tc is the target temperature of the compartment(s) in °C;
- $\frac{25-Tc}{20}$ is the thermodynamic factor (value of Tc is -18 °C in case of chest and upright freezers)

FF, CC and BI are volume correction factors that reflect air movement in a compartment, their climate class and whether the appliance is of built in type or not. Their values are as given in Table 5.

Table 5: Correction factors FF, CC and BI for EEI calculation

Correction	Values	Conditions
FF (Forced air factor)	1.2	for forced air
	1	for non-forced air
CC (Climate Class)	1.2	For T class (tropical) appliances
	1.1	For ST (subtropical) appliances
	1	Otherwise
BI (Built In)	1.2	For built-in appliances under 58 cm in width
	1	Otherwise

Notes
(i) FF is the volume correction factor for frost-free compartments, (ii) CC is the volume correction factor for a given climate class. If a refrigerating appliance is classified in more than one climate class, the climate class with the highest correction factor is used, (iii) BI is the volume correction factor for built-in appliances

Based on the EEI values, efficiency class and corresponding color-codes are marked on the appliance. The label ratings corresponding to their EEI values are given in Table 6.

Table 6: Efficiency classification basis EEI

Efficiency Class	EEI
A+++	EEI < 22
A++	22 < EEI < 33
A+	33 < EEI < 42
A	42 < EEI < 55
B	55 < EEI < 75
C	75 < EEI < 95
D	95 < EEI < 110
E	110 < EEI < 125
F	125< EEI < 150
G	EEI > 150

Test Conditions

The summary of test conditions for EU standards is given in Table 7.

Table 7: Summary of EU test conditions

Standard	IEC 62252
Ambient for class 24 hrs. energy consumption	Test conducted at 16 and 32 ± 0.5°C and value interpolated at 25°C
Ambient for class T (only for checking cabinet temperature control)	32 ± 0.5°C
Fresh food compartment temperatures	+4°C
Freezer Compartment Temperature	One star - 6°C , Two -star -12°C, Three-star-18°C Four-star -18°C
Anti-condensation heater	Off
Freezer compartment loading	Filled with as many packages as can be fitted into freezer*
Energy consumed during defrost cycle	Covered
Energy consumption during defrost period	Not Covered
How to calculate 24-hour energy consumption at required temp.	Test to measure energy consumption at two settings and interpolate
Error limit	If higher than 15% of claim, test 3 more. Mean value needs to be ≤ 10% higher than rated value to pass.

China

Review of China freezer rating methodology

The methodology followed by the Chinese comparative labeling is similar to the EU methodology. It is based on the calculation of energy efficiency Index (EEI). The energy efficiency table for China is shown in the table below-

Energy-Efficiency Grade	Energy Efficiency Index
1	η< 50%
2	50%≤η< 60%
3	60%≤η <70%
4	70%≤η< 80%
5	80%≤η≤ 90%

Energy Efficiency Index (EEI)

The energy efficiency index is calculated by the formula

$$\eta = \frac{\mathrm{Et}}{\mathrm{Ebase}}$$

Where:

- η is the energy efficiency index
- Et represents the tested value of energy consumption (kWh/day), and
- Ebase is the base energy consumption value in kWh/day, and is calculated as follows

$$\mathrm{Ebase} = (\mathrm{M\ x\ Vadj} + \mathrm{N} + \mathrm{CH}) * \mathrm{SR}/365$$

M and N are unique linear parameters for each appliance, their values are derived using statistical techniques such as regression.

Table 8: M and N constant values for EEI calculation China

Class	Refrigerator Type	*M*	*N*
1	Refrigerator, 1-star compartment	*0.611*	*181*
2	Refrigerator, 2-star compartment	*0.428*	*233*
3	Refrigerator, 3-star compartment	*0.624*	*233*
4	Refrigerator Freezer	*0.697*	*272*
5	Chest frozen food cooler	*0.530*	*190*
6	Chest food freezer	*0.567*	*205*

CH is the same as in the EU methodology

- SR = 1 for chest freezers and upright freezers

- Vadj = adjusted volume

Calculations for Vadj adjusted volume

The formula for calculating the adjusted volume as follows

$$V_{eq} = \sum_{C=1}^{n} Vc\ X\ Fc\ X\ Wc\ X\ CC$$

- n – Number of compartments
- VC = measured storage volume of a specific type of compartment (Liters)
- FC = Constant, equal to 1.4 for forced air cooling or 1.0 for non-forced air
- CC = Climate type correction coefficient, (= 1 for N or SN, =1.1 for ST and = 1.2 for climate type T)
- WC = (25-Tc/20) where Tc is the compartment temperature

Test Conditions

The summary of test conditions for China standards is presented in Table 9.

Table 9: Summary of China Test Conditions

Standard	GB 12021.2
Ambient for 24 hrs. energy consumption	Test conducted at 16 and 32 ± 0.5 °C and value interpolated at 25 Deg.C
Ambient for class T (only for checking cabinet temperature control)	32 ± 0.5°C
Anti-condensation heater	Off
Freezer Loading	For V<50 as many as possible; For 50<V≤100: 40 kg/100 L; For V>100 : 25 kg/100 L*
Energy consumed during defrost cycle	Not Covered
Energy consumption during defrost period	Not Covered
24-hour energy consumption at required temperature	Test to measure energy consumption at two settings and interpolate
Usage Factor" based on appliance type (Used in calculation of 24-hr energy consumption)	Not included in the Standard
Thermal Adjustment Factor	Not included in the Standard
Error limit	Within 10% of claim

USA

Review of USA freezer rating methodology

USA follows Energy guide labeling program for deep freezers, which is mandatory. The label displays the minimum / maximum values of energy consumed per year for a similar class of products. It also displays actual value of energy consumed per year by the product that helps the consumer in comparing and thereby assisting his purchase decision. The maximum value of energy consumption for a similar class of products has to comply with the minimum energy

performance standards (MEPS) set by Department of Energy (DOE). The minimum and maximum values on the labels are updated each year. The methodology for determining the maximum energy use for freezers is depicted below in Table 10.

Table 10: Equations for maximum energy use (KWh /Year)

Product class (Scope)	Based on AV ($ft.^3$) *	Based on av (L)**
Upright freezers with manual defrost	7.55AV + 258.3	0.27av + 258.3
Upright freezers with automatic defrost without an automatic icemaker	12.43AV + 326.1	0.44av + 326.1
Chest freezers and all other freezers except compact freezers	9.88AV + 143.7	0.35av + 143.7
Compact upright freezers with manual defrost	9.78AV + 250.8	0.35av + 250.8
Compact upright freezers with automatic defrost	11.40AV + 391	0.40av + 391
Compact chest freezers	10.45AV + 152	0.37av + 152

USA also follows a variety of endorsement labels such as Energy star, International Energy star, Green seal and standby. Energy star program identifies the most efficient product in a similar class of products, either because it is in the top efficiency percentile of the market or because it exceeds the MEPS level by a specified margin. To be eligible for energy star program the product should have 15% less measured energy use than the minimum federal efficiency standards given in Table 10.

AHRI Standard 1250–2014 establishes definitions, test requirements, rating requirements, minimum data requirements for published ratings, operating requirements, marking and nameplate data and conformance conditions for walk-in coolers and walk-in freezers. This testing standard applies to mechanical refrigeration equipment that consists of an integrated, single-package refrigeration unit, or as separate unit cooler and condensing unit components, where the condensing unit can be located indoors or outdoors. Controls can be integral or can be added by a separate party, as long as their performance is tested and certified with the listed mechanical equipment.

Japan

Review of Japanese freezer rating methodology

Japan follows Top Runner program for freezers. The target efficiency values are set based on values of most efficient products in the market. Star rating (1 to 5, 5 being the most efficient) is assigned on the basis of the compliance level achieved against the top runner target. The standard formulas for calculating the target efficiency values are given in Table 11.

Table 11: Standard energy consumption Japan

Category	Shape	Formula for standard energy consumption
3A	Vertical type	E=1.96V+186nF+295dF+788
3B	Horizontal type	E=4.12V+157nF+157dF+349
4A	Chest Freezer	E=1.16V+211
4B	Freezer stocker	E=1.39V+359

Table 12: Adjusted Internal volume calculation

Where V is the adjusted volume, (the calculation methodology for adjusted volume (V) is given in Table 12.

E = Energy consumption efficiency (kWh/year)

nF = number of places behind side-by-side doors of freezers where center pillar is not installed

dF= 1 for freezers with multiple doors otherwise dF= 0

d= depth (mm) based on external dimension as stipulated in JIS B8630:2009

VF= Rated internal volume

Shape	Adjusted internal volume
Vertical type	V =800/d×VF
Horizontal type	V=600/d×VF
Chest Freezer	V=VF
Freezer stocker	V= VF

India

Overview of Indian standards for deep freezers: IS 7872

The standard for deep freezers in India is IS 7872. The standard was first published in 1975 which was revised in 2018. The brief scope of IS 7872 is as follows-

- The standard covers front access and top access freezers working on vapor compression refrigeration using natural or forced draught air-cooled condenser
- It covers capacity range of freezers of net and gross storage volume from 50 to 1000 litres
- It does not apply to freezers or freezer compartments built in refrigerators, refrigerator cum freezers or walk in coolers.

Table 13 presents the list of standards that have been referred while drafting IS 7872.

Table 13: List of standards referred for IS 7872

Standard No.	Title
IS 302 – 2 -24	Safety for household and similar electrical appliances, Particular requirements, Section 24 Refrigerators, food freezers, Ice makers
IS 732	Code of practice for electrical wiring installations
IS 9844: 1981	Methods of testing corrosion resistance of electroplated and anodized aluminium coatings by neutral salt spray test
IS 10617: 2013	Hermetic compressors – Specifications (first revision)
IS 5149-2: 2014	Refrigerating systems and heat pumps – safety and environmental requirements design, construction, testing, marking, documentation.

IS 7872: Test Requirements

The compliance tests specified under IS 7872 are classified into 3 broad categories. These tests mainly pertain to the constructional, quality and performance aspects of the freezers. The classification is as follows –

Type tests	Production routine tests (Conducted after completion of freezer at manufacturer works)	Acceptance tests
• Door seal tests • Test for mechanical strength of shelf and similar components • Thermal insulation tests • Pressure test • High voltage test • Insulation resistance test • Performance test at no load • Performance test at load	• High voltage / Electric strength test • Leakage current test • Insulation resistance test • Thermostat tests	• If agreed between purchaser and manufacturer, production routine test shall be repeated at manufacturer works

IS 7872: Performance Requirements

The following performance requirements are specified in IS 7872 –

- No load test
- Pull down time
- Power consumption and percentage running time
- Energy consumption test

Comparison of IS and IEC standards

Table 14 summarizes the key differences between Indian and International test standards for deep freezers.

Table 14: Comparison of test standards

Country:	**EU**	**China**	**India**
Standard:	**EN (Reference from IEC 62552:2015)**	**GB 12021.2 (Reference from IEC 62552:2015)**	**IS 7872**
Ambient for class N, ST, T for 24 hrs. energy consumption	Test conducted at 16 and 32 ± 0.5 °C and value interpolated at 25 Deg.C	Test conducted at 16 and 32 ± 0.5 °C and value interpolated at 25 Deg.C	38 ± 1°C
Anti-Condensation heater	Off	Off	Not specified
Freezer Compartment Temperature	-18°C	-18°C	-18°C
Energy consumed during defrost cycle	Covered	Not Covered	Not specified
How to calculate 24-hour energy consumption at required temp.	Test to measure energy consumption at two temperatures (one higher and other lower) and interpolate	Test to measure energy consumption at two temperatures (one higher and other lower) and interpolate	Energy consumption at one target temperature
Tolerance limit for energy consumption test	If higher than 15% of claim, test 3 more. Mean value needs to be ≤ 10% higher than rated value to pass.	Within 10% of claim	Within 10% of claim. If higher than 10% of claim, test 3 more. Mean value has to be ≤ 10% higher than rated value to pass.

Freezer compartment loading	As many packages as possible till the freezer limit	For V<50 as many as possible, For 50<V≤ 100 : 40 kg/100 L For V>100 : 25 kg/100 L	Test conducted at no load conditions
Measurement of Storage Temperature	Measuring probe within copper mass of 25 g of diameter and height 18 mm long	Measuring probe within copper mass of 25 g of diameter and height 18 mm long	Measuring probe within copper mass 25 g and of min. diameter and height of 15.2 mm long
Target temperature	Average temp. of all M - packages should be -18 Deg.C	Average temp. of all M - packages should be -18 Deg.C	Average temp. inside the compartment should be -18 Deg.C

Testing facilities / Infrastructure in India

As per our interactions with manufacturers, majority of the deep freezers in India are tested as per the internal standards of manufacturers in the manufacturers owned test labs. Currently no manufacturer / OEM has NABL accreditation for testing as per IS 7872 standards, although most of manufacturers have NABL accreditation for refrigerator standards which require similar lab infrastructure for carrying out performance testing of deep freezers.

There are third party labs such as **CPRI, Intertek, United laboratories (UL) etc.** which have NABL accreditation for conducting performance testing of similar products (such as refrigerators). These labs were contacted during the project, but they also lack NABL accreditation for IS 7872 although some labs have accreditation as per IEC standards for deep freezers. As reported by the labs the NABL accreditation process for IS 7872 takes 3- 4 months.

Key Findings

- There is a national standard IS 7872 for chest and upright type deep freezers. The standard specifies constructional and performance requirements of front access and top access type freezers.
- Since a significant market share of the deep freezers is imported from China, most of the products comply with GB 12021.2 standards. Reference for GB 12021.2 has been taken from IEC 62552. IEC 62552 specifies the testing requirements, methods for determination of volume, energy consumption characteristics and defines how these can be assembled to estimate energy consumption under different usage and climate conditions.
- Most of the manufacturers that have local manufacturing facilities test their products internally in non-accredited facilities.
- The ambient temperature condition for 24-hour energy consumption test is 38 Deg.C, this as per most of the OEM's is very stringent. Secondly, the M package temperature requirement (warmest package should be -18 Deg.C) is also difficult to achieve in case of glass top freezers. OEM's have requested BEE to revisit both these values.

This section discusses the methodology adopted for proposing the star rating bands for chest freezers (hard top and glass top). Upright freezers are therefore suggested to not be included in the labeling program as its market share is only 1% (or less) as mentioned in section 2.

A detailed review and discussion of the labeling scheme for deep freezers of all the countries (refer section 3) provides a strong basis for the recommendation for the approach for the labeling program in India which is based on the relationship between energy consumption and capacity.

The following information was requested for all models of the chest freezers from all the manufacturers:

- Energy consumption data
- Net / storage volume and gross volume data

The data for 62 models of chest freezer was received from most manufacturers, to which linear regression analysis was applied to derive the relationship between energy consumption and net volume / storage volume (V). The linear regression equations arrived at from the analysis are as follows -

- *No load 24 hr. energy consumption = 0.010*V+ 0.289 – (Hard top chest freezer)*
- *No load 24 hr. energy consumption = 0.018*V + 1.167 – (Glass top chest freezer)*

These regression models for hard top and glass top chest freezers have a correlation factor (R-square) of 72% and 77% respectively, implying a very good fitness of the regression model. These regression equations were then converted into Annual Energy Consumption (AEC) by multiplying both the regression equations with a constant value of 365.

- *Annual Energy Consumption (AEC) = 3.52*V+ 105.54 – (Hard top chest freezer)*
- *Annual Energy Consumption (AEC) = 6.40*V + 425.97 – (Glass top chest freezer)*

The resulting equation for determining the star rating band of any chest freezer model is as follows -

- *Star Rating Band (SRB) = K_{dc} * V+ C_{dc}*

Where -

K_{dc} = Constant Multiplier (kWh/Litre/Year),

V = Net / Storage Volume (Litre),

C_{dc} = Constant Fixed Allowance (kWh/Year)

Figure 14: Scatter plot for glass top deep freezers

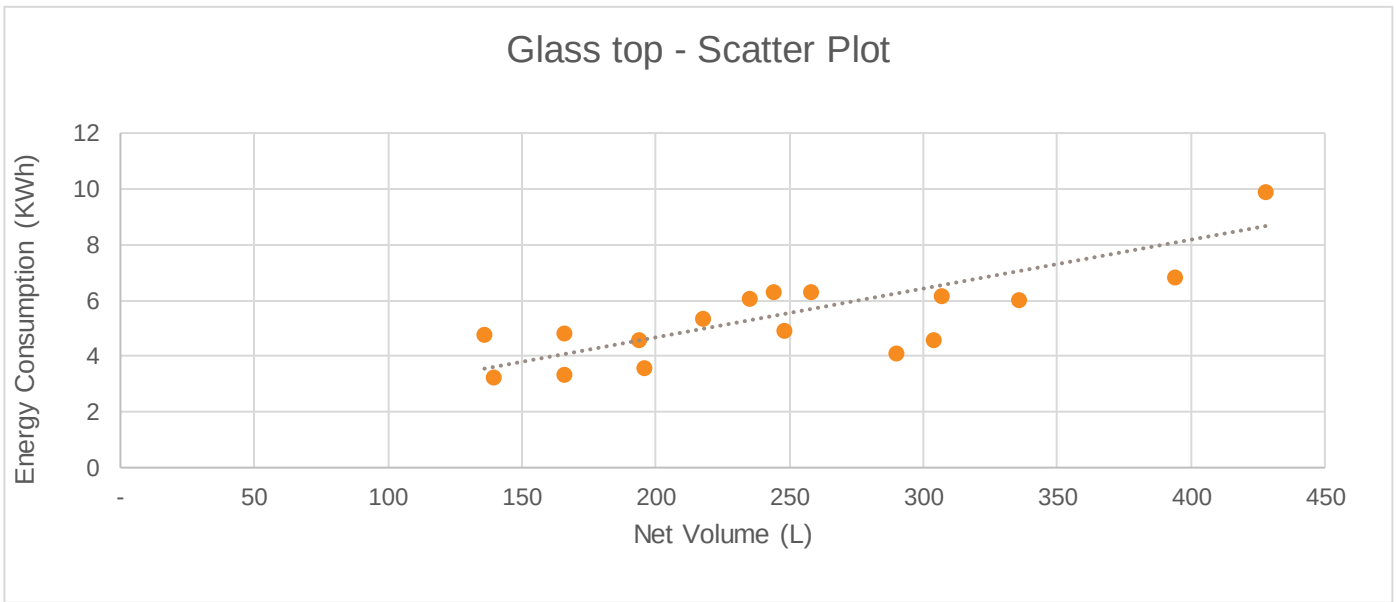
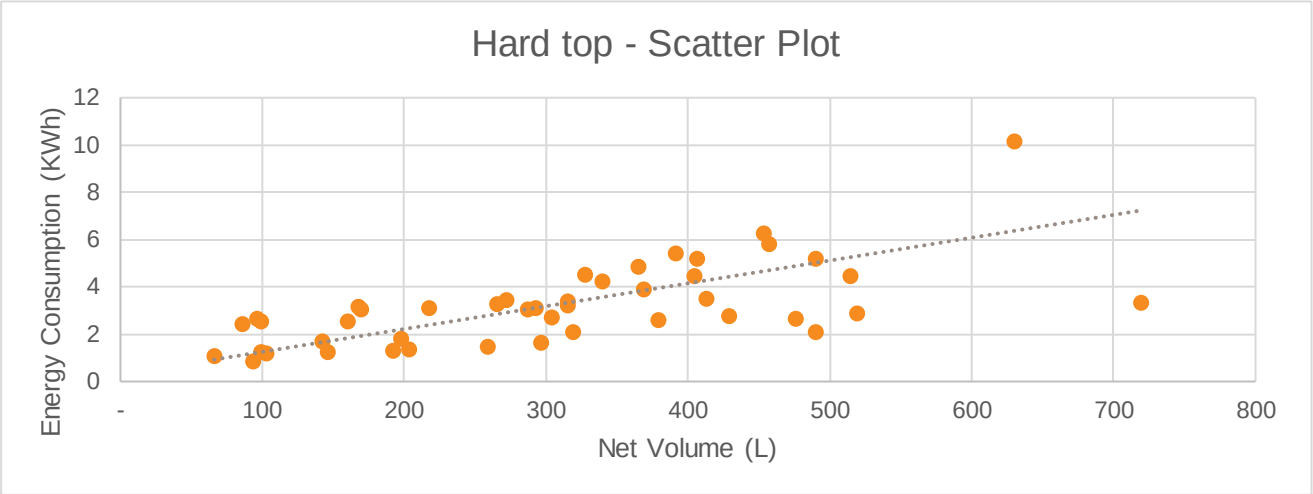


Figure 15: Scatter plot for hard top deep freezers



The analysis points to a significant difference of 2.5- 3 times in energy consumption between hard top and glass top models of the same capacity. It was therefore recommended to define separate star rating band for hard top and glass top models.

The annualized base regression equations are kept at upper end of 3-star band. K_{dc} and C_{dc} values have been suggested at 20% higher and lower to derive equations for subsequent star rating bands as depicted in Table 15.

Table 15: Star Rating Band for hard top and glass top chest freezers

	Hard Top type Chest Freezers	**Glass Top type Chest Freezers**
Star rating	**Annual Energy Consumption in kWh/year at 38 ºC**	**Annual Energy Consumption in kWh/year at 38 ºC**
1 Star *	4.23*V + 126.65 ≤ AEC < 5.07*V + 151.98	7.68*V + 511.17 ≤ AEC < 9.21*V + 613.40
2 Star * *	3.52*V+ 105.54 ≤ AEC < 4.23*V + 126.65	6.40*V+ 425.97 ≤ AEC < 7.68*V + 511.17
3 Star * * *	2.82*V + 84.43 ≤ AEC < 3.52*V+ 105.54	5.12*V + 340.78 ≤ AEC < 6.40*V+ 425
4 Star * * * *	2.25*V + 67.55 ≤ AEC < 2.82*V + 84.43	4.09*V + 272.62 ≤ AEC < 5.12*V + 340.78
5 Star * * * * *	AEC < 2.25*V + 67.55	AEC < 4.09*V + 272.62

05 Estimation of energy saving and GHG reduction

This section projects the energy and GHG savings from the proposed labeling program, based on the following assumptions–

Table 16: Assumptions for baseline scenario

Baseline Scenario 2019				
	Average energy consumption (KWh/yr.)	**Market share (%age)**	**Sales figure for all segments**	**Year over year growth till 2030 for all segments**
< 200 L	480	22	6 lakhs	15%
200L – 300L	591	31		
300L – 500L	767	35		
> 500 L	1059	12		

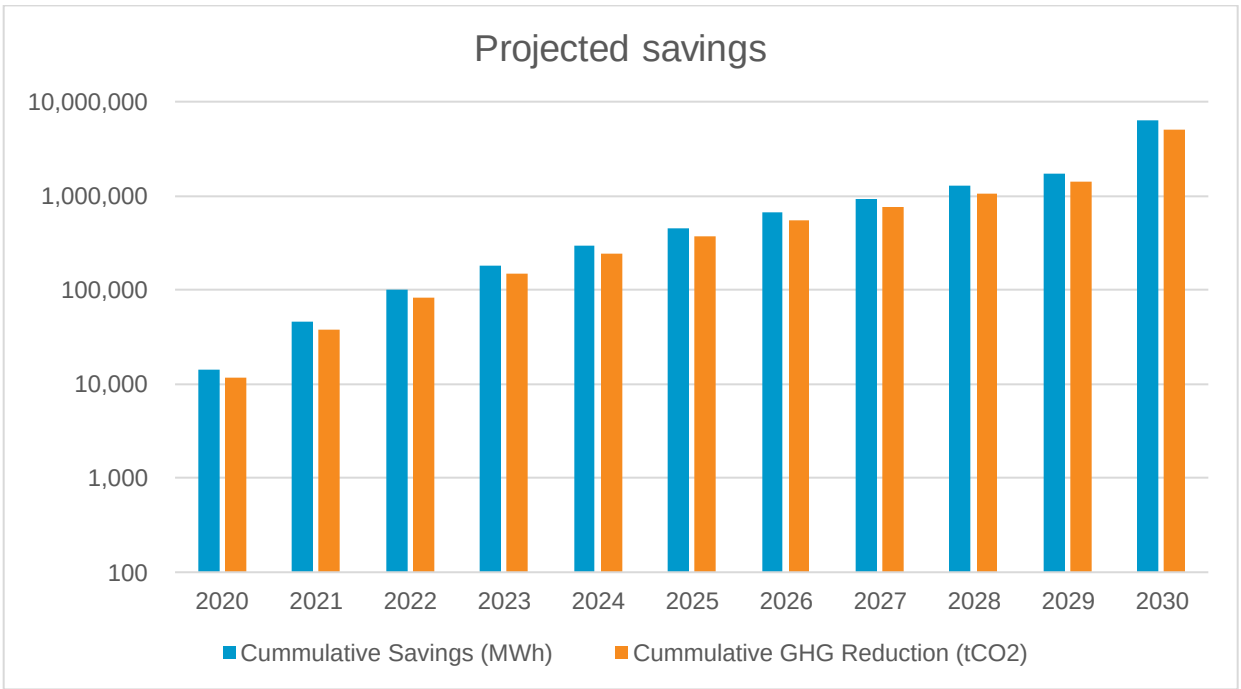
- *The market share for each segment has been considered same as baseline scenario for the subsequent years till 2030*

Table 17: Estimated Electricity and CO_2 savings from the proposed policy

	In 2030		By 2030	
Savings	Electricity Savings (TWh)	CO_2 savings (MT CO_2)	Electricity Savings (TWh)	CO_2 savings (MT CO_2)
	0.14	0.11	6.2	5.3

The cumulative savings as a result of the proposed chest freezer labeling program is estimated to be 6.2 TWh and 5 $MtCO_2$ by 2030

Figure 16: Savings projections for the chest freezer labeling program



A.1. Annexure

General Details

Deep freezer manufacturer details

Name of Manufacturer	Manufacturing facility address (in case of multiple facilities enter address in the next row)	Manufacturing facility capacity (of each facility in case of multiple)	Name of concerned representative for deep freezer	Designation of the representative	Contact Number of the representative	Email_Id of representative

Estimate of market size for deep freezers (cumulative for all manufacturers)

S. No.	Freezer type	FY 14-15	FY 15-16	FY 16-17	FY 17-18
1	Market size for Top Access (Quantity in nos.)				
2	Market size for Front Access (Quantity in nos.)				

Manufacturer market / sales data

Manufacturer market size (in nos.) basis volume

S. No.	Freezer type	Volume Segment (Gross Volume in litres)	FY 14-15	FY 15-16	FY 16-17	FY 17-18
1	Top Access (Quantity in nos.)	Less than or equal to 200L				
		More than 200L but less than 300L				
		More than 300L but less than 500L				
		More than or equal to 500L				
2	Front Access (Quantity in nos.)	Less than or equal to 200L				
		More than 200L but less than 300L				
		More than 300L but less than 500L				
		More than or equal to 500L				

Manufacturer market size (in nos.) basis volume

S. No.	Freezer type	Volume Segment (Gross Volume in litres)	FY 14-15	FY 15-16	FY 16-17	FY 17-18
1	Top Access (Quantity in nos.)	Less than or equal to 200L				
		More than 200L but less than 300L				
		More than 300L but less than 500L				

		More than or equal to 500L
2	Front Access (Quantity in nos.)	Less than or equal to 200L
		More than 200L but less than 300L
		More than 300L but less than 500L
		More than or equal to 500L

Manufacturer Export quantity (in nos.) basis volume

S. No.	Freezer type	Volume Segment (Gross Volume in Litres)	Major countries of Export	FY 14-15	FY 15-16	FY 16-17	FY 17-18
1	Top Access (Quantity in nos.)	Less than or equal to 200L					
		More than 200L but less than 300L					
		More than 300L but less than 500L					
		More than or equal to 500L					
2	Front Access (Quantity in nos.)	Less than or equal to 200L					
		More than 200L but less than 300L					
		More than 300L but less than 500L					
		More than or equal to 500L					

Manufacturer supply chain details

Deep freezer component sourcing

S. No.	Component	Please select procurement source from drop down
1	Compressor	Procured from local vendor
2	Evaporator Coil	Procured from local vendor
3	Condenser coil	Manufactured in house
4	Thermostat	Manufactured in house
5	Condenser / Evaporator fans	Procured from local vendor
6	Expansion Valve	Procured from local vendor
7	PUF Panel	Procured from local vendor
8	Insulation expanding chemical	Procured from local vendor
9	Door liner/ seal	Manufactured in house
10	Relays	Procured from local vendor

Laboratory and test standard details

Test standard details

Test standards category	IS No.	ISO No.	IEC No.	others
Please mention standard numbers				

Type of tests conducted

	Type tests	Acceptance tests	Routine tests	Tests as per International standards, if applicable
Please choose type test from drop down	In house laboratory	In house laboratory	In house laboratory	
Please choose type test from drop down	Other labs in India	Other labs in India	Abroad	
Please choose type test from drop down	Abroad	Abroad	Abroad	

Laboratory details

Name of the Lab
Location / address of the Lab
Capacity (Units / month)
Accreditation