European Commission DG ENTR

Preparatory Study for Eco-design Requirements of EuPs
[Contract N° S12.515749]

Lot 1

Refrigerating and freezing equipment:

Service cabinets, blast cabinets, walk-in cold rooms, industrial process chillers, water dispensers, ice-makers, dessert and beverage machines, minibars, wine storage appliances and packaged condensing units

Task 1: Product definition

Final Report

May 2011

Bio Intelligence Service - Scaling sustainable development
Industrial Ecology - Nutritional Health

Bio Intelligence Service S.A.S - bio@biois.com
20-22 Villa Deshayes - 75014 Paris - France
Tél. +33 (0)1 53 90 11 80 - Fax. +33 (0)1 56 53 99 90

Contact BIO Intelligence Service S.A.S.
Shailendra Mudgal – Jonathan Bain
☎ +33 (0)1 53 90 11 80
shailendra.mudgal@biois.com
jonathan.bain@biois.com

Project Team

BIO Intelligence Service

Mr. Shailendra Mudgal

Mr. Benoît Tinetti

Mr. Jonathan Bain

Mr. Raul Cervantes

Mr. Alvaro de Prado Trigo

Disclaimer:

The project team does not accept any liability for any direct or indirect damage resulting from the use of this report or its content.

This report contains the results of research by the authors and is not to be perceived as the opinion of the European Commission. The European Commission is not responsible for any use that may be made of the information contained therein.

Contents

1. Task 1: Definition ....

1.1. Introduction 11

1.1.1. Refrigeration market diversity 12

1.1.2. Institutional and other actors for standards and legislation 12

1.1.2.1 EU level 13

1.1.2.2 MS level 14

1.1.2.3 Third country standards organisations 15

1.1.2.4 Other actors 16

1.1.3. Basic concepts of refrigeration 16

1.1.3.1 Cooling (or refrigeration) load 17

1.1.3.2 Vapour-compression cycle 18

1.1.3.3 Absorption cycle 18

1.1.3.4 Total energy consumption (TEC) 19

1.1.3.5 Refrigerants 19

1.1.3.6 Refrigeration systems 20

1.1.3.7 Efficiency measurement 20

1.1.3.8 Insulation properties 21

1.2. Product definitions 22

1.2.1. Service cabinets 22

1.2.1.1 General product definition 22

1.2.1.2 Existing product definitions 22

1.2.1.3 Product description 24

1.2.1.4 Functional unit and performance parameter 25

1.2.1.5 Service cabinet classification and scope for the study 26

1.2.2. Blast cabinets 28

1.2.2.1 General product definition 28

1.2.2.2 Existing product definitions 28

1.2.2.3 Product description 28

1.2.2.4 Functional unit and performance parameter 30

1.2.2.5 Blast cabinets' classification and scope for the study 31

1.2.3. Walk-in cold rooms 33

1.2.3.1 General product definition 33

1.2.3.2 Existing product definitions 33

1.2.3.3 Product description 34

1.2.3.4 Functional unit and performance parameter 36

1.2.3.5 Walk-in cold rooms' classification and scope for the study 36
1.2.4. Process chillers 40
1.2.4.1 General product definition 40
1.2.4.2 Existing product definitions 40
1.2.4.3 Product description 42
1.2.4.4 Functional unit and performance parameter 47
1.2.4.5 Chiller classification and scope for the study 48
1.2.5. Remote condensing units 52
1.2.5.1 General product definition 52
1.2.5.2 Existing product definitions 53
1.2.5.3 Product description 53
1.2.5.4 Functional unit and performance parameter 55
1.2.5.5 Remote condensing units classification and scope for the study 55
1.2.6. Prodcom definitions 58
1.3. Product test standards, their development and other standards 60
1.3.1. Service cabinets 60
1.3.1.1 EN ISO 23953:2005 (under revision) 61
1.3.1.2 EN 441:1995 63
1.3.1.3 DE DIN 18872 (draft standards in progress) 66
1.3.1.4 ANSI/AHRI 1200-2008 (US) 66
1.3.1.5 US ASHRAE Standard 72-2005 70
1.3.1.6 CAN/CSA-C827-98 (R2008) 70
1.3.1.7 Comparison of volume measurement methods 71
1.3.1.8 Testing and protocols 72
1.3.2. Blast cabinets 75
1.3.2.1 EN 328:1999 75
1.3.2.2 EN 327:2000 75
1.3.2.3 DE DIN 8953/8954 75
1.3.3. Walk-in cold rooms 75
1.3.3.1 Introduction 75
1.3.3.2 European Technical Approval Guideline (ETAG) 021 and 016 76
1.3.3.3 EN 14509:2006 80
1.3.3.4 EN 13164:2009-02 and EN 13165:2009-02 80
1.3.3.5 EN 12664:2001, EN 12667:2001 and EN 12939:2001 81
1.3.3.6 ISO 12567-1:2010 81
1.3.3.7 EN ISO 6946:2007 82
1.3.3.8 EN 12114:2000 82

1.3.3.9 BS EN 4376-1:1991 ... 83
1.3.3.10 Agreement on the international carriage of perishable foodstuffs (ATP) ... 83
1.3.3.11 PAS 57:2003 ... 84
1.3.3.12 AHRI 1251 (SI) (and AHRI 1250 (I-P)) ... 86
1.3.3.13 US test procedures for walk-in coolers and freezers ... 87
1.3.3.14 US DOE proposed test procedures for walk-in coolers and freezers ... 87
1.3.4. Process chillers ... 94
1.3.4.1 EN 14511:2007 ... 94
1.3.4.2 EN 15218:2006 ... 95
1.3.4.3 prEN 14825 ... 95
1.3.4.4 AHRI 550/590-2003 ... 96
1.3.4.5 ANSI/AHRI 560-2000 ... 99
1.3.4.6 CAN/CSA-C743-09 ... 102
1.3.4.7 AS/NZS 4776: 2008 ... 103
1.3.5. Remote condensing units ... 103
1.3.5.1 EN 13771:2003/ EN 13771:2007 ... 103
1.3.5.2 EN 13215:2000 ... 103
1.3.5.3 ASHRAE Standard 23-2005 ... 104
1.3.5.4 ISO/R 916:1968 ... 104
1.3.6. Standards related to the design, use and safety of products ... 105
1.3.6.1 EU EN 631-1:1993 – Gastronorm ... 105
1.3.6.2 EN 1672:1997 Food processing machinery hygiene requirements ... 105
1.3.6.3 EN ISO 14159:2002 ... 105
1.3.6.4 EN 60335-2-24:2010 ... 106
1.3.6.5 EN 12464-1:2004 ... 107
1.3.6.6 FR NF AC D40-003:2006 ... 107
1.3.6.7 DE VDMA 11499 Operation and use of refrigerated display cabinets ... 109
1.3.6.8 DE VDMA 24247 Energy efficiency of refrigerating systems ... 109
1.3.6.9 US NSF/ANSI 7:2009 ... 109
1.3.7. Standards affecting the use of refrigerants ... 110
1.3.7.1 EU EN 378:2009 ... 110
1.3.7.2 DE VDMA 24020 Operational requirements for refrigerating systems ... 111
1.3.7.3 US ASHRAE Standard 34-2008 ... 111
1.3.8. Summary of existing standards ... 111
1.3.8.1 Service cabinets ... 112
1.3.8.2 Blast cabinets ... 112
1.3.8.3 Walk-in cold rooms ... 113

1.3.8.4 Process chillers ...114

1.3.8.5 Remote condensing units ...114

1.4. Existing legislation and voluntary agreements ...115

1.4.1. Service cabinets ...116

1.4.1.1 UK ECA incentive scheme for plug-in commercial service cabinets ...116

1.4.1.2 US DOE MEPS ...117

1.4.1.3 US CEC MEPS ...118

1.4.1.4 Canada CAN/CSA-C827-98 Energy performance standard for food service refrigerators and freezers 119

1.4.1.5 Australia/New Zealand refrigerated display cabinets MEPS ...120

1.4.1.6 US Energy Star voluntary programme for commercial solid door refrigerators and freezers 121

1.4.1.7 US CEE Commercial Kitchens Initiative ...122

1.4.1.8 US AHRI certification programme for commercial refrigerated display merchandisers and storage cabinets ...122

1.4.2. Blast cabinets ...123

1.4.2.1 FR commercial food preparation hygiene requirements law of 29/09/1997 ...123

1.4.2.2 UK Department of Health Guidelines ...123

1.4.2.3 Austrian Hygiene Certificate Guideline ...123

1.4.3. Walk-in cold rooms ...123

1.4.3.1 US minimum requirements for walk-in cold rooms and walk-in freezers ...123

1.4.3.2 UK ECA incentive scheme for cellar cooling equipment ...125

1.4.3.3 PQS Quality Assurance protocol E01/CR/FR-VP2 ...127

1.4.3.4 ATP agreement on the international carriage ...128

1.4.4. Process chillers ...131

1.4.4.1 EU EUROVENT certification programme for liquid chilling packages ...131

1.4.4.2 UK ECA incentive scheme for packaged chillers (only for High temperature- Air conditioning)134

1.4.4.3 US ASHRAE 90.1-2007 ...136

1.4.4.4 CAN CSA-C743-09 performance standard for packaged water chillers ...136

1.4.4.5 Australia/New Zealand water chillers MEPS ...137

1.4.5. Remote condensing units ...138

1.4.5.1 UK ECA incentive scheme for air-cooled condensing units ...138

1.4.6. EU environmental legislations ...140

1.4.6.1 European Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE)..140

1.4.6.2 European Directive 2002/95/EC on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS) ...140

1.4.7. Legislation related to refrigerant fluids ...141

1.4.7.1 European Regulation N°2037/2000 on Ozone Depleting Substances (ODS) ...141

1.4.7.2 European Regulation N° 842/2006 on certain fluorinated greenhouse gases.................. 142
1.4.7.3 DK statutory order 552.. 143
1.4.7.4 Austria Ordinance No 447/2002 143
1.4.7.5 Norway - Tax and refund scheme for imported HFCs 143
1.4.8. Energy-efficiency and use legislation 144
1.4.8.1 EuP TREN Lot 13 – Legislation related to household refrigerating appliances 144
1.4.8.2 EuP TREN Lot 11 – Electric motors 145
1.4.8.3 Legislation related to the lighting system 147
1.4.8.4 Legislations related to tertiary and domestic lighting.. 147
1.4.8.5 European Directive on Electromagnetic Compatibility (ECM) 2004/108/EC 147
1.4.8.6 European Directive on construction products 89/106/EEC 147
1.4.9. Health and safety legislation 148
1.4.9.1 European Directive 95/16/EC on Machinery, amended by 2006/42/EC 148
1.4.9.2 European Directive 2001/95/EC on General Product Safety 149
1.4.9.3 European Directive 73/23/EEC on Low Voltage Equipments (LVD) 149
1.4.9.4 Pressure Equipment Directive (PED) 1997/23/EC.. 149
1.4.9.5 European Directive 98/83/EC on quality of water 149
1.4.9.6 Hazard Analysis Critical Control Point (HACCP).. 150
1.4.9.7 Summary of temperature and time constraints for cooked foodstuff 150
1.4.10. Other voluntary agreements 150
1.4.10.1 EUROVENT certification programmes for refrigeration components.............................. 150
1.4.10.2 ASERCOM certification of refrigerant compressors 150
1.4.10.3 DK demanufacture of refrigeration equipment 150
1.4.11. Summary of existing legislation and voluntary measures... 151
1.4.11.1 Service cabinets.. 151
1.4.11.2 Blast cabinets 154
1.4.11.3 Walk-in cold rooms 154
1.4.11.4 Process chillers... 155
1.4.11.5 Remote condensing units.. 155
1.5. Conclusions for Task 1 157
ANNEXES 158
Annex 1-1: Additional standards related to refrigeration and freezing equipment ....
1.6. EN 153:2006 160
1.7. EN ISO 15502:2005 (corrigendum 1:2007) 161
1.8. EN 28960:1993 (ISO 8960:1991).. 164
1.9. ANSI/ARI 420-2008 164
1.10. ANSI/ARI 530-2005 165

1.11. ANSI/ARI 520-2004 165
1.12. ANSI/ARI 540-2004 165
1.13. ISO 5149:1993........ 168
1.14. ATP agreement 169
1.14.1. Introduction 169
1.14.2. Definitions 169
1.14.3. Requirements........ 169
1.14.4. Test methods and procedures (Annex 1, Appendix 2 of the agreement) 171
1.14.4.1 Definitions and general principles (Section 1)........ 171
1.14.4.2 Insulating capacity of equipment (Section 2)........ 171
1.14.4.3 Effectiveness of thermal appliances [*applications*] of the equipment (Section 3)........ 172
1.14.4.4 Procedure for measuring the effective refrigerating capacity of unit when evaporator is free from frost (Section 4)........ 172
1.14.4.5 Checking the insulating capacity of equipment in service (Section 5) 173
1.14.4.6 Verifying the effectiveness of thermal appliances of equipment in service (Section 6) 174
1.14.5. Compliance and enforcement........ 175
1.15. Other related standards 177
Annex 1-2: Summary of data for selection of the Base Cases ....
Annex 1-3: Summary of data for minibars........
Annex 1-4: Summary of data for wine storage appliances ....
Annex 1-5: Summary of data for dessert and beverage machines ....
1.15.1.1 General product definition........ 188
1.15.1.2 Existing product definitions........ 188
1.15.1.3 Product description 188
1.15.1.4 Functional unit and performance parameter........ 188
1.15.1.5 Dessert and beverage machine classification and preliminary scope for the study 189
Annex 1-6: Summary of data for water dispensers ....
1.15.1.6 General product definition........ 190
1.15.1.7 Existing product definitions........ 190
1.15.1.8 Product description 190
1.15.1.9 Functional unit and performance parameter........ 191
1.15.1.10 Water dispenser classification and water dispensers included in the scope 191
Annex 1-7: Summary of data for ice-makers ....
1.15.1.11 General product definition........ 194
1.15.1.12 Existing product definitions........ 194
1.15.1.13 Product description 194

1.15.1.14 Functional unit and performance parameter 196

1.15.1.15 Ice-maker classification and ice makers in the scope of the study 196

Annex 1-8: Other information 2

Glossary.. 2

1. Task 1: Definition

1.1. INTRODUCTION

Task 1 provides a technical description of all products, including the suggested functional unit, and preliminary data on energy consumption.

The product definitions are based in particular on definitions available from external sources (e.g. EU trade statistics, existing standards and regulations, voluntary initiatives, the industry, and dictionaries). Key technical parameters impacting the environmental performance of the product are identified as a basis for further analysis in the next steps of the study. Harmonised test standards and additional sector-specific procedures for product-testing are identified and discussed. Finally, Task 1 presents any relevant legislation, voluntary agreements, and labelling initiatives at EU level, in Member States, and in third countries.

The Ecodesign Directive (2005/32/EC) is expected to improve the environmental performance of major refrigerating and freezing equipment in the EU through ecodesign. In this context, a first preparatory study (TREN Lot 12[1]) was conducted during 2006-07, focussing on refrigerated display cabinets (both remote and plug-in), beverage coolers, ice-cream freezers, and cold vending machines. Commercial refrigeration equipment and additional industrial refrigeration equipment, not covered by TREN Lot 12 will be covered by this study, namely:

- service cabinets;
- blast cabinets;
- walk-in cold rooms;
- process chillers;
- water dispensers;
- ice-makers;
- dessert and beverage machines;
- minibars;
- wine storage appliances; and
- remote condensing units.

This study aims at proposing solutions to improve the energy performance of these product categories and reduce their environmental impacts during their life-cycle.

As in all Ecodesign preparatory studies, a common and coherent methodology[2] is used to analyse the environmental impact and improvement potential of the products, and ecodesign options are analysed from a life cycle cost perspective. This methodology consists of seven main tasks, conducted in an iterative manner to allow integration of new information throughout the project.

[1] BIO Intelligence Service, *Ecodesign Preparatory Study TREN Lot 12, Final Report*, European Commission (DG TREN), 2007. Available at: www.ecofreezercom.org/documents_1.php

[2] VHK, *Methodology for Ecodesign of Energy-using Products (MEEuP), Final Report*, European Commission (DG ENTR), 2005. Available at: ec.europa.eu/enterprise/eco_design/finalreport1.pdf

At an interim stage of the project, a matrix of data was developed to prioritise product groups from the list described above. This information was drawn from the literature and stakeholder input, and was distributed to stakeholders for comment. The matrix is described in annex 1-2, and the following product groups were selected in light of their significant potential for improvement through ecodesign and subsequent reduction of environmental impacts across the EU. These product groups were:

- service cabinets;
- blast cabinets;
- walk-in cold rooms;
- process chillers; and
- packaged remote condensing units.

The information relating to the remaining product groups is summarised in annexes 1-3 to 1-7.

1.1.1. Refrigeration market diversity

Refrigeration products covered in ENTR Lot 1 span a large range of applications and the products are used in diverse environments such as supermarkets, restaurants, hotels, pubs, cafés and industrial facilities. These products are estimated to consume a significant proportion of electricity in the EU (as an example, in the UK this is around 3% of total energy consumption and 1% of total greenhouse gas emissions[3]). Moreover, they may cause other negative environmental impacts during their life-cycle due to their material content, such as refrigerants and insulating agents.

When designing such appliances to reduce the impacts related to climate change and global warming, manufacturers usually focus on the energy requirement of the appliance and on the choice of the refrigerant (e.g. HFCs, which are being replaced by alternatives). Many such initiatives for a more environmentally-friendly design may derive from various sources, such as national and international regulations, financial incentives and manufacturers' commitment towards the environment. The end-user, although conscious of the energy performance of these products (as they directly affect their electricity bills), is not always influenced by environmental performance during their purchase decision.

1.1.2. Institutional and other actors for standards and legislation

Standards, legislation (such as Minimum Energy Performance Standards, MEPS) and voluntary agreements related to the products covered by ENTR Lot 1 and discussed in Task 1 have been developed at EU level, in individual MS, and in several third countries.

[3] Refrigeration Road Map. An action plan for the retail sector. Carbon Trust, 2010

1.1.2.1 EU level

The approach defined in the European Council (EC) Resolution of May 1985, introduced, among other things, a clear separation of responsibilities between the EC legislator and the European Standards Bodies (CEN[4]/CENELEC[5]) in the legal framework allowing for the free movement of goods[6]:

- EC Directives define the "essential requirements", e.g., protection of health and safety, which goods must meet when they are placed on the market.
- The European standardisation bodies have the task of drawing up the corresponding technical specifications meeting the essential requirements of the directives; compliance with the standard will provide a presumption of conformity with requirements of the directive. Such specifications are referred to as "harmonised standards".

◆ **European standards**

European standards, denoted by prefix "EN", are adopted by CEN, CENELEC or ETSI and imply an obligation to implement an identical national standard and to withdraw any conflicting national standards[7]. Such standards may also be issued by an international standardisation organisation such as the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC) and are recognised at both the international and EU levels (this includes international standards that have been adopted by European Standards Bodies, for example, "EN ISO" or "EN IEC" standards).

CEN/CENELEC internal regulations define a standard as a document, established by consensus and approved by a recognised body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context. Standards should be based on consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits.

◆ **European Organisation for Technical Approvals (EOTA)**

The European Organisation of Technical Approvals (EOTA), which groups together the national approvals bodies, can draw up technical approvals guidelines in respect of a construction product or family of construction products, acting on a mandate from the Commission and after consulting the Standing Committee on Construction[8], in the context of Directive 89/106/EEC on construction products (§1.4.8.6). European technical approvals are used to assess the suitability of a product for its intended use in cases where there is no harmonised standard, no recognised national standard and no mandate for a European standard and where the Commission feels, after consulting the Member States within the Standing Committee on Construction, that a standard cannot or cannot yet be prepared.

---

[4] European Committee for Standardisation: www.cen.eu
[5] European Committee for Electrotechnical Standardisation: www.cenelec.eu
[6] European Commission website: ec.europa.eu/comm/enterprise/newapproach/standardization/harmstds/index_en.html
[7] European Committee for Standardisation: www.cenorm.be/cenorm/index.htm
[8] ec.europa.eu/enterprise/sectors/construction/documents/legislation/cpd/index_en.htm

◆ **European Federation of Catering Equipment Manufacturers (EFCEM)**

EFCEM represents manufacturers of commercial kitchen equipment and includes the key European national associations in its membership. The federation is active in the formulation of standards for the industry and through its meetings seeks to identify and act on issues of common interest.

◆ **EUROVENT certification programme (EUROVENT)**

The EUROVENT programme is a voluntary minimum performance and labelling scheme which includes components, and products similar to the products within the scope of ENTR Lot 1.

◆ **Association of European Refrigeration Compressor and Control Manufacturers (ASERCOM)**

ASERCOM has established a certification scheme for the performance of refrigeration compressors which aims at helping buyers to select their products based on performance criteria.

1.1.2.2 MS level

Several EU Member States have also developed relevant standards and legislation which are used internationally, such as France (FR), Germany (DE), Denmark (DK) and the UK.

◆ **Normes Française (FR NF)**

In France, the national standards body, NF, develops various standards, including those related to refrigeration and freezing equipment.

◆ **Verband Deutscher Maschinen- und Anlagenbau (DE VDMA)**

The German Engineering Federation, VDMA, is one of the key service provider associations in Europe and offers the largest engineering industry network in Europe. It is involved in the development of standards relating to refrigeration and freezing equipment and systems.

◆ **Enhanced Capital Allowance Scheme[9] (UK ECA)**

The UK ECA scheme was designed to encourage businesses to invest in energy saving equipment allowing business to claim 100% first year capital allowance in such investments[10]. Enhanced Capital Allowances (ECAs) can only be claimed on energy-saving products listed in the Energy Technology List (ETL) that meet the relevant criteria for their particular technology group. Energy using appliances under this program include packaged chillers and commercial service cabinets (plug-in only).

The ETL is divided into two parts:

- the Energy Technology Criteria List which contains details of the energy-saving criteria that must be met for each of the technology classes; and
- the Energy Technology Product List which contains a list of products that have been certified as meeting those standards.

[9] ECA website: www.eca.gov.uk
[10] ECA website: www.eca.gov.uk/etl/about/What+equipment+is+eligible.htm

- **Market Transformation Programme[11] (UK MTP)**

The UK's MTP was launched following a consultation paper[12] issued by the Environment & Business Division, in October 1997 and supports the development and implementation of UK Government policy on sustainable products.

Domestic or commercial appliances including commercial refrigeration (liquid chillers, service cabinets, cold rooms, cellar cooling equipment, ice-making machines, refrigerated display cases, and refrigerated vending machines).

Please see annex 1-8 for more information on this programme.

1.1.2.3 Third country standards organisations

In the USA, several organisations are involved in the development of standards which are relevant to Lot 1.

- **Air-Conditioning, Heating, and Refrigeration Institute (AHRI)**

The AHRI is the trade association representing manufacturers of air conditioning, heating, and commercial refrigeration equipment. It also develops industry standards and voluntary certification programs (AHRI performance certification programs) for refrigeration equipment. The ARI standards mainly aim at measuring the energy performance of the refrigeration appliances and of their components.

- **American National Standards Institute (ANSI)**

The ANSI is the American National Standards Institute that oversees the creation, promulgation and use of norms and guidelines as well as accrediting programs that assess conformance to standards. The ANSI standards mainly aim at enhancing "the global competitiveness of U.S. business and the American quality of life"[13].

- **American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE)**

This association develops standards for refrigeration appliances, heating appliances, ventilation and air conditioning. They are also in charge of promoting sustainability through research, publications and education.

- **US Department of Energy (US DOE)**

The US Energy Policy Act of 2005 prescribes new and amended energy conservation standards and test procedures that apply to commercial refrigeration equipment. The US Energy Independence and Security Act of 2007, enacted on 19 December 2007, establishes energy conservation standards for certain consumer products and commercial and industrial equipment, including walk-in cold rooms and walk-in freezers.

Final responsibility for the appliance of energy standards in policy measures resides with the US DOE.

- **California Energy Commission (US CEC)**

---

[11] MTP website: www.mtprog.com

[12] Department of the Environment, Transport and the Regions.*Energy Efficient Consumer Products: A 'Market Transformation' Strategy for More Sustainable Consumption*, 1997

[13] Website: www.ansi.org/standards_activities/overview/overview.aspx

The US CEC adopted the California Appliance Efficiency Regulation, which became effective 29th December2007. It was reviewed in 2009 and the document CEC-400-2009-013 was produced.

The California Appliance Efficiency Regulation[14] includes energy efficiency levels for the following types of new appliances (within the scope of ENTR Lot 1): automatic commercial ice-makers, refrigerators and freezers with doors (i.e. service cabinets), walk-in refrigerators and freezers, and water dispensers. The Regulation excludes certain refrigeration appliances with a volume exceeding 85 ft^3 (2.4 m^3) and automatic commercial ice-makers with a harvest rate lower than 50 lbs (22.7 kg)/24 hours or greater than 2,500 lbs. (1,134 kg)/24 hours.

- **US Energy Star labelling programme**

Energy Star is a joint program of US DOE and the US Environmental Protection Agency. It is a scheme to promote energy efficiency, through setting minimum performance standards and providing a label to those products that qualify, allowing end-users to identify energy efficient products.

- **Canada**

In Canada, the standards organisation involved in standards development is the Canadian Standards Association (CAN CSA).

Canadian Energy Efficiency Regulations set technical requirements for various classes of Energy-using Products, including commercial refrigeration under which products are separated into different product categories. Canadian regulations affect products such as chillers, service cabinets, water and beverage dispensers and ice-makers.

- **Australia/New Zealand**

In Australia and New Zealand, the organisations involved in the development of standards are Standards Australia and Standards New Zealand (AS/NZS).

The MEPS programmes are mandatory in Australia by state government legislation and regulations which give force to the relevant Australian Standards. Regulations specify the general requirements for MEPS for appliances, including offences and penalties if a party does not comply with the requirements.

1.1.2.4 Other actors

Many other actors are involved in the refrigerant market including, for example, those that draft legislation for health and safety (for example, to maintain food quality, maximum refrigeration storage temperatures are defined) and develop voluntary schemes related to maintenance.

1.1.3. Basic concepts of refrigeration

This section aims to facilitate the understanding of refrigeration technology. It introduces the basic refrigeration concepts, provides a description of the two main types of refrigeration cycles used in commercial refrigeration equipment, and the fundamental components required. The design of any cooling appliance follows some basic principles of thermodynamics:

[14] Website: www.energy.ca.gov/appliances/2009regulations/

- Heat naturally flows from high to low temperature points.
- Energy in the form of heat is necessary to vaporise[15] a liquid. During an evaporation process, the liquid absorbs heat from its surroundings, thus cooling its surroundings. Contrarily, a substance releases heat to its surroundings during a condensation process[16].
- The evaporating and condensing temperatures of a substance are correlated with the pressure. If the pressure of a substance decreases, its evaporating and condensing temperature will also decrease.

1.1.3.1 Cooling (or refrigeration) load

The cooling load (also called refrigeration load) is the total amount of heat that must be removed by an appliance (or a refrigeration system) in order to maintain a desired constant temperature. It is one of the factors that determine the energy consumption of an appliance, along with system efficiency: the lower the cooling load is, or the greater the system efficiency is, the smaller its energy consumption.

The cooling load is influenced not only by the desired temperature inside the appliance, but for example by possible heat gains from the external environment and operating components inside the appliance (e.g. fan motors, compressor motor, or lighting).

The energy consumption of refrigerator will depend also on the type of foodstuff to be cooled down. Food with highly water content will require more energy to be cooled than lower water content foodstuff. These products tend to have higher specific heat capacities[17].

[15] Phase transition from liquid to gas
[16] Phase transition from gas to liquid

[17] http://www.engineeringtoolbox.com/specific-heat-capacity-food-d_295.html

1.1.3.2 Vapour-compression cycle

The vapour-compression cycle is the most widespread technology in refrigeration[18]. It is defined as a closed-loop process (see Figure 1-1), in which a refrigerant circulating through a pipe loop is used to remove heat from a product (or area) and discharges it elsewhere. All refrigeration equipment using vapour-compression technology incorporates the following four main components: an evaporator, a compressor, a condenser, and an expansion device.

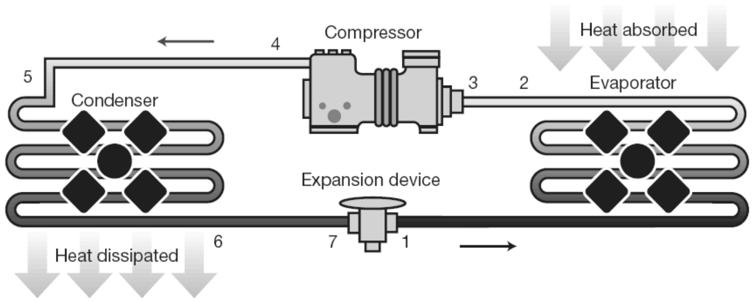


Figure 1-1 : Vapour-compression cycle[19]

Some appliances integrate all four components within the product itself and are called "plug-in" appliances (also known as integrated or self-contained appliances). In contrast, another type of refrigeration equipment includes only the evaporator and the expansion devices, and is known as a "remote" appliance. Remote equipment is connected to either a packaged condensing unit(s) or a central refrigeration plant containing the compressor(s) and condenser(s) and providing the refrigerating energy, via the refrigerant circuit (pipe loop), to form a remote refrigeration system. Remote condensing units and central plants can serve several refrigerating appliances (see § 1.1.3.6 for more details).

Most of the appliances in commercial refrigeration present several differences in design and components for low temperatures (negative temperatures) and medium and high temperatures (positive temperatures). Due to these different operating temperatures, some characteristics of the system such as refrigerant liquid, compressor, oil circulator or expansion valves can be designed in different ways for low temperature applications and for medium and high temperature applications. These differences will be further investigated in the Base Cases in Task 4.

1.1.3.3 Absorption cycle

The absorption cycle has two closed circuit loops in which the two working fluids are circulated, one for the refrigerant and one for the absorption medium. Similar to a vapour-compression system, an absorption system consists of a condenser, an expansion device, and an evaporator. However, instead of a mechanically operated compressor, it has a thermal unit comprising an absorber and a generator (see Figure 1-2).

---

[18] "Nearly all current applications use compression-compression refrigeration technology" in IPCC Special Report on Safeguarding the Ozone Layer and the Global Climate System Issues related to Hydrofluorocarbons and Perfluorocarbon, Chapter 4, *Refrigeration*, 2005. Available at: www.mnp.nl/ipcc/pages_media/SROC-final/SROC04.pdf

[19] Energy Efficiency Best Practice Programme UK. *Energy efficient refrigeration technology – the fundamentals*. Good Practice Guide 280. 2000

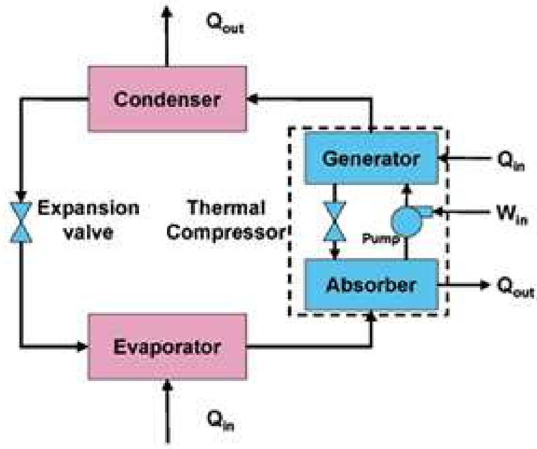


Figure 1-2: Absorption cycle[20]

As the main driver of the absorption cycle is the heat provided to the generator, the absorption technology is used mostly when electricity is unreliable or costly, where noise from the compressor is problematic, or where surplus heat is available. Within the scope of ENTR Lot 1, process chillers and mini-bars are the only products that are sensitive to absorption processes.

1.1.3.4 Total energy consumption (TEC)

The total energy consumption (TEC) of a refrigeration product is the sum of the refrigeration energy consumption (REC) and the direct energy consumption (DEC):

$$TEC = REC + DEC$$

- **REC**: Refrigeration Electrical energy Consumption. This refers to the share of electricity consumption of the components located outside of the equipment (i.e. the condenser and the compressor) which provide the cooling capacity.
- **DEC:** Direct Electrical energy Consumption. This refers to the electricity consumption of the components actually included within the equipment.

1.1.3.5 Refrigerants

All substances that exist in liquid and vapour states absorb heat during evaporation and can therefore be used as refrigerants. A refrigerant should evaporate at the required cooling temperature (i.e. at the temperature sought in the evaporator of the refrigerating equipment), at a reasonable pressure, and should be able to be condensed by an available cooling medium at a practical pressure. Commonly used refrigerants in refrigeration applications are the following:

- HCFCs: Hydrochlorofluorocarbons
- HFCs: Hydrofluorocarbons
- HCs: Hydrocarbons
- Unsaturated HFCs (also known as HFOs or Hydrofluoroolefins)

[20] Department of Energy Technology; Royal Institute of Technology KTH. *Refrigerating Engineering*. Stockholm, 2005.

- NH_3: Ammonia
- CO_2: Carbon dioxide

Refrigerants have widely varying properties and impacts and, due to the significant environmental impact of certain refrigerant types, can be heavily regulated during manufacture, use and disposal. Refrigerants will be assessed in detail in Task 4, covering the above issues, as well as their performance and environmental impact.

1.1.3.6 Refrigeration systems

As described in § 1.1.3.2, a remote refrigeration system consists of remote refrigerating equipment connected either to packaged condensing unit(s) or to a central plant, via the refrigerant circuit.

Refrigeration system components can have a great impact on the performance of refrigeration products, and many have specific standards, tests and specifications to ensure their own quality and performance.

Four main configurations exist for remote refrigeration systems:

- direct expansion system;
- indirect expansion system or secondary refrigerant loop;
- distributed system;
- cascade system with two superposed refrigerant cycles.

Absorption based central refrigeration systems are less common, but in principle similar configurations are possible. The only difference would be that the compressor of the vapour-compression cycle is then replaced by the absorber and generator of the absorption cycle.

A technical annex to this report, based on literature review and stakeholder consultation, describes the various remote vapour-compression refrigeration systems, analyses their market, and assesses their respective environmental impacts, energy consumption and potential for improvement.

1.1.3.7 Efficiency measurement

The efficiency or performance of refrigeration systems indicators are normally the relation between the energy input and the cooling capacity (output) or unit of internal storage volume. The units commonly used are[21]:

- Coefficient Of Performance (COP): defined as the cooling capacity divided by the energy input to the compressor, where higher numbers indicate more efficient equipment. This number does not have a unit of measurement.
- Energy Efficiency Ratio (EER): this value is defined as the ratio of net cooling capacity (Btu/h[22]) to the total electricity input watt hour (Wh). Higher values indicate more efficient equipment.

[21] Source: www.engineeringtoolbox.com/cop-eer-d_409.html

[22] 1 BTU/h = 2.931×10^{-4} kW

- Energy Efficiency Index (EEI): used to compare performance of service cabinets per unit of storage volume, this is calculated from the total energy consumption per 48 hours, divided by the net internal volume of the product (kWh/48hrs/m^3).
- The performance of equipment can be also evaluated by the ratio of energy consumption aggregated over a period of time with a characteristic dimension of the equipment or physical capacity (volume) (m^3, litre, and kg).

1.1.3.8 Insulation properties

The thermal transmission, or thermal resistance, properties of insulating components can be described using the following factors:

- Lambda (λ) – thermal conductivity. This represents the thermal transmission through a fixed thickness of a material, in W per metre, considering a one degree temperature difference across the material (λ = W/m.K). In the US, it is known as the "K factor". In the EU producers must declare the aged value, or λ_{design} (also termed "lambda 90/90"). As ageing has a detrimental impact on insulation material, the aged λ value will be greater than direct λ value.
- U value - thermal transmittance. This represents the thermal transmission through a unit of surface area, in W per square metre, considering a one degree temperature difference across the material (U = W/m^2.K).
  - In the context of buildings it can also represent the overall heat transfer coefficient (an averaged thermal conductance in W/m^2.K), and the terminology used in this context can be the "K value". In testing of mobile refrigeration, the terminology used for this factor is "K coefficient" (an averaged thermal transmission for the insulating box in W/m^2.K) (§1.14.).
- R value – thermal resistance value. This represents the thermal resistance of a material, and is the inverse of the thermal conductivity, λ, multiplied by the thickness (R = m^2.K/W). The conversion between SI and US units of R-value is 1 h.ft^2.°F/Btu = 0.176110 K.m^2/W.

1.2. PRODUCT DEFINITIONS

This section aims to define the terminology for the products covered in ENTR Lot 1. Firstly, detailed information is provided on the technical description and precise definition for each product category. An initial classification of products is based on their function. This also includes a discussion[23] of the technical features (such as components and design) which play a significant role in the energy consumption and other life-cycle environmental impacts caused by different products.

PRODCOM definitions related to commercial refrigeration appliances are then described to evaluate whether or not the product classifications match the database categories, and hence if this information can be added to the market analysis.

1.2.1. SERVICE CABINETS

1.2.1.1 General product definition

Professional service cabinets are designed for the storage, but not the sale, of chilled and frozen foodstuff. A professional service cabinet is a refrigerated enclosure (with a gross internal volume of around 100 to 2 000 litres[24]) containing goods which are accessible via one or more doors and/or drawers. The sizes of the products are typically based on the Gastronorm standard (see §1.3.6.1) and are used in a commercial environment.

"Commercial" refrigerators and freezers are related to the supermarket sector, whereas "professional" refrigerators and freezers are related to a different market: restaurants, hospitals, canteens, supermarket (i.e. locations not in direct contact with the public). The main difference is not related to installation environment, but to the user: a "commercial" refrigerator is used by a customer, and will display produce, while a "professional" refrigerator is used by trained staff, and will store the produce before use. Hence the terminology "professional" is inferred when discussing service cabinets in ENTR Lot 1. Frequently existing definitions refer to "commercial" service cabinets, when in fact "professional" use of the products is relevant, therefore it is noted that terminology varies for identical products.

1.2.1.2 Existing product definitions

Below is a list of definitions provided by existing schemes.

- **UK ECA**

Professional service cabinets have been defined under the ECA scheme Energy Technology List (ETL) as "products that are specifically designed to store, but not

[23] Such technical analysis will be further detailed in the subsequent Tasks (4-6) for products prioritised in Task 1.4

[24] Gross internal volume should be differentiated from net (internal) volume – gross volume is is defined as the volume within the inside walls of the cabinet without internal fittings and with all doors (and drawers) closed, while net volume is measured using different methodologies, defined with test standards. Please see §1.3.1.7 for further details.

to display, chilled and frozen foodstuffs",however, they are referred to as "commercial". The scheme covers three categories of product, as described below.

Table 1-1: UK ECA product categories

Type	Gross internal volume (litres)*
Single door commercial service cabinets	400 and 600 (+/- 15%)
Double door commercial service cabinets	1,300 (+/- 15%)
Under counter and counter commercial service cabinets with solid doors or drawers	150 to 800 (+/- 15%)

**Gross internal volume is defined as the volume within the inside walls of the cabinet without internal fittings and with all doors (and drawers) closed.*

To be considered under the scheme, service cabinets must also fulfil the following criteria:

- they are designed to store chilled or frozen foodstuffs, whilst maintaining them within prescribed temperature limits;
- they are fitted with solid-faced lids, drawers or doors that:
    - are normally kept closed, but can be opened to access the contents;
    - obscure the contents of the cabinet from view when closed;
    - enable users to access the contents of any part of the interior without stepping into the refrigerated space; and
- they are a "plug-in" type cabinet with an integral refrigeration system (as opposed to "remote" equipment with remotely located condensing unit).

The UK ECA scheme does not include remote type refrigerated service cabinet or display cabinets, or cabinets with transparent doors, even if designed for storage.

◆ US Energy Star

The Energy Star energy efficiency scheme defines a service cabinet as a "refrigerator, freezer, or refrigerator-freezer for storing food products or other perishable items at specified temperatures and designed for use by commercial or institutional facilities."[25] Although the standard refers to "commercial" use, due to the fact that it refers to storage of foodstuff and solid doors, rather than display and transparent doors, the products are in fact intended for professional use.

This scheme distinguishes products on the basis of operating temperature and cabinet design.

On the basis of operating temperature, a "refrigerator" is defined as a cabinet designed for storing items between 0°C and +4°C and a "freezer" refers to a cabinet designed for storing items below 0°C. A "refrigerator-freezer" is defined as a cabinet comprising more than one compartment, at least one of which is a refrigerator and at least one of which is a freezer.

---

[25] US Energy Star program requirements for commercial sold door refrigerators and freezers: www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CRF

These products can then be classified on the basis of cabinet design:

- reach-in: an upright commercial, self-contained refrigeration cabinet with hinged, solid doors.
- horizontal: an upright commercial, self-contained refrigeration cabinet with or without a worktop surface which has hinged, solid doors.
- roll-in or roll-through cabinet: an upright, self-contained commercial refrigeration cabinet with hinged, solid doors that allows wheeled racks of products to be rolled into or through the refrigerator or freezer.
- pass-through cabinet: an upright commercial, self-contained refrigeration cabinet with hinged, solid doors on both the front and rear of the refrigerator or freezer.

That said, the Energy Star scheme does not differentiate minimum performance standards by these categories.

The scheme differentiates by size, operation temperature and product orientation (vertical and chest), and includes remote type refrigerated service cabinets only.

1.2.1.3 Product description

Service cabinets are closed cabinets designed for the storage of foodstuffs and that have at least one door, drawer or lid. Different configurations are available on the market and some are shown in Figure 1-3. They are largely used in food-service establishments, such as restaurants, hotels and cafeterias. A very small fraction of "professional" service cabinets contain glass in their doors, drawers or lids (as opposed to "commercial" service cabinets that display food and hence frequently incorporate glass)[26].

If the operation temperature is below 0°C, the unit is called a freezing service cabinet, whereas when operation temperature is equal to or above 0°C the unit is known as a refrigerated service cabinet. Some service cabinets may have a design in which there are two or more compartments operating at different temperatures, one above 0°C and the second one at temperatures below 0°C.

Analysis based on major EU manufacturers' catalogue data, existing definitions presented above, and previous studies on commercial refrigeration, shows that the majority of service cabinets rely on compression technology (approximately 99%) and are mostly plug-in appliances (approximately 98%): i.e. all components supporting the refrigeration cycle are included in the cabinet[27]. More detailed data on the market composition is provided in Task 2.

---

[26] Source: Foster

[27] Source : replies to the 1st ENTR Lot 1 stakeholder questionnaire

Figure 1-3: Configurations of service cabinets

The majority of the market is for chilled or frozen upright cabinets with one or two doors (between 400 and 600 litres for single door cabinets and 1,300 litres for double door cabinets) or horizontal units with up to four doors (150 to 800 litres). According to stakeholder feedback and product technical specifications, the energy consumption for service cabinets varies depending on their function and size, but an average product of 600 litres gross might consume 2000 kWh per year[28], while a freezer service cabinet of the same internal volume could consume approximately double to triple this figure. Stakeholders stated that the dominant model is an upright plug-in refrigerator, of approximately 600 litres.

Table 1-2: Specifications of service cabinets

Configuration	Operation temperature	Number of doors / drawers / lids	Approx. net volume, V (litres)*
Vertical	Refrigerator	1	400 < V < 700
		2+	700 < V < 1500
	Freezer	1	400 < V < 700
		2+	700 < V < 1500
Horizontal	Refrigerator	1+	150 < V < 800
	Freezer	1+	150 < V < 800
Chest	Freezer	1+	300 < V < 800

**Measured according to EN 441*

The size of this equipment is often based on the Gastronorm standard sizes (see § 1.2.1.3).

1.2.1.4 Functional unit and performance parameter

The function of a service cabinet is to maintain products contained inside the refrigerated space at a temperature below a pre-determined maximum, under specific conditions (climate classes). The energy consumption under these

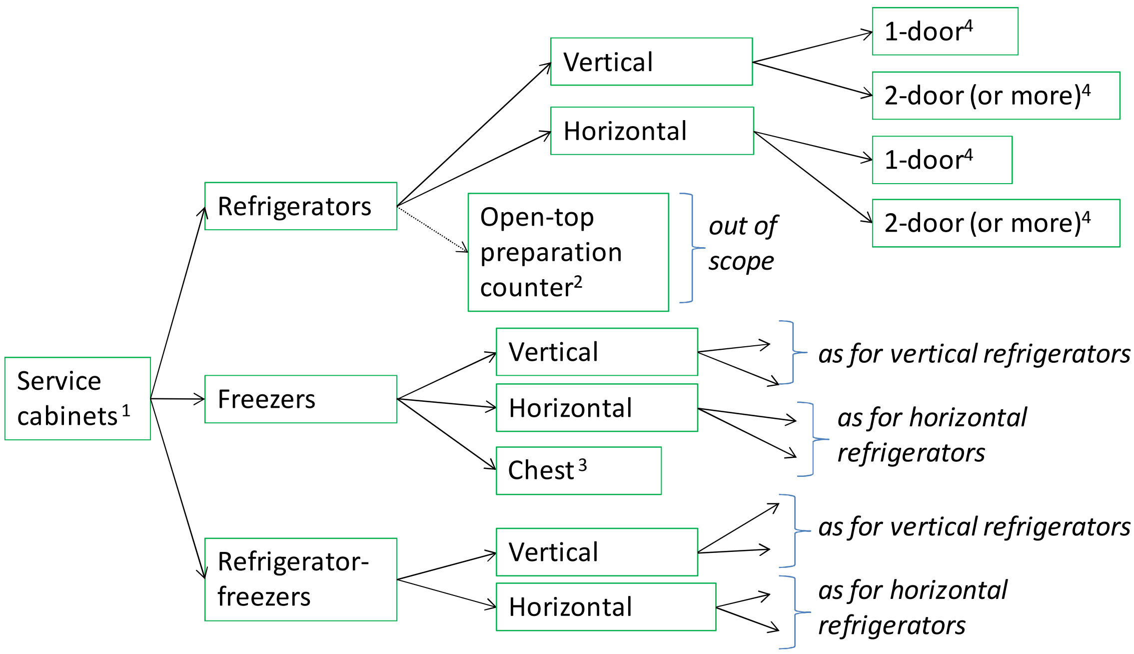
[28] Source: Electrolux

conditions is measured then this value is related to the internal net volume of the machine (energy efficiency index).

The functional unit for service cabinets is a unit of storage volume (litres), maintained at a specified temperature. The primary performance parameter is defined as the electricity consumption per unit of storage volume in kWh/litres/year.

1.2.1.5 Service cabinet classification and scope for the study

A classification is proposed for service cabinets to be included in the scope of the study and is illustrated below.



1 – Professional products, either plug-in or remote
2 – Also known as 'saladettes', this product configuration is not included in the scope of ENTR Lot 1 due to different functionality
3 – Freezers and 1-door only
4 – Or with a combination of drawers

Figure 1-4: Service cabinet classification

This is based on stakeholder feedback and the similarities in definitions specified in the product description summaries above (UK ECA[29] and US Energy Star). Both remote (although rare) and plug-in service cabinets are included in the scope of the present study.

Some stakeholders stated that the scope of the product group covered should exclude equipment with glass doors, drawers or lids, and that almost all "professional" service cabinets have only solid doors (glass doors for "commercial" service cabinets are covered in TREN Lot 12, but not those in "professional" service cabinets). With the recent distinction in terminology in ENTR Lot 1 between "professional" and "commercial" service cabinets, the exclusion from ENTR Lot 1 of

[29] Source: ECA Energy technology criteria list 2009 – Refrigeration equipment. Commercial service cabinets. 2009

“professional” service cabinets with glass doors, drawers or lids could create a loophole in regulation.

Open-top preparation tables are considered out of scope, as they are usually distinguished as a different product in standards definitions, and stakeholders commented that their functionality (they have openings in the product shell to cool storage trays, provide short-term storage and have frequent door openings – they are also often not based on Gastronorm sizes) varies from service cabinets (which is sealed equipment, providing longer-term storage and with fewer door openings). In addition, they often include features that can impair refrigeration efficiency, e.g. they can offer a base for the end-user to add a char-grill, griddle or grilling top[30].

The following table describes some of the main differentiating criteria related to the product group, which may impact on energy consumption.

Table 1-3: Specifications of service cabinets

Categorisations	Explanation	Notes
Operation Temperature	Differentiating technical and refrigerant requirements at low freezing and high/medium refrigeration temperature	Temperature will influence energy consumption, which will be higher for freezing compared to refrigeration
Climate class	The climate class reflects the ambient conditions, which can influence the choice of the refrigerant, as well as the performance	-
Volume	Fairly standard sizes, with some variability, based around modular units	Size ranges linked to configuration Evidence that relationship with energy efficiency is non-linear
Configuration	Vertical, horizontal, chest Reach-in, roll-in and pass-through options Preparation counters	Open service counters such as pizza preparation tables with refrigeration units may be considered for exclusion due different functionality.
Location of condensing unit	Plug-in, remote condensing unit or remote central plant	Influences ambient temperature - climate zones (air-on temperature) northern/southern EU relevant for remote Remote type very rare
Number of doors	Can be a variety of combinations, usually based around modular units.	-
Door type	Solid or transparent	Transparent covered in TREN Lot 12 as display cabinets
Drawers	Some horizontal include drawers, based around modular units	Door-type model could be used as a proxy for calculating energy consumption
Condenser type	Water, air, evaporative	Stakeholder feedback has determined that most of the market is air cooled
Refrigerant	The choice of refrigerant depends on the operation temperature, ambient temperature, refrigeration system type	The most commonly used refrigerants are R134a and R404a
Glass	Rarely used	Although rarely used, glass has a much greater U-value, hence its use

[30] Source: Foster Refrigeration

		will increase thermal infiltration and increase heat load on the refrigeration system

1.2.2. BLAST CABINETS

1.2.2.1 General product definition

Blast cabinets use a blast of cold air to bring down the temperature of hot food rapidly so it can be stored safely avoiding bacteria growth, and can be chilled or frozen.

1.2.2.2 Existing product definitions

- **California** Energy Commission (CEC)

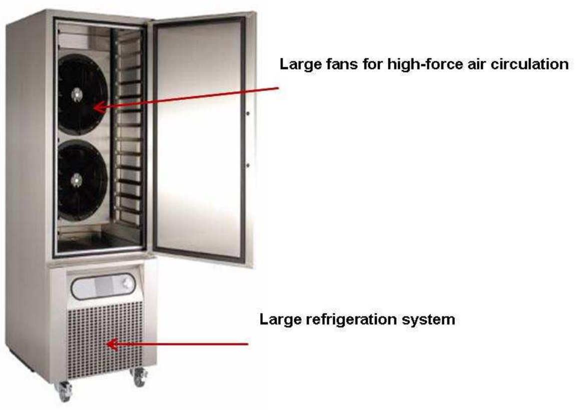
According to CEC Appliance efficiency Regulations[31] (CEC-400-2009-013), blast cabinets, otherwise named blast chillers, are defined as machines that are able to decrease foodstuff's temperature from +140°F to +40°F (+60°C to +4°C) within 4 hours. However, the regulation does not go into further detail for this definition since this kind of appliance is not included within its scope.

- **FR AC D 40-003**

The *Equipment for collective restaurant – refrigerating equipment. General design and construction rules for ensuring hygiene in use* defines blast equipment as appliances which are used to rapidly decrease the temperature of foodstuff below +10°C in the case of chilling and below -18°C in the case of freezing. They exist in different configurations, only chilling, only freezing and a combination of the two.

1.2.2.3 Product description

Blast cabinets are similar in construction to service cabinets. However, they rely on relatively larger refrigeration systems in comparison to service cabinets, some even using up to two compressors per cabinet. Blast cabinets also contain additional fans which blast cold air over food to cool it rapidly. A typical blast refrigerator is shown below in Figure 1-5. Under the scope of this study, blast walk-in rooms and continuous-process blast equipment will not be included. For both machine types, the use patterns differ from those of blast cabinets.



[31] Source: California Energy Commission. *2009 Appliance Efficiency Regulations*. CEC-400-2009-013. 2009

Figure 1-5: Typical blast refrigerator/freezer

In the market, there exist other configurations of blast equipment. These are referred to as pass-through and trolleys units. In this case, cars or trolleys are used to organise the foodstuff before it goes into the equipment. The capacity of this equipment is higher, but, as was mentioned by stakeholders, their efficiency is lower because of their need to cool down the trolley itself, among other reasons. Glass-door equipment has not been identified in industry catalogues.

All fresh food products contain a natural bacterial load which, under favourable ambient conditions (temperature and humidity), multiplies, increasing the risk of illness and cross contamination with other food. The most dangerous temperature range occurs between +35°C and +65°. Blast cabinets are designed to lower the temperature at the centre of the pre-cooked food product as quickly as possible, to avoid prolonging the period at which food temperature is within this range. This not only prevents bacterial load from reaching dangerous levels, it also prolongs the shelf-life of the product. Energy efficiency is therefore not often a priority for the average product.[32]

The increase of energy consumption is not linear with the capacity. For larger sizes of equipment, more non-foodstuff material will require cooling as well, and hence, the efficiency decreases. An approximate relation between size and energy consumption is shown in the table below.

Table 1-4: Energy consumption per equipment capacity for chilling and freezing cycle reach-in (R) configuration[33]

Size	Number of trays (GN 1/1)	Average food stuff capacity (kg)	Approximate energy consumption (kWh/chilling cycle)	Approximate energy consumption (kWh/freezing cycle)
Small R	1-3	3-9	1 - 2	1.5-4
Medium R	5-10	15-30	1 - 4	5.5
Large R	12-15	36-45	2 - 5	5.5-11
Extra-large R	> 16	> 48	> 6	> 9

Note: average capacity per GN 1/1 tray: 3-3.5kg of foodstuff

The size of equipment trays is normally determined according to Gastronorm standard sizes (see § 1.2.1.3). It is estimated that each GN 1/1 tray has a capacity of 3 to 3.5kg of foodstuff (as referred in NF AC D40-003, see $ 1.3.6.5).

The size classification for trolley using equipment (roll-in and pass-through) is given in Table 1-5 below.

Table 1-5: Size description of trolley (T) equipment (roll-in and pass-through)

Size	Number of trays (GN 1/1)	Trolleys	Average food stuff capacity (kg)

[32] Based on brochures and direct feedback of stakeholders

[33] Stakeholders feedback

Small T	10 – 30	1 – 3	30 – 90
Medium T	90 – 50	4 – 5	91 – 150
Large T	60 – 80	6 – 8	151 – 240

Testing of blast cabinets has limitations regarding the amount of food that has to be cooked and heated. Stakeholders stated that a limitation of 60kg of foodstuff as maximum quantity to be processed and tested. Limitations are related to the cooling process itself and costs of the process.

1.2.2.4 Functional unit and performance parameter

The functional unit for blast cabinets can be defined as one kg of food (referred to in this case as the testing material specified in NF AC D 40-003) cooled in a specific cycle (kg/cycle) occupying a specific volume; the cycle defining the temperature change and duration of cooling.

The use of mashed potatoes as referred in NF AC D 40-033 would overcome the problems of heat resistance typical of other measurement loads, as stated by stakeholders. Also, the reason why considering only the mixture of mashed potatoes is to harmonize the material, as other foodstuff specific heat capacity can change the results.

The performance of blast cabinets can therefore be defined as the net weight of foodstuff that the cabinet can cool down at a certain temperature within a certain period of time in certain conditions (e.g. ambient conditions, operating conditions). The primary performance parameter can therefore be defined as the electricity consumption per unit of foodstuff (referred to the testing material as per NF AC D 40-003) refrigerated/frozen weight in kWh/kg within the fixed cooling or freezing cycle.

Typical operating cycles include[34]:

- Cooling cycle: 90mins to 110mins for a specified mass of food (normally the manufacturer's declared unit capacity) with starting temperatures ranging from +60°C to +90°C and finishing temperatures ranging from +2°C to +10°C, satisfying European food safety standards and regulations.
- Freezing cycle: 240mins for a specified mass of food (normally the manufacturer's declared unit capacity) with starting temperatures ranging from +60°C to +90°C and finishing temperatures ranging from -10°C to -20°C, satisfying European food safety standards and regulations.
- Many appliances will sound an alarm to signal that the cooling/freezing cycle has finished and then continue to maintain the final temperature for the food, essentially operating then as a service cabinet until the operator removes the food.

These appliances are available both in plug-in and remote configurations.

For plug-in blast refrigerators/freezers, the electricity consumption is straightforward to assess: it is the total amount of electricity consumed by the appliance.

[34] Figures based on product technical specifications and existing product definitions

Remote blast refrigerators/freezers (i.e. units where the compressor and the condenser are located outside the appliance) operate within a broader system. Therefore, the following should be distinguished:

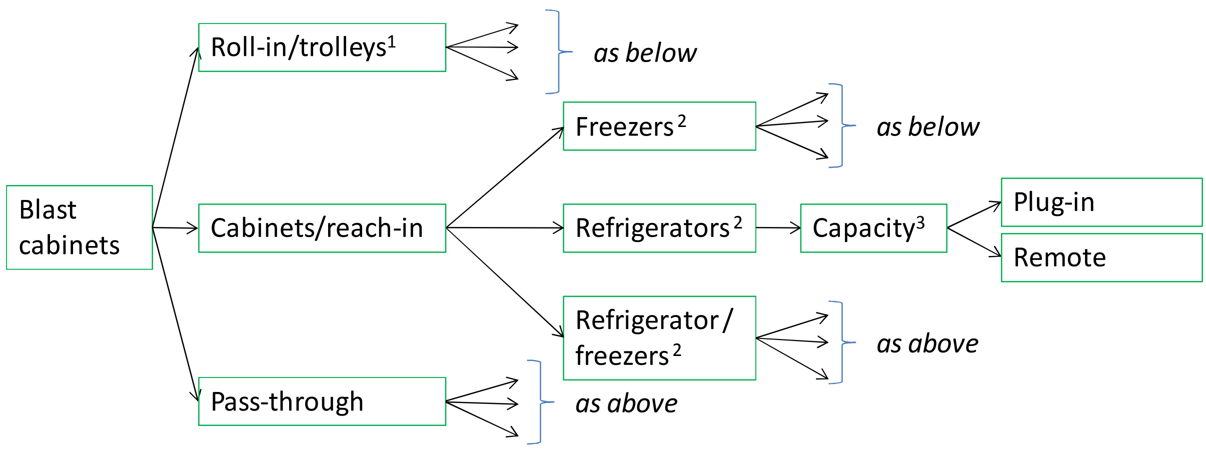
- the electricity consumption of the remote blast cabinet itself (containing only the evaporator and the expansion device);
- the electricity consumption arising from the remote system (condensing unit and piping system), to which the blast cabinet is connected, and which delivers the refrigerating energy. This remote system may serve several refrigerating appliances.

Currently there is no standardised way of calculating the electricity consumption of remote blast cooling devices. However, the ISO 23953 related to remote display cabinets can provide insights for developing a possible method.

In the ISO 23953 standard on refrigerated display cabinets, the energy consumption is given by the total energy consumption in kilowatt hours per 24-hour period (TEC). The means to calculate TEC for remote refrigerated display cabinets is discussed in § 1.2.1.4.

1.2.2.5 Blast cabinets' classification and scope for the study

This section provides a classification for blast cabinets to be included in the scope of the study. Blast cabinets are produced according to the final operation temperature required and the time to reach this requirement and the capacity of food (by weight) that they can cool in this time[35] as well as the overall orientation of the product (reach-in, roll-in and pass-through).



1 – Small Roll-in equipment is can be found in Plug-in configuration (normally up to 60kg or 90kg), bigger units in remote configuration
2 – For large equipments (from around 60kg or 90kg) remote configuration represents 90% of sales
3 – Lower capacities correspond to reach-in equipment, being from 3kg to 100kg. Pass-though and roll-in equipment capacity varies from around 30kg to 240kg (described in Table 1-4 and Table 1-5)

Figure 1-6: Blast cabinet classification

Figure 1-6 illustrates the categorisation for blast cabinets including the main energy influencing parameters. Blast cabinets are characterised first by the structure of the equipment (roll-in, cabinet or pass-through), then by the

[35] Source: www.hennypenny.com/

operation temperature (chiller, freezer or chiller-freezer), and finally by capacity (kg, m^3, etc). If required, they can also be characterised by the location of the condensing unit in the arrangement (plug-in or remote – either packaged remote or connected to a central plant).

Table 1-6: Specifications of blast cabinets

Categorisations	Explanation	Notes
Capacity	Technical specification and energy will depend on the capacity of the equipment. It can vary from 3kg to 100kg in the case of reach-in equipment or from 30kg to 240kg in the case of trolley equipment	Since safety requirements demand a specific target temperature in a specific time, the unit will consume more or less energy according to the load Larger equipment is less common in the market
Configuration	Roll-in equipment and pass-through are typically larger appliances than reach-in	Roll-in and pass-through energy efficiency is generally lower than reach-in. However this is compensated by the fact that most trolley equipment is remote
Operation temperature	European equipment is typically used in for a chilling function. Its energy consumption is lower than equipment in freezing operation Freezing equipment has almost been phased-out in some markets, but is still in production in others. Chilling/freezing (combination models). Several stakeholders estimate that this equipment is rarely used in freezing cycles; however, their energy consumption is similar to a freezer in this function	Energy consumption testing will be influenced by the ambient conditions, and the functioning of the equipment Arrangement to be considered within the testing methodology
Climate class	The climate class reflects the ambient conditions, which can influence the choice of the refrigerant, and the performance as well	Two main climate zones could be distinguished in the EU-27: around +11°C for northern Europe and around +15°C for southern Europe
Location of condensing unit	Plug-in, equipment with integral condensing unit Remote, connected to a central plant or exterior condensing unit.	Influences ambient temperature - climate zones (air-on temperature) northern/southern EU relevant for remote
Condenser type	Water (rarely found), air, evaporative (rarely found)	Stakeholder feedback has determined that most of the market is air-cooled
Refrigerant	The choice of refrigerant depends on the operation temperature, ambient temperature, refrigeration system type	The most commonly used refrigerants is R404a

Both remote condensing and plug-in blast cabinets are included in the scope of the present study. While stakeholder estimates predict that a great majority (85%) of the market is dedicated to plug-in blast cabinets, remote condensing units are still considered a subcategory of blast cabinets in this study.

Typically, blast cabinets are sold to consumers according to the final operating temperature required, the time to reach this requirement and the capacity of food (by weight) that they can cool in this time[36].

Classification beyond these parameters could be done by type of condensing coolant used (water, air, evaporative), however stakeholder feedback has determined that this is not relevant as most of the market is air cooled.

1.2.3. WALK-IN COLD ROOMS

1.2.3.1 General product definition

According to the definition provided in the International Dictionary of Refrigeration, a cold room is a room or cabinet maintained by a refrigerating system at a temperature lower than ambient temperature. Walk-in cold rooms are insulated rooms that provide refrigerated storage for a variety of items (mainly foodstuff, but also flowers, etc.). They may exist as refrigerators or freezers. Walk-in cold rooms with both a refrigerating and freezing compartment are normally referred to as "dual compartment" and have two separate refrigeration systems.

1.2.3.2 Existing product definitions

- UK Defra

According to the UK Defra, a walk-in cold room is defined as follows:

"A walk-in cold store is an insulated enclosure with similar operational principles to any refrigerator, but capable of storing significantly more goods. Generally, they are fabricated on site and are a customised product, although the prefabricate market is growing in size. Refrigeration is delivered through a forced-air evaporator located in the cooled space, coupled to a condensing unit located externally".

- EU EOTA

The EOTA's definition, presented in the European Technical Approval (ETA) and implemented by the European Technical Approval Guidelines 021 (ETAG 021) for cold rooms covers prefabricated cold storage room kits and cold storage building enclosure and building kits. According to ETA, kits within the scope are those constructed with insulating panels (sandwich type with insulation core) designed to perform store products at temperatures from below +15°C to above -40°C. Under appropriate maintenance a walk-in cold room kit should last 10 years.

- US DOE

The US statutory definition of walk-in coolers and freezers:

"The terms "walk-in cooler' and "walk-in freezer' mean an enclosed storage space refrigerated to temperatures, respectively, above, and at or below 32 degrees Fahrenheit [0°C] *that can be walked into, and has a total chilled storage area of less than 3,000 square feet."* [(42 U.S.C. 6311(20)(A))]

The definition excludes:

[36] Source: www.hennypenny.com/

"products designed and marketed exclusively for medical, scientific, or research purposes." [(42 U.S.C. 6311(20)(B))]

- **US CEC**

CEC through the 2009 Appliance Energy Regulation[37] (CEC-400-2009-013) establishes the definition for walk-in coolers and walk-in freezers, differentiating units with and without transparent, doors as follows:

"Walk-in coolers means an enclosed storage space refrigerated to temperatures above 32°F [0°C] that can be walked into and has a total chilled storage area than 3 000 square feet. Walk-in coolers do not include products designed and marketed exclusively for medical, scientific, or research purposes. Walk-in freezer means an enclosed storage space refrigerated to temperatures at or below 32°F [0°C] that can be walked into and has a total chilled storage area of less than 3 000 square feet. Walk-in freezer does not include products designed and marketed exclusively for medical, scientific, or research purposes".

- **Natural Resources Canada**

Natural Resource Canada Office of Energy Efficiency defines walk-in cold rooms as:

"Walk-in refrigerators and freezers commonly used in fast-food and other restaurants, institutional kitchens, convenience stores and other businesses are room-sized insulated compartments, typically between 7 and 23m^2 of floor area, 2.4m high, and refrigerated by a self-contained system. Much larger refrigerated rooms are used in large supermarkets and food processing and packaging plants, but these are usually supplied by large central refrigeration systems."[38]

It therefore only considers plug-in walk-in cold rooms.

1.2.3.3 Product description

Walk-in cold rooms have at least one door that is large enough to allow a person to go inside the insulated compartment. The main purpose of walk-in cold rooms is for temporary storage of refrigerated or frozen perishable products. They are widely used in restaurants, hotels, convenience stores, food wholesalers, florists and warehouses.

Walk-in cold rooms can either be located indoors (i.e. constructed within a building as part of that building) or outdoors (fabricated as a stand-alone structure or an extension of an existing building). For external installations weather-proofing must be considered, such as resistance to: wind load, snow load, rain, direct sunlight, effect of potentially corrosive atmospheres, among others.

A typical walk-in cold room consists of following elements:

- an insulated enclosure, the refrigerated storage space being accessible via an insulated door;
- a condensing unit located external to the refrigerated storage space;

---

[37] California Energy Commission. *2009 Appliance Energy Regulation.* CEC-400-2009-013, August 2009.

[38] Natural resources Canada, Office of Energy Efficiency. Available at: ttp://oee.nrcan.gc.ca/industrial/equipment/commercial-refrigeration/index.cfm?attr=24

- an evaporator fan-coil located within the refrigerated storage space (usually situated near the ceiling in the room), which may or may not be integrated with the condensing unit; and
- a system of pipes and controls to allow the refrigeration circuit to cool the storage space.

The insulated enclosures are constructed from self supporting, pre-fabricated, insulation panels. These panels are made of two steel skins that are injected with high pressure, often polyurethane, foam.

Analysis based on major EU manufacturers' catalogue data, existing definitions[39], and previous studies[40] on commercial refrigeration shows that walk-in cold rooms use vapour-compression technology. Further, walk-in cold room refrigeration systems (condensing unit plus evaporator unit) can be found in different configurations.

- Remote refrigeration systems: evaporator coil within the insulated box, connected to a condensing unit located remotely (i.e. condensing unit located outdoors). Products can also be connected to a central refrigeration system where the condensing unit serves many different refrigerating appliances (e.g. in supermarkets where cooling energy is provided by a refrigeration plant to several appliances including not only the cold room but also, for example, display cabinets) - see Figure 1-7.

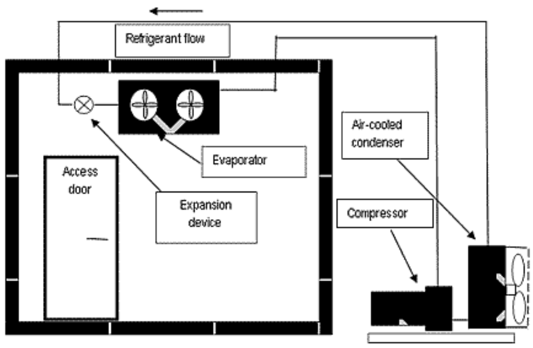


Figure 1-7: Typical walk-in cold room and major components[41]

- Packaged refrigeration systems : include all required elements (evaporator fan-coil, condensing unit, and piping) and are either integrated or attached (such as the "monoblock" type) to the walk-in cold room insulated box, forming part of the product (see Figure 1-8).

[39] Source: UK Enhanced Capital Allowance scheme, US Energy Star Program
[40] Arthur D. Little Inc, *Energy Savings Potential for Commercial Refrigeration Equipment*, US DOE, 1996 and Mark Ellis & Associates, *Self-Contained Commercial Refrigeration*, Australian Greenhouse Office, 2000 and Mark Ellis & Associates, *Remote Commercial Refrigeration*, Australian Greenhouse Office, 2000
[41] Natural resources Canada, Office of Energy Efficiency. Available at: http://oee.nrcan.gc.ca/industrial/equipment/commercial-refrigeration/index.cfm?attr=24

Figure 1-8: Typical Walk-in cold room with packaged refrigeration system

If the operation temperature is below 0°C, the unit is called a walk-in freezer, whereas if the operation temperature is equal to or above 0°C the unit is known as a walk-in refrigerator. Some walk-in cold rooms may have a design in which there are two compartments operating at different temperatures, one above 0°C and the second one at temperatures below 0°C.

Estimates of walk-in cold rooms integrating glass windows and/or doors sold in the EU range from 1 to 5% of the market[42]. These can include in-store products with one or more sides facing the store for display and providing direct rear access to display cases within the store.

There is a lack of data describing typical electricity consumption of walk-in cold rooms, but indicative figures of 14,600kWh/year for a 48.31m^3 walk-in refrigerator, and 15,600 kWh/year for a 13.4m^3 walk-in freezers[43], have been identified.

1.2.3.4 Functional unit and performance parameter

The function of walk-in cold rooms is to store a certain volume of foodstuff at a desired temperature. The functional unit for walk-in cold rooms can be defined as a unit of internal volume maintained at a specified temperature, for a specific period of time, in specific ambient conditions.

The functional unit for walk-in cold rooms is a unit of net internal volume (m^3), maintained at a specified temperature. The primary performance parameter is defined as the electricity consumption per unit of net internal volume in kWh/m^3/year.

Electricity consumption for plug-in units is straightforward to assess. In the case of remote units connected to a refrigeration system, energy consumption could be assessed as explained for service cabinets.

1.2.3.5 Walk-in cold rooms' classification and scope for the study

Apart from the distinctions drawn in §1.2.3.3 on the operation temperature and refrigeration system type, other examples of potential classification are now considered. Various operation temperature ranges for different applications are described in Table 1-7.

[42] Source: Smeva, GR Scott

[43] US Department of Energy, 2009 US DoE. Available at: www1.eere.energy.gov/buildings/appliance_standards/commercial/pdfs/wicf_framework_publicmtg_slides.pdf

Table 1-7: Walk-in cold rooms application temperature ranges[44]

Type of equipment	Operation temperature (°C)	Main use
Cellar rooms	+10 to +12	Beer cooling, food preparation area
General purposes	+1 to +4	Generic foodstuff storage
Meat rooms	-2 to +2	Meat storage
Deep freeze	-22 to -18	Ice cream storage and other deep-frozen foodstuff

An alternative classification classification for walk-in cold rooms based on the size of the equipment is described in Table 1-8.

Table 1-8: Walk-in cold rooms categorisation[45]

Equipment type	Size (m^3)	Storage temperature	Average COSP
Small	< 20	Refrigeration	1.84
		Freezing	1.32
Medium	20 < 100	Refrigeration	2.41
		Freezing	1.47
Large	100 < 400	Refrigeration	2.66
		Freezing	1.47

COSP: Coefficient of system performance

A third classification for walk-in cold rooms, based on the size of the room and configuration of the refrigeration system, is described in Table 1-9.

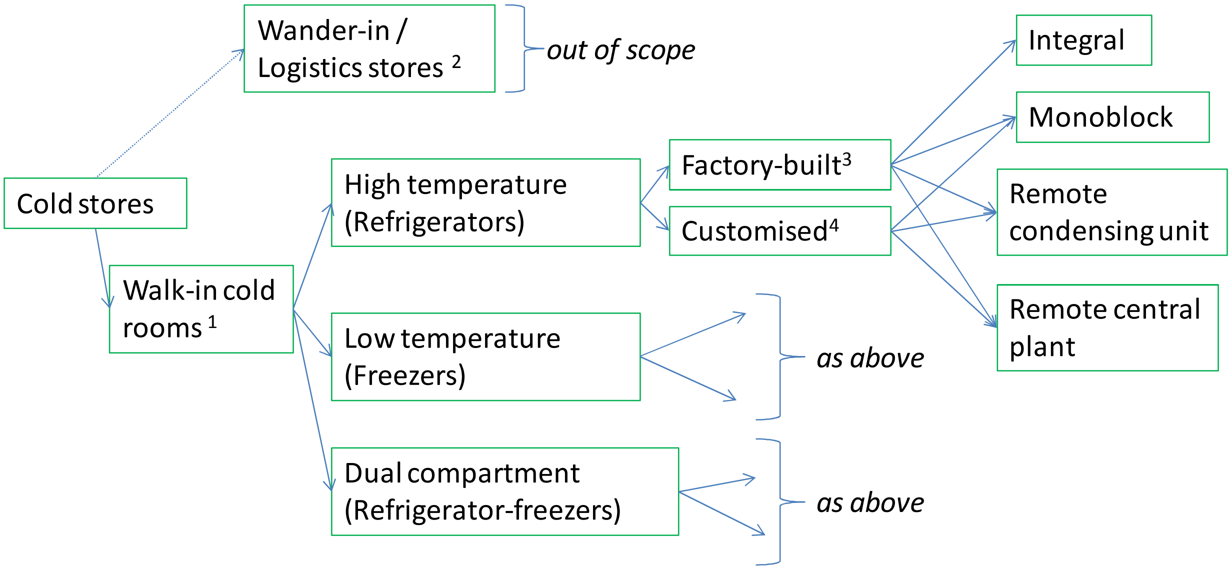
Table 1-9: Walk-in cold rooms categorisation[46]

Equipment type	Typical (attached refrigeration system) equipment characteristics		Size (m^3)	Nominal capacity (W at +5°C)
Mini	Packaged unit	Plug-in	< 27	2,250
Small			< 72	4,100
Medium	Medium condensing unit	Remote	< 144	9,000
Large	Centralised plant or large condensing unit		< 400	20,400

Larger walk-in cold rooms are typically bespoke projects constructed in-situ with component parts from various sources to match the specifications of the end-user (henceforth termed "customised"), while smaller rooms are typically constructed from pre-fabricated insulated enclosures (henceforth termed "factory-built").

The following classification, adapted from those above and informed by stakeholder feedback, is proposed for walk-in cold rooms.

[44] Source: Equipment installer
[45] UK MTP estimates
[46] Mark Ellis, *Strategies to increase the energy efficiency of non-domestic refrigeration in Australia & New Zealand*, 2009



1 – Products up to 400m^3
2 – Cold stores above 400m^3 in size, or those forming part of a building, or those as a stand-alone external building, or those incorporating loading bays are not covered in ENTR Lot 1
3 – Products that are pre-designed and supplied in modular series
4 – Designed and constructed by specialist installers

Figure 1-9: Classification for walk-in cold rooms

There are three main options for the refrigeration system configuration: packaged, remote condensing unit and remote central plant, as described in §1.2.3.3.

There are certain products that are excluded from the scope, including products designed and marketed exclusively for medical, scientific, or research purposes; due to tighter temperature control requirement they have a different functionality, which will have an impact on testing and energy consumption. The scope covers only "walk-in" products and not cold stores (which are more complex constructions). Large systems over 400m^2 are therefore excluded; there would be smaller cold air spill from the product when its door is opened and there are likely to be other heat loads such as vehicle loading bays. Those products incorporated into a building are excluded (apart from cold storage building kits) as they are already covered by existing regulations and are a not similar type of product.

The table below describes factors that are important in the consideration of product design, functionality and performance.

Table 1-10: Specifications of walk-in cold rooms

Categorisations	Explanation	Notes
Size	Small, medium and large products	At approximately 100m^2, a loading dock might be included in a walk in cold store – these have other sources of heat that should be considered; rooms with loading docks are considered out of the scope due to different functionality 400m^3 too big to be classified as 'walk-in' cold rooms.
Construction	Classification should note if the unit	Rooms constructed as part of a building, or that

Categorisations	Explanation	Notes
	is prefabricated or constructed as part of the building	are over 2.5m in height are considered out of the scope due to different functionality
Configuration	Packaged (refrigeration system manufactured as a complete product by manufacturer or integrated into one of the panels) or customised (designed individually)	Could differentiate between products testable under a test standard, and those more complex products that require a different regulatory mechanism (i.e. unique field-erected designs)
Operation and ambient temperatures	Differentiating technical and refrigerant requirements at low freezing and high/medium refrigerating temperature	The functioning temperature will influence the heat load and energy consumption, which will be higher for freezing compared to refrigeration
Climate class	The climate class reflects the ambient conditions, which can influence the choice of the refrigerant, as well as the performance	Two main climate zones could be distinguished in the EU-27: around +11°C for northern Europe and around +15°C for southern Europe
Location of condensing unit	Integrated as part of the insulated enclosure, remote condensing unit or remote central plant	Heat rejection process is different between remote and plug-in configurations System performance is influenced by the ambient temperature - climate zones (air-on temperature) northern/southern EU relevant for remote
Condenser cooling	Air-cooled or water-cooled	-
Application	Foodstuff / pharmaceutical application; Logistics and large industrial applications vs. small retail and storage uses	Equipment for pharmaceutical storage is similar but has more narrowly controlled temperatures, stability specifications and stricter build specification (they use a double freezing system; rooms with these more accurate/double refrigeration systems are considered out of the scope due to different functionality
Internal space arrangement	The internal space arrangement can vary according to requirement of the customer	Affects performance through change of the internal air flow
Insulation thickness	This can range from 50mm to 180mm	-
Condenser type	Water, air, evaporative	Stakeholder feedback has determined that most of the market is air cooled
Refrigerant	The choice of refrigerant depends on the operation temperature, ambient temperature, refrigeration system type	The most commonly used refrigerants is R404a

1.2.4. PROCESS CHILLERS

1.2.4.1 General product definition

According to the International Dictionary of Refrigeration[47], a chiller is a piece of equipment designed to cool water for air-conditioning plants or units in commercial and industrial processes.

In general, a chiller is a refrigerating machine that removes heat from a liquid through a vapour compression or absorption cycle. Chillers can be used in a wide range of applications[48]:

- Plastics: during plastics manufacturing, these equipments are used to cool hot plastics being injected, blown, extruded or stamped, as well as the equipment used during these processes.
- Injection moulding: while removing heat from a source – e.g. during manufacture of plastic products – chillers can transfer heat to make the processes more efficient moulding stage.
- Printing: chillers are able to remove the heat generated by the friction of the rollers and for cooling down the paper after the ink drying process.
- Laser: chilling systems are used to cool down laser and power supplies in the laser cutting and light projection industries.
- Rubber: during the different process of rubber production, temperature control is very important; the use of chillers is common to control these conditions.
- Air conditioning: commonly used in comfort appliances to remove heat from buildings. These machines are considered within the upper operation temperature range. Equipment working in this temperature range will not be included in this preparatory study, instead they will be analysed within the scope of ENTR Lot 6.
- Magnetic resonance imaging: chillers can remove heat from scanners if necessary.
- Anodising: chillers are used to cooled down the water used in these processes to increase the efficiency in warmer climates.

Refrigeration systems that remove heat from foodstuffs in order to preserve it can beneficiate from chiller technology. The temperatures reached in these appliances must meet requirements for food preservation.

1.2.4.2 Existing product definitions

◆ **EUROVENT certification programme**

The EUROVENT certification programme defines liquid chilling packaged as: "a factory assembled unit, designed to cool liquid, using a compressor, an evaporator and an integral or remote condenser and appropriate controls." The certification

[47] International Institute of Refrigeration. *International Dictionary of Refrigeration*. 2007
[48] Source: www.1stchoicechillers.com/products.htm

programme applies to standard chillers used for air conditioning and for refrigeration. They may operate with any type of compressor, but only electrically driven chillers are included. All refrigerants are considered. Chillers may be air-cooled, water cooled or evaporative cooled and with remote condenser. Reverse cycle chillers are also included and certified both in cooling and in heating mode (see § 1.4.10.).

The UK Defra uses the same definition and specifies that **“**Packaged chillers are commonly used in both central plant air-conditioning systems for the built environment where typical applications include offices, retail, commercial and public premises, and for other ‘process’ cooling applications including; food & drink manufacturing, the chemical industry, plastics injection moulding and engineering to name but a few.”

- **UK ECA**

The UK ECA scheme defines packaged water chiller functionality as:

“Packaged chillers generate chilled water that can be used to provide space cooling in summer in large air-conditioned buildings. They can also be used to generate chilled water or brine needed by industrial process cooling. Reversed cycle packaged chillers are able to provide space heating in winter, as well as space cooling”.

- **US AHRI 550/590-2003**

The AHRI 550/590-2003 standard for water-chilling packages using the vapour compression cycle defines water chillers as follows:

“Water-Chilling Package is a factory-made and prefabricated assembly (not necessarily shipped as one package) of one or more compressors, condensers and evaporators, with interconnections and accessories, designed for the purpose of cooling water. It is a machine specifically designed to make use of a vapour compression refrigeration cycle to remove heat from water and reject the heat to a cooling medium, usually air or water. The refrigerant Condenser may or may not be an integral part of the package.”

It further defines a subcategory as follows:

“Heat Reclaim Water-Chilling Package is a factory-made package, designed for the purpose of chilling water and containing a Condenser for reclaiming heat. Where such equipment is provided in more than one assembly, the separate assemblies are to be designed to be used together, and the requirements of rating outlined in this standard are based upon the use of matched assemblies. It is a package specifically designed to make use of the refrigerant cycle to remove heat from the refrigerant and to reject the heat to another fluid (air or water) for heating use. Any excess heat may be rejected to another medium, usually air or water”.

- **US AHRI 560-2000**

The ANSI/AHRI 560:2000 standard for rating absorption water chilling and water heating packages defines absorption chillers as follows:

“Absorption Water Chilling and Water Heating Package Is a factory designed and prefabricated assembly employing water as the refrigerant and consisting of an evaporator, absorber, condenser, generator(s) and solution heat exchangers, with interconnections and accessories used for chilling or heating water. The package utilises single or multiple reconcentrations of an absorbent solution. The reconcentrations of the absorbent are known as effects. A single effect package employs one step reconcentration of the absorbent in the generator. Water vapour is released after the heat energy is introduced into the generator. The concentrated absorbent is returned to the absorber where its double effect package employs a two step reconcentration of the absorbent through the use of an additional high temperature generator. An absorption package can be further defined by the following:

- Direct Fired Package. This type of package reconcentrates the absorbent from heat energy through the combustion of natural gas, LP gas or oil.
- Indirect Fired Package. This type of package reconcentrates the absorbent from heat energy from steam or hot water."

1.2.4.3 Product description

Chillers can be used both in industrial applications for refrigeration purposes and in buildings for air-conditioning purposes. They comprise a refrigeration system and are connected to a water (or water/glycol mix) circuit driven by a pump.

Chillers can be found either as packaged factory assembled units or can be field erected assembly with different components. Both vapour-compression and absorption refrigeration cycles are used. This can be explained by the fact that in buildings or industrial processes, heat losses can occur which can be used to drive the absorption based chillers, leading to significant electricity savings compared to the use of a vapour-compression based chiller.

Chillers' operation temperatures range from -25°C to +15°C, with 3 sub-classifications retaken by EUROVENT Certification program and discussed with stakeholders:

- high temperature chillers: leaving chilled water temperature between +2°C and +15°C;
- medium temperature chillers: leaving brine temperature between -12°C and +3°C; and
- low temperature chillers: leaving brine temperature between -25°C and -8°C.

High temperature chillers are predominantly used for comfort cooling, and are hence excluded from the scope of the study, while medium and low temperature chillers are used for industrial process refrigeration applications and are investigated. High operation temperature equipment will be considered under the scope of ENTR Lot 6.

In order to reach low and medium temperatures, the water used in the chiller is mixed with Ethylene glycol or propylene glycol. The efficiency of the equipment will decrease with the increase of the concentration of this substance. Another factor affecting the efficiency corresponds to the differential of temperature.

The choice of the type of technology depends mostly on the application range, as described in Table 1-11.

Table 1-11: Technologies applied in chillers according to capacity range[49]

Cycle	Technology	Typical Capacity Range (kW) (and tonne of refrigeration)[1]	Typical Capacity Range (kW) (and tonne of refrigeration)[2]	Typical Capacity Range (kW) (and tonne of refrigeration)[3]
Vapour Compression	Centrifugal compressor	>200 (60)	-	300 – 9,000 (85 – 2,600)
	Screw compressor	200-1,500 (50-400)	100 – 1,900 (30 – 540)	100 – 1,900 (30 – 540)
	Scroll compressor	< 750 (215)	10 – 250 (3 – 70)	15 – 200 (4 – 50)
	Reciprocating compressor	75 – 500 (20 – 150)	0.5 – 200	-
Absorption		> 15 (5)	Non-applicable	Non-applicable

[1]Relevant for air conditioning
[2]Relevant for refrigeration, air-cooled
[3]Relevant for refrigeration, water-cooled
-: Non-available data

Process chillers

Process chillers for refrigeration are used in many different applications[50] to provide cold water and process refrigeration and can be either plug-in appliances (packaged) or uniquely designed to meet customers' specifications.

A single chiller cannot fit every temperature level requirement. Some chillers are designed to cool to very low temperatures while others are designed for only mid-range applications. Some designs can support very high flow rates of fluid and others are designed for low rates of fluid. The same issues apply with ambient temperatures. Some chillers use refrigerant suited for a high ambient temperature environment while other refrigerants are formulated for cooler conditions.

Packaged chillers are factory-assembled refrigeration units that are designed to cool liquid using a plug-in, electrically-driven mechanical vapour-compression system or gas fired absorption system. Packaged chillers based on vapour compression systems include the refrigeration compressor(s), controls (e.g. temperature settings, etc.) and the evaporator in the packaged unit. The condenser may also be integrated or remote, air-cooled or water-cooled (see Figure 1-10). Some packaged chillers may also include a unit comprising a chilled water (or water/glycol mix) buffer tank and a chilled water (or water/glycol mix) circulation pump which constitutes the coolant circuit hardware (see Figure 1-11).

[49] Alliance for Responsible Atmospheric Policy, *Global Comparative Analysis of HFC and Alternative Technologies for Refrigeration, Air Conditioning, Foam, Solvent, Aerosol Propellant, and Fire Protection Applications*, Final Report, March 21, 2002

[50] E.g. Plastics & Rubber: presses, injection, moulding, extrusion, blow moulding, thermoforming, PET; Lasers: cutting, welding, profiling, optics, medical, engraving; Food & Beverage: confectionary, bakeries, distilleries, breweries, wineries, dairies, bottling, carbonation, meat and fish, processing, vegetable and salad processing, storage; Chemical & Pharmaceutical: jacketed, vessels, polyurethane foam mixers, natural gas, industrial cleaning, laboratories, healthcare, solvents, paints, photo processing, oil cooling; Metal Working: processing and transformation of precious metals, aluminium working and processing; Mechanical & Engineering: machine tools, welding machines, rolling mills, presses, extruders, cutting, profiling, polishing, electric spark machinery, hydraulic control unit oil, oiling, pneumatic transport, heat treatment; Paper & Related Applications: printers, cardboard, labels, plastic film and other applications

Packaged chillers without these two components of the coolant circuit integrated are also known as “split” chillers” (see Figure 1-10).

These units deliver a cooling capacity ranging from 1.75kW to 700kW in the case of packaged chillers with air-cooled condensers, and up to 7,050 kW in the case of packaged chillers using a water-cooled condenser.

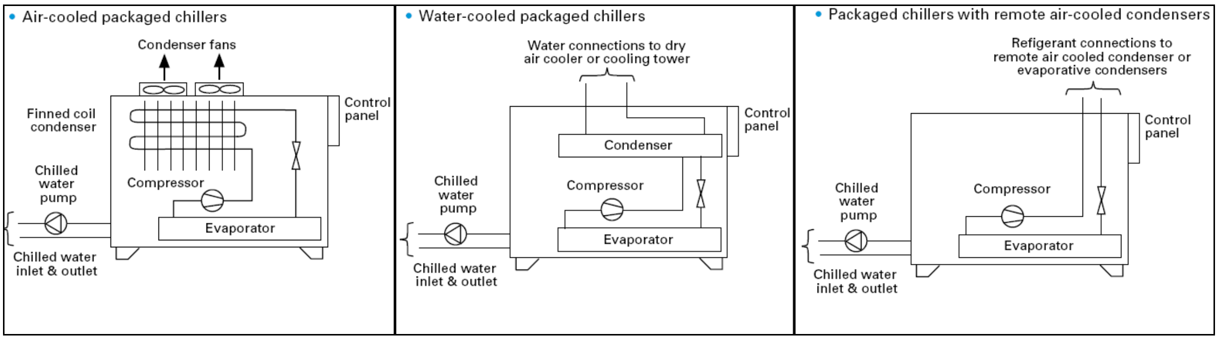


Figure 1-10: Existing configurations for packaged chillers[51]

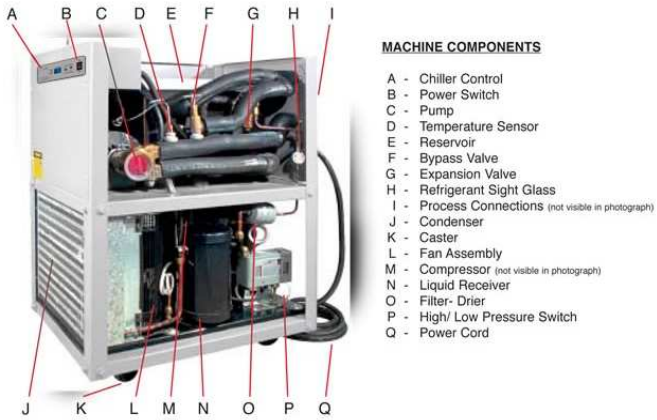


Figure 1-11: Packaged chiller integrating the coolant circuit pump and tank[52]

Packaged absorption based chillers also exist which are driven by gas combustion. Such products include a gas burner which serves as the heat source to drive the generator.

[51] UK Carbon Trust, *Industrial refrigeration equipment, A guide to equipment eligible for Enhanced Capital Allowances. 2009*

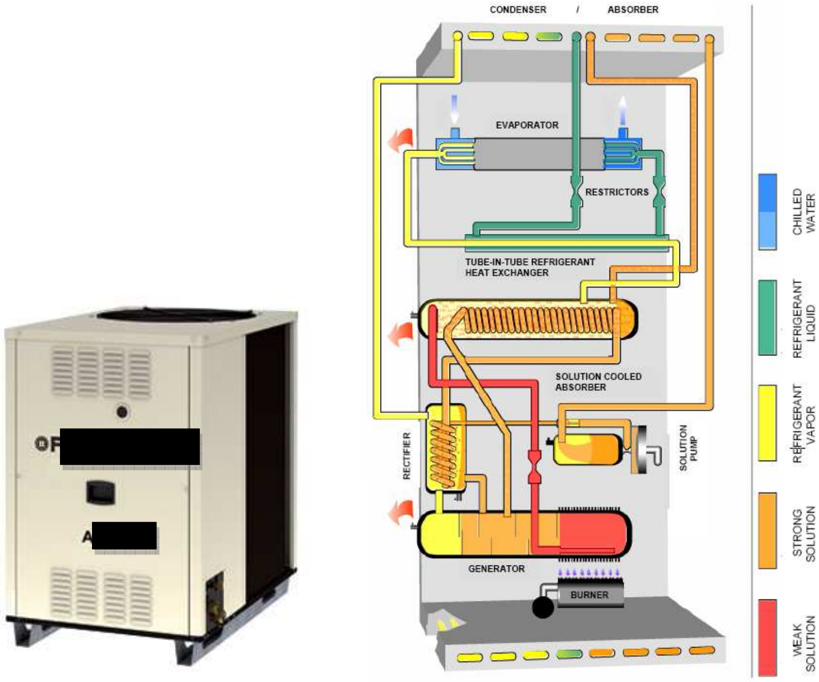


Figure 1-12: Packaged absorption chiller (packaged) and its refrigeration cycle[53]

Larger compression chillers are referred to as “packaged chiller plants” and are factory-assembled units but without any casing. These larger chillers can rely on compression or absorption technologies and can provide cooling capacities up to thousands of kW. These larger central plants can incorporate a pump and tank or not.

Some manufacturers also propose customised solutions. Such chillers are bespoke projects assembled in-situ with component parts from various sources to match the design specifications.

It is assumed that the average typical electricity consumption for industrial process chillers amounts to around 400,000 kWh/year[54].

[53] Source : ROBUR www.robur.com
[54] MTP, *What If tool*, data updated April 2008. Available at:whatif.mtprog.com/Level3/ProductDetail.aspx?ScenarioID=0&Comparison=False&Year=2008&SchemeID=1&ProductID=51

- **Chillers used in air-conditioning processes**

Chillers used in air conditioning processes are the core of a larger system which comprises air-handling units, with a network of pipes and pumps to connect them (see Figure 1-13).

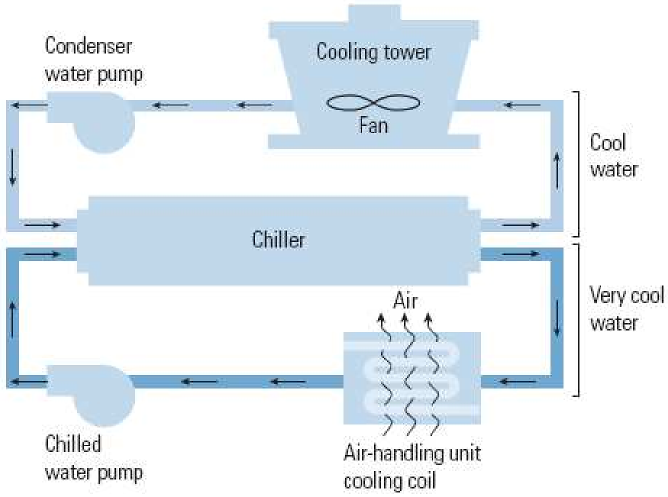


Figure 1-13: Typical water cooled chiller system[55]

Such chillers can either rely on the vapour-compression (Figure 1-14) cycle or the absorption-cycle (Figure 1-15).

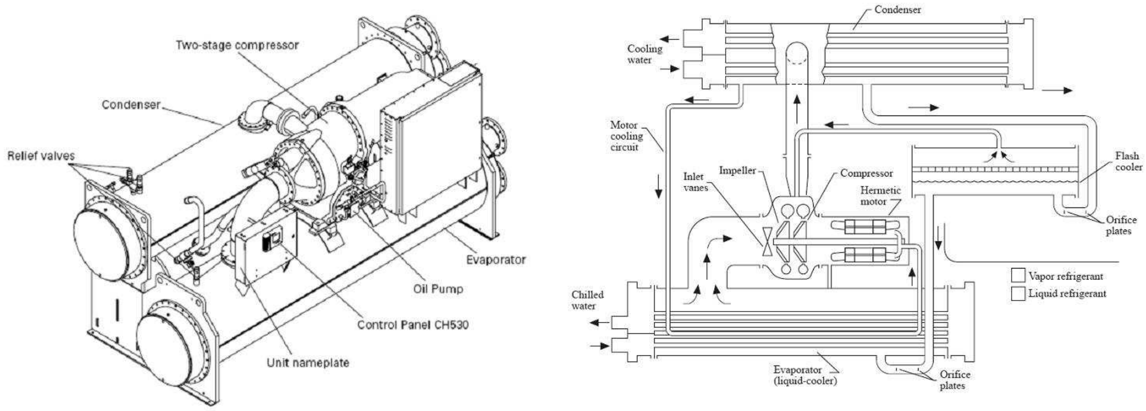


Figure 1-14: Typical water cooled chiller using compression technology[56]

[55] Source: US Energy Star www.energystar.gov/ia/business/EPA_BUM_CH9_HVAC.pdf

[56] TRANE. Operation Maintenance Manual CVGF-SVU02B-E4.

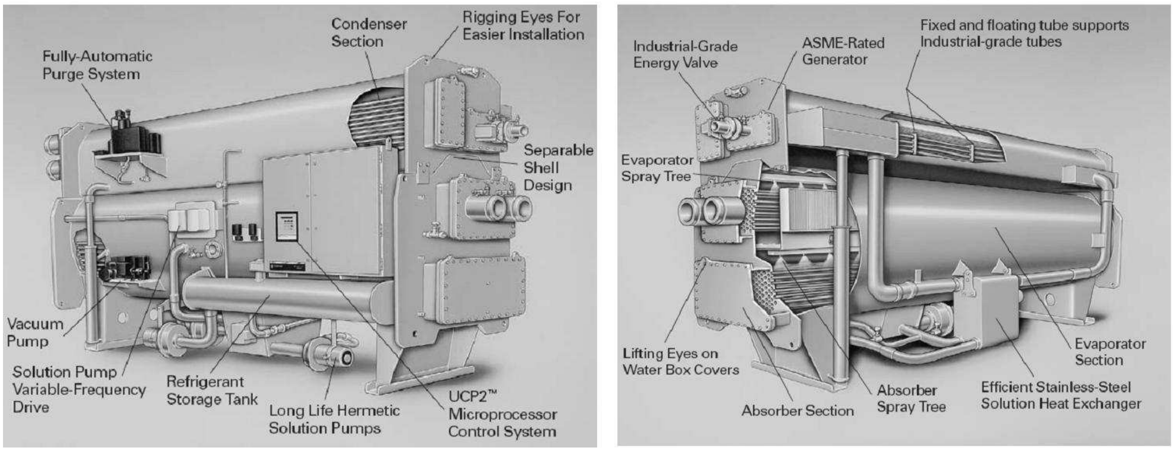


Figure 1-15: Typical water cooled chiller using absorption technology[57]

The variation of the efficiency according to the outlet temperature for an equipment of the same capacity is shown in Table 1-12. The factor of variation was provided by stakeholders and is only an approximation, as the same equipment is not likely able to perform at extremely different temperature ranges.

Table 1-12: Change of the efficiency according to outlet temperature for equipment of the same capacity, considering high temperature equipment as base

Outlet temperature range (°C)	Average outlet temperature (°C)	Efficiency factor
+2 / +15	+7	X
-12 / +3	-5	0.7X
-25/-8	-15	0.5X

1.2.4.4 Functional unit and performance parameter

The primary function of a chiller is to cool down and maintain the temperature of a liquid (e.g. water, water/glycol mix) to cool an environment, process or product to an appropriate level of temperature. **The functional unit is therefore the cooling capacity, in kW, considering a reference ambient temperature at which the measurement is done (+30°C for water-cooled equipment and +35°C for air-cooled equipment)**

The performance parameter of chillers is expressed using the COP[58], which is the ratio between the cooling capacity and the power input.

The heating performance of chillers is also expressed using the COP which is the ratio of the heating capacity (i.e. heat given off from the refrigerant to the liquid being heated per unit of time in reverse cycle operation) to the power input of the unit.

Chillers usually operate at full load only during a limited period of time during a year. Therefore, the part load performance is much closer to reality. In the US, the performance of chillers is expressed as the Integrated Part Load Value (IPLV) which

[57] TRANE. Trane horizon Absorption Series. ABS-PRC0016EN

[58] COP: Coefficient of Performance: ratio between cooling capacity and power input

is the average power input based upon a chiller operating at part loads through a cooling season.

In the EU, an index called ESEER – Seasonal energy efficiency ratio – is used. This index is similar to IPLV and takes into account several parameters in order to establish an average use of chillers throughout EU: weather data, building load characteristics, operational hours etc. Stakeholders commented that this ratio was soon to be replaced by the SEER, as mentioned in prEN 14825:2009.

1.2.4.5 Chiller classification and scope for the study

Chillers represent a very wide range of products, not only in terms of applications but also technologies.

AHRI 550/590:2003 proposes a classification to water chillers depending on the cooling medium (Water-cooled chillers, evaporatively-cooled and air-cooled), while ANSI/AHRI 560 proposes a classification for absorption chillers based on the technology (single stage indirect fired, two-stage indirect fired and two-stage direct fired)

EUROVENT certification program presents classification of equipments depending on the following parameters:

- heat rejection: water cooled or air cooled;
- system: packaged, split or remote condenser;
- operation type: cooling only or cooling/heating;
- duct: ducted or non-ducted;
- compressor type (centrifugal, screw, etc.)

The UK ECA scheme classifies packaged chillers according to their capacity related to the technology implemented in the system. However, it only includes within the scope vapour-compression units. It considers the following four groups[59]:

- air-cooled packaged chillers that only provide cooling and have a cooling capacity that is less than or equal to 1,500kW;
- air-cooled, reverse cycle, packaged chillers that provide heating and cooling and have a cooling capacity that is less than or equal to 750kW;
- water-cooled packaged chillers that only provide cooling and have a cooling capacity that is less than or equal to 2,000kW; and
- water-cooled, reverse cycle, packaged chillers that provide heating and cooling and have a cooling capacity that is less than or equal to 2,000kW.

The sub-classifications for the cooling capacity, related to EER and COP are shown in Table 1-28.

[59] ECA Energy Technology Criteria List 2009 – Refrigeration Equipment. *Packaged Chillers*

Table 1-13: UK ECA packaged chillers classification by technology and cooling capacity

Product Category		Cooling Capacity CC (kW)
Air-cooled packaged chillers that provide cooling only	Without integral free cooling mechanisms	< 1,500
	With integral free cooling mechanisms	< 1,500
Air-cooled, reverse cycle, packaged chillers that provide heating and cooling		< 750
Water-cooled packaged chillers that provide cooling only		< 2,000
Water-cooled, reverse cycle, packaged chillers that provide heating and cooling		< 2,000

This classification corresponds to comments from stakeholders. For higher capacities, only water cooling is applicable.

The classification from the industry is firstly related to the use phase (heating, air-conditioning, applied systems and refrigeration) and the required capacity or size (Table 1-1410). Under the scope of this study, only refrigeration systems are taken into consideration.

Table 1-14: Industry's common classification of chillers

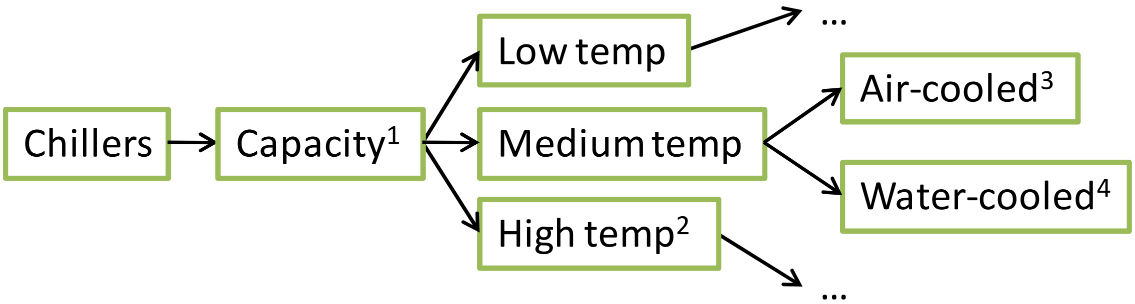
Size	Capacity (kW)
Small	10 – 17
	18 – 50
	51 – 100
Medium	101 – 200
	201 – 350
	351 – 500
Large	501 – 700
	701 – 900
Extra-large	> 901

Industry disaggregates chillers according to the type of compressor used:

- rotary vane: mostly used for low capacities (<15kW) being air-cooled;
- scroll: used for medium capacities (15 – 250 kW) being water-, air-cooled and condenser-less;
- screw: used to obtain medium high cooling capacities (150 – 2,000kW) being water-, air-cooled and condenser-less; manufactures claim to reach low temperature though the use of semi-hermetic screw compressors;
- centrifugal: equipment using this technology are able to reach high cooling capacities (300 – 9,000kW), being water-cooled;
- reciprocating: 0.5 – 181 kW, being air-cooled.

Classification by temperature range (-25°C/-8°C; -12°C/+3°C; +2°C/+15°C) is suitable for discriminating the final use of chillers. The lower and medium ranges are normally used for refrigeration and cold storage, while the highest range corresponds to comfort. Some industrial processes have output water chilled between +4°C and +6°C – these products might require specific performance constraints different from air-conditioning equipment. Some stakeholders stated that the power capacity and size are common classifications because they provide with the necessary information about energy and working capacity (even if they reach the same temperatures). The cooling system of each chiller is relevant as it will have environmental consequences. Also, it is very important to take into account the type of refrigerant for environmental reasons. However, the energy performance of the equipment is more related to the configuration than the type of refrigerant used[60].

According to stakeholders, there is a size limitation for packaged chillers, having up to 5MW of cooling capacity if it is water-cooled, and up to 1,500-1,800kW if it is air-cooled (due to limitations regarding noise problems). Air cooled equipment is also less energy efficient than water cooled ones[61].



1 – Capacities to be from 15kW to 1000kW. The compressor type will be related to the capacity required
2 – Low temperature: -25°C / -8°C. Medium temperature: -12°C / +3°C. High temperature: +2°C / +15°C (not considered under the scope of ENTR Lot 1, therefore absorption chillers are not considered in the scope of the study)
3 – Relevant specially for small capacity equipment
4 – Only relevant for big capacity equipment

Figure 1-16: Chiller classification

The following table describes some of the main differentiating criteria related to the product group, which may impact energy consumption.

[60] Mark Ellis consultation 2010.
[61] Energy Efficiency Ratio (EER) - a ratio of the cooling capacity in Btu/h to the power input values in watts at any given set of Rating Conditions expressed in Btu/(W·h)

Table 1-15: Specifications of process chillers

Categorisations	Explanation	Notes
Configuration	Field-erected or packaged	Comments from stakeholders indicated that the configuration of the equipment does not significantly influence the energy consumption (as long as it is properly installed)
Operation temperature	High, medium or low	The efficiency of chillers decrease for lower temperatures.
Location of condensing unit	Packaged equipment with integral condensing unit Remote, connected to a central plant or exterior condensing unit	Influences ambient temperature - climate zones (air-on temperature) northern/southern EU relevant for remote
Ambient temperature	The ambient temperature can influence the choice of the refrigerant, as well as the performance	Two main climate zones could be distinguished in the EU-27: around +11°C for northern Europe and around +15°C for southern Europe
Cooling capacity	The compressor and system used depends on the operating temperature and the cooling capacity of the product.	For low cooling capacities, the most used compressor is hermetic reciprocating; while for medium and high cooling capacities the compressor can be semi-hermetic reciprocating, scroll or screw. Large cooling capacities require compressor packs and racks
Refrigeration system	Vapour compression or absorption	-
Compressor type	There are different technologies applicable to compressors: • reciprocating (hermetic and semi-hermetic); • scroll ; • rotary ; • and screw	-
Condenser type	Water, air, evaporative	-
Refrigerant	The choice of refrigerant depends on the operation temperature, ambient temperature, refrigeration system type	-
Anti-freezing agent	Additive to avoid water freezing at lower temperatures. Ethylene glycol, propylene glycol and brine are typically used from 10% to 40% depending on the target temperature.	-

Chillers covered in the study are those that operate at low and medium temperature (see § 1.2.4.3) – those that are predominantly used for commercial and industrial freezing or chilling – and chillers used for high temperature applications are excluded (to be covered by ENTR Lot 6).

1.2.5. REMOTE CONDENSING UNITS

1.2.5.1 General product definition

Remote condensing units are a classification of products which only comprise of part of the refrigeration cycle: the compressor and the condenser. The evaporator and expansion valve are components which, as supplied, are integrated in the cold storage devices (cabinets, cold rooms, etc.) and are required to complete the system.

There are typically three fundamental system arrangements:

- packaged condensing units (PCUs) with one or more compressors;
- non-packaged condensing units with independent compressor and condenser;
- compressor packs or racks independent from the condenser.

PCUs are products which include one or more compressor(s) and condensing equipment for cooling rooms or large spaces, such as cool storage rooms, or for providing refrigeration service to other locations. Remote refrigerating appliances (i.e. not plug-in appliances), including the products discussed above, can be connected to the PCU.

PCUs are commonly installed in walk-in cold rooms in clubs, pubs, hotels, butchers and other food preparation and service industries. They are also widely used in supermarkets. In most of these places, additional refrigeration energy is provided by self-contained central refrigeration units, however the large majority of refrigeration energy is provided by PCUs[62].

Non-packaged condensing units are independent compressors and condensers that can be sold and installed separately and thus can be considered as a customised cooling system.

Compressor packs are framed packages of up to ten compressors, the average is three, with one or more remote condensers designed for commercial refrigeration purposes. When compressor packs are used for industrial processes, they are designed as compressor racks. These appliances are designed to be incorporated into a refrigeration system and normally mounted indoors in mechanical rooms, for large applications such as supermarkets. They require an external condensing unit (or less commonly can have integrated water cooled condensers). A compressor pack or rack is defined as an assembly of one or more compressors complete with interconnecting pipe work. They may include liquid receivers, filter driers, oil separators, shut-off valves and related controls, and are supplied on a structurally rigid frame. Most packs are in the range 30 kW to 400 kW, reaching a maximum of 900 kW. They are generally customised, adjusted and installed according to the needs of the customer.

A typical compressor pack (commercial cooling) or rack (industrial cooling) is factory assembled and incorporates at least the following components:

[62] Analysis of Potential for Minimum Energy Performance Standards for Remote Commercial Refrigeration, Mark Ellis & Associates, 2000

- one or more electrically driven refrigeration compressors; and
- a control system that controls the product's compressor(s) and cooling fan(s).

Non-packaged condensing units and compressor packs/racks, which operate independently from the condenser, are not complete condensing units because they do not have condensers integrated, but only compressors and controls. These two parts are sold independently, and thus the performance is measured only on the compressor or on the condenser fan motors. When the compressor is sold as an independent product it is affected by the regulation EC 640/2009 for electric motors.

For this reason, non packaged condensing units and compressor packs/racks are not under the scope of this preparatory study and will not be further investigated.

1.2.5.2 Existing product definitions

A condensing unit is defined as an assembly of a condenser and one or more compressors completed with interconnecting pipe work. They may include liquid receivers, filter driers, oil separators, shut-off valves and related controls, as well as a weatherproof housing[63].

PCUs cover products that are specifically designed to provide cooling to other equipment that incorporate evaporators (and associated expansion valve control systems).

According to the International Dictionary of Refrigeration[64], a condensing unit is an assembly including a compressor with motor, a condenser, and a liquid receiver when required.

In the EN 13215:2000 standard, condensing unit is defined as "combination of one or more compressors, condensers or liquid receivers (when applicable) and the regularly furnished accessories".

In the EN 13771-2:2007 standard, a condensing unit is defined as a "factory assembled unit comprised of refrigeration compressor and motor, condenser and any necessary associated ancillaries".

In the UK ECA Scheme certification programme, air cooled condensing units are defined as "factory-assembled units that consist of an air-cooled condenser, one or more compressors, and interconnecting pipe work. They may include liquid receivers, filter driers, oil separators, shut off valves and related controls, and a weatherproof housing".

1.2.5.3 Product description

PCUs are factory-assembled, packaged units that consist of a refrigeration compressor, a motor, a condenser, and various others components. This packaged unit does not contain a complete refrigeration system, but is designed to provide a cooling for a cold room or other equipment fitted with an evaporator that is controlled by an expansion valve.

[63] ECA Energy Technology Criteria List – Technology: Refrigeration Equipment, August 2004.
[64] International Institute of Refrigeration. *International Dictionary of Refrigeration*. 2007

A typical PCU is factory assembled and incorporates at least the following components:

- refrigerant condenser;
- one or more electrically driven refrigeration compressors; and
- a control system that controls the product's compressor(s) and cooling fan(s).

PCUs are placed on the market as a complete product. Configuration of the system (such as the piping system between the condensing unit and the remote appliance(s)) may be dealt with by the installer or the user.

Figure 1-17: Typical packaged condensing units - individual compressor unit and parallel compressor unit.

PCUs are used in a variety of commercial and industrial cooling applications, including cold rooms, refrigerated display cabinets, back-bar equipment, temperature controlled food preparation areas, and for air conditioning systems.

The average remote condensing unit is based on the Standard Specifications[65]. Two main types of PCUs were identified: 3-20 kW (air cooled); and 20-420 kW (air cooled).

However, this classification of capacity ranges does not match the classification split used in the industry, because most of the condensing units are between 3-50 kW and capacities higher than 100 kW are only used for large systems. Thus, the classification proposed by this preparatory study follows the recommendations made by stakeholders.

The most commonly used RCUs are air cooled and consist of an hermetic reciprocating compressor, air-cooled condenser coil, fan, motors, refrigerant reservoir, and operating controls. These figures will be further explained in the market data section.

According to the answers received to the 1st ENTR Lot 1 questionnaire[66], it is assumed that the average RCU equipment (a condensing unit using a single reciprocating compressor with on/off motor, running R404A as refrigerant liquid and with 5 to 7 kW of cooling capacity measured at +32°C ambient temperature

---

[65] Specification Standards from University of Washington

[66] BIO Intelligence Service. *First ENTR Lot 1 online questionnaire to stakeholders*. Different versions of the questionnaire are available depending on the product category and can be downloaded from www.ecofreezercom.org/documents_1.php

and +10°C evaporating temperature, with a condenser fan of 130W) consumes around 20,000 kWh/year. This estimation varies depending on the ambient temperature, evaporating temperature, refrigerant used, type of compressor and fan, characteristics of the system and workload, leakage rate, etc.

1.2.5.4 Functional unit and performance parameter

The function of remote refrigeration systems is to provide refrigeration service to other appliances. Therefore the way of calculating the electricity consumption of the remote condensing units is using the REC, in kilowatt hours per 24-hour period. This refers to the electricity consumption of the condenser and the compressor which is used to provide cooling energy to the appliance. REC is based on the input and output temperatures of the liquid refrigerant circulating in and out of the remote product.

The remote condensing units work an average of 15-17 hours per day, 365 days per year. These working hours are not continuous, and the length of each working time depends on the needs of the system. The rest of the time the condensing unit does not consume energy, according to information received from stakeholders.

The ambient temperature varies for the different countries in the EU, from an average of +11°C in northern member states to +15°C in the southern member states. However, the ambient temperature stated in the testing standard EN 13215:2000 is +32°C.

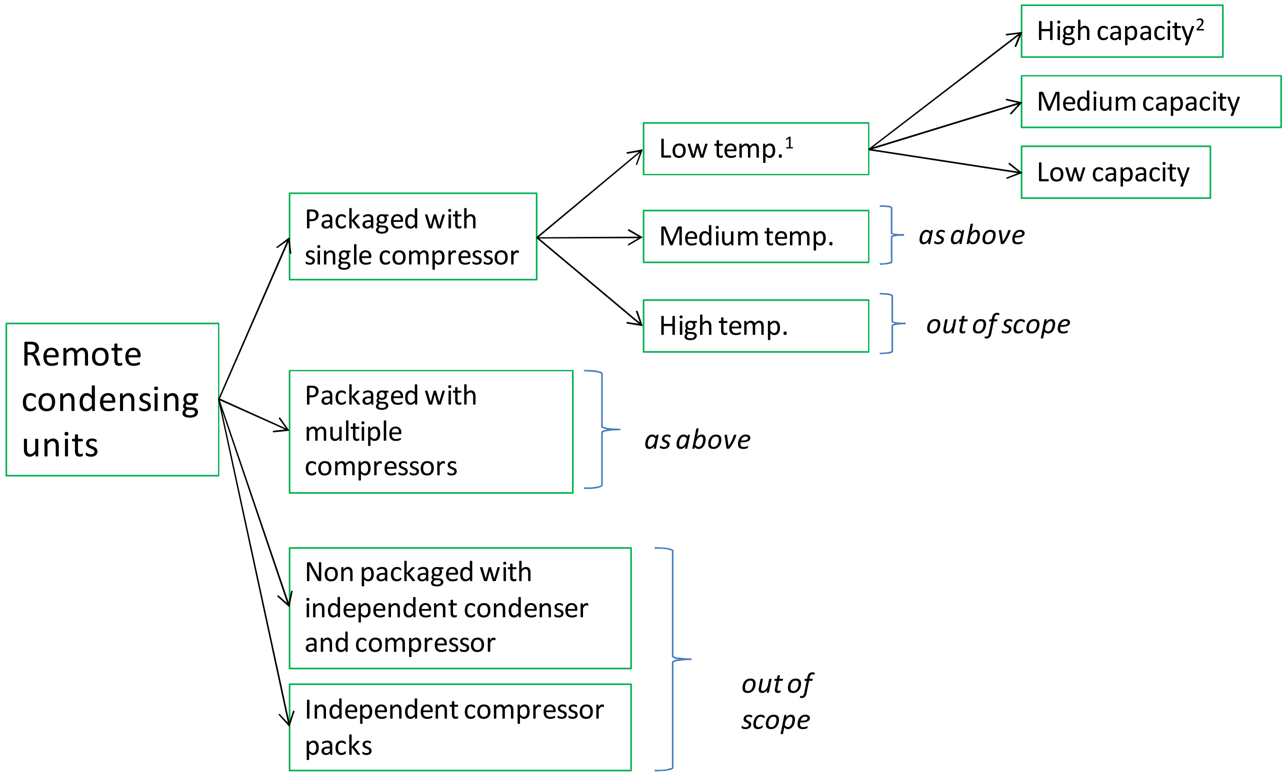
The functional unit identified for these equipments is kW of cooling capacity.

The proposed performance parameter is the coefficient of performance (COP[58]).

1.2.5.5 Remote condensing units classification and scope for the study

A classification for RCUs included in the scope of the study is illustrated below in Figure 1-18. This classification was developed with the industry and considers the parameters typically used.

Categorisation of appliances begins with the layout of the refrigeration components. Packaged condensing units with integrated compressors which are intended to be mounted outside are one category, the next category being packaged condensing units with multiple compressors. Compressor packs requiring externally mounted condensers and independent compressors and condensers do not fit the existing definitions of condensing units and are left out of the scope of this study, as explained above. The packaged condensing units can then be subcategorized by the evaporating temperature which determines the capacity, size of compressor, energy consumption, etc. Finally the capacity of the unit can help to classify the product. Other characteristics to further classify remote condensing units are compressor type (reciprocating, scroll, screw or rotary), compressor motor speed drive (on/off, two speeds, variable speed) and condenser cooling (air or water cooled).



1 – High temperature: +5°C; Medium temperature: -10°C; Low temperature: -35°C
2 – High capacity: > 50kW; Medium capacity: 20kW-50kW; Low capacity: 0.2kW-20kW

Figure 1-18: Remote condensing unit classification

Condensing units for high evaporating temperature (+5°C) are used in air conditioning systems whereas, in commercial refrigeration, only medium (-10°C) and low (-35°C) temperatures are used. As the scope of this preparatory study is commercial refrigeration, and air conditioning products are covered in ENER Lot 6 preparatory study (air conditioning and ventilations systems), condensing units for high temperatures are left out of the scope of the present preparatory study and will not be further investigated. However, some of the appliances designed for medium temperature can work at high temperature and vice-versa. The aim of this preparatory study is to inform the later discussion and consultation process which may lead to regulation the performance of the remote condensing units working on commercial refrigeration temperatures, even though the products affected can be used for other purposes. The share of the market that this kind of appliance represents is not taken into account in the various calculations.

The following table describes some of the main differentiating criteria related to the product group, which may impact energy consumption.

Table 1-16: Specifications of condensing units

Categorisations	Explanation	Notes
Configuration	The condensing units can be designed and sold as: • packaged with single compressor(compressor and condenser on the same plate); • packaged with twin compressors or more • compressor packs or racks • independent compressor and condenser	Packaged and independent configurations can be sold as independent products by the industry Both packaged units and independent systems can use up to 10 compressors in order to obtain higher cooling capacities and efficiencies.
Evaporating temperature	Evaporating temperatures in food conservation applications are driven by legislation: frozen foodstuff must be under -18°C (LT). • Low evaporation temp.: -35°C • Medium evaporation temperature: -10°C • High evaporation temp.: +5°C	The operating temperature determines the appropriate refrigerant and required cooling capacity.
Cooling capacity	The compressor and system used depends on the operating temperature and the cooling capacity of the product.	For low cooling capacities, the most used compressor is hermetic reciprocating; while for medium and high cooling capacities the compressor can be semi-hermetic reciprocating or scroll. Screw compressors are used in larger cooling capacities and mostly for air conditioning. Extra large cooling capacities require compressor racks.
Compressor type	There are different technologies applicable to compressors: • reciprocating (hermetic and semi-hermetic) • scroll • screw • rotary	The most used compressor is reciprocating hermetic
Compressor motor drive	The compressor motor can be driven with different technologies: • on/off • 2-speed • variable speed drive	In partial load conditions, 2 speed and variable speed drive can achieve higher efficiencies than on/off compressors, but under full load conditions the on/off technology is more efficient.
Condenser type	Water cooled, air cooled.	Stakeholder feedback has determined that most of the market is air cooled.
Refrigerant	The choice of refrigerant depends on the operation temperature, ambient temperature, refrigeration system type.	The most commonly used refrigerant is R404a.
Ambient temperature	The ambient temperature can influence the choice of the refrigerant, as well as the performance of the condensing unit.	Two main climate zones can be distinguished in the EU-27: around +11°C for northern Europe and around +15°C for southern Europe EN 13215:2000 standard establishes +32°C as standard temperature for testing; UK ECA Scheme establishes MEPS for +20°C ambient temperature.

Categorisations	Explanation	Notes
Location	The location of the condensing unit can impact its performance.	Should be placed in a well ventilated area, away from direct sunlight.

Only packaged condensing units are included in the scope of the present study. The manner in which these products interact with the system they operate under is very important for the overall efficiency of the system and therefore must be analysed from an ecodesign perspective.

1.2.6. PRODCOM DEFINITIONS

In order to better identify the types of equipment that can be considered as refrigeration and freezing equipment, existing product classifications used by PRODCOM[67] are identified. PRODCOM classifies commercial refrigerators and freezers in the category NACE 29.23 – "Manufacture of non-domestic cooling and ventilation equipment". In its subcategories different types of refrigerating appliances are listed, which are presented in Table 1-17.

Table 1-17: PRODCOM classification of commercial refrigeration equipment

PRODCOM code	PRODCOM category
29.23.13	Refrigerating and freezing equipment and heat pumps, except household type equipment
29.23.13.33	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator for frozen food storage
29.23.13.35	Refrigerated show-cases and counters incorporating a refrigerating unit or evaporator (except for frozen food storage)
29.23.13.40	Deep-freezing refrigerating furniture (except for chest freezers of a capacity ≤ 800 litres, upright freezers of a capacity ≤ 900 litres)
29.23.13.50	Refrigerating furniture (except for deep-freezing, show-cases and counters incorporating a refrigerating unit or evaporator)
29.23.13.73	Compression type units whose condensers are heat exchangers, heat pumps
29.23.13.75	Absorption heat pumps
29.23.13.90	Other refrigerating or freezing equipment

It can be observed that commercial refrigeration appliances appear in this classification explicitly. However, apart from the capacity and the temperature, few criteria are used to distinguish between different types of products (e.g. no differentiation between plug-in and remote appliances).

As some of the equipment of the commercial refrigeration sector is technically similar to domestic refrigeration equipment (e.g. service cabinets), the table below provides PRODCOM references for household-type refrigerators and freezers.

[67] PRODCOM Classification: List of Products of the European Union

Table 1-18: PRODCOM classification of household refrigeration equipment

PRODCOM code	PRODCOM category
29.71.11	Refrigerators and freezers, of the household type
29.71.11.10	Combined refrigerators and freezers, with separate external doors
29.71.11.33	Household type refrigerators (including compression-type, electrical absorption type, excluding built-in)
29.71.11.35	Compression-type, built-in
29.71.11.50	Chest freezers of capacity ≤ 800 litres
29.71.11.70	Upright freezers of a capacity ≤ 900 litres

1.3. PRODUCT TEST STANDARDS, THEIR DEVELOPMENT AND OTHER STANDARDS

The aims of this section are to give an overview of existing product standards, standards under development and associated test methods, to identify gaps, and to highlight needs for forums to discuss development of standards and creation of new standards. Please also see annex 1-2 for other standards related to the product groups.

A "testing standard" is a standard that sets out a test method but does not indicate what result is required when performing that test. Therefore, strictly speaking, a testing standard is different from a "technical standard". In technical use, a standard is a concrete example of an item or a specification against which all others may be measured or tested. Often it indicates a required performance level to be achieved in order to comply with the standard. Testing standards are also (but not exclusively) defined in the technical standard itself. For example, an ISO standard for a product or process gives detailed technical specifications, which are required in order to conform to that standard. It also defines testing methods to be followed for validating such conformity. A standard can be either product- or sector-specific, and it can concern various stages of a product's life cycle.

The main focus in this subtask is on environmental performance and related technical aspects (e.g. energy consumption and resource consumption) in relation to functional performance. However, for the sake of completeness, other standards (such as health and safety-related standards) related to refrigeration equipment are also considered.

Test methods and standards exist for nearly all components used within refrigeration equipment and are presented in Annex 1-1.

It is important to note that for product performance testing, different testing methodologies can lead to significant variations in test results for the same product, and that frequently for refrigeration there are requirements concerning limits to temperature fluctuations within the refrigerated space that relate to food safety. Therefore, although some standard performance parameter figures quoted in the literature may seem comparatively low, it is not always stated what standard methodology these figures have been measured under, and whether the product satisfies the food safety requirements.

1.3.1. SERVICE CABINETS

Historically EN 441 has been the standard methodology for testing of service cabinets. It has been proposed that a new standard be developed for professional service cabinets in the EU, based on EN ISO 23953, and this process is being driven by EFCEM[68]. This development has been slightly confused due to the different technical committees that are responsible for safety and performance of these products. TC59/61/E-C is relevant to safety, whereas TC59X is relevant to performance. Stakeholders estimated that the variation in results of performance testing can be 5 to 10% between EN 441 and EN ISO 23953 when evaluating the

[68] Source: EFCEM, ENTR Lot 1 3rd stakeholder meeting

same product[69]. The differences between these two test methodologies are compared in §1.3.1.7 and §1.3.1.8.

1.3.1.1 EN ISO 23953:2005 (under revision)

Relevance: Service cabinets, possible adaptability for blast cabinets

EN ISO 23953:2005 **“**Refrigerated display cabinets – Vocabulary, Classification, requirements and test conditions” (replacing former EN 441:1995) is used for energy consumption measurement of commercial refrigerated display cabinets for the sale and/or display of food products. In principle this standard can be used for measuring the energy performance of service cabinets as well.

Scope: This standard does not cover service cabinets intended for use in catering or similar non-retail appliances, minibars, ice-makers, ice cream machines, milkshake machines and cold rooms. However, this standard could be used for performance calculation of professional service cabinets (for example, former version EN 441:1995 is used as a reference testing method in the framework of the UK ECA for commercial service cabinets).

The test for closed refrigerated cabinets should always be carried out on a complete cabinet, regardless of the number of doors or lids. The requirements state that the cabinet lighting should be switched on for a period of 12 h; followed by 12 h with the cabinet lighting switched off. With the night covers removed, leave the cabinet lighting switched on for a period of 12 h; followed by 12 h with the night covers on and the cabinet lighting switched off.

Start	0 - 12 hours	12 – 24 hours
3 min open (2)	each door or lid opened 6 times per hour for 6 seconds(3)	each door closed

(2)Where a cabinet is provided with more than one door or lid, each door or lid shall be opened for 3 min consecutively.

(3)Door open at an angle of greater than 60° for 4 s. If the cabinet has multiple doors, the doors are opened in sequence within each 10-min period — where there are two doors, for example, open door no. 1 at 0 min, door no. 2 at 5 min, door no. 1 at 10 min, door no. 2 at 15 min, and so on.

◆ **Revisions**

EFCEM and CECED Italia, in partnership with European manufacturers, are currently adapting EN ISO 23953:2005 for testing of professional service cabinets. The main changes are in the procedure used to evaluate the units, as the door openings required in the current version for commercial cabinets are considered as not representative of the typical use pattern for professional service cabinets. Recommended alterations include the following aspects.

- For calculation of net volume, where *n* is the number of shelves: Shelf or drawer base area x (loading height – *n* x thickness of shelf). Please see §1.3.1.7 for further discussion on measurement of internal storage volume.

[69] Source: ARNEG

- Test packages[70] have to follow air circulation direction. For temperature monitoring: as described in the picture below (§Figure 1-19), this should be carried out with one probe on the left, one in the centre and one on the right.

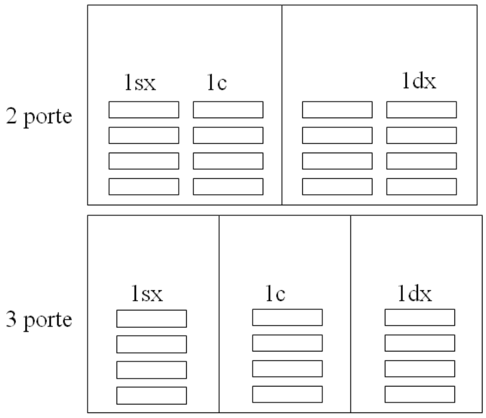


Figure 1-19: Packages arrangement during temperature monitoring.

- Changes proposed to the timings of door/lid openings;.

Procedure: during the 24 hours, consumption measurements should be recorded as follows.

Freezing

Start	0 - 4 hours	4 – 8 hours	8 hours	8 – 12 hours	12 – 24 hours
1 min open	each door opened 6 times per hour for 6 seconds(4)	each door closed	1 min open	each door opened 6 times per hour for 6 seconds(4)	each door closed

Refrigeration

Start	0 – 12 hours	12 – 24 hours
2 min open cycle	each door opened 6 times per hour for 6 seconds(4)	each door closed

(4)Where more than one door or lid pertains to the cabinet to be tested, the sequence in which the doors and lids are opened shall be staggered.

One issue to note concerns the terminology used in EN ISO 23953. ENTR Lot 1 uses the term “horizontal” to define the orientation of the product. However, within EN ISO 23953, “horizontal” is a term used to describe the display area orientation (Part 1, Annex A). This potentially confusing terminology should be revised or clarified.

[70] Manufactured gel (cellulose) with specific constrains to test service cabinets according to different standards. In some cases, thermocouple temperature sensors can be inserted into this device. www.frperc.bris.ac.uk/home/restopcs/frigtest.htm. 2010

1.3.1.2 EN 441:1995

Relevance: Service cabinets

EN 441, "Refrigerated display cabinets. General mechanical and physical requirements", has been used as a standard to measure performance of service cabinets. It is composed of several parts providing terms, definitions, mechanical and physical requirements, dimensions, general tests, a temperature test, a classification according to temperature, a defrosting test, a water vapour condensation test, electrical energy consumption, a test for absence of odour and taste, an installation and user's guide, and measurement of the heat extraction rate of the cabinets when the condensing unit is remote from the cabinet. Although this standard has been withdrawn, it is still in use.

In Part 1 of the standard, the net volume definition is described: *Volume containing food products within the load limit. Parts necessary for the proper functioning of the cabinet, including shelves used in the calculation of refrigerated shelf area, are fitted as intended and the volume representing the space occupied by these parts is deducted from the gross volume when the net volume is determined.*

In Part 3 (Linear dimensions, areas and volumes), it states:

- Physical dimensions - the manufacturer shall for each cabinet state nominal data, including net volume, according to the definitions given in EN 441-1. Measurements shall be made with the cabinet not in operation but situated in ambient conditions corresponding to the climate class (see EN 441-4) for which it is intended.
- Tolerances - the area and volume values required in 3.1 (Physical dimensions) and calculated according to the definitions given in EN 441-1 shall not be less than 97% of the stated values.
- Test report – this should clearly state, amongst others, the net volume for each temperature class declared and the volumes shall be expressed in litres without decimal or cubic metres (to three decimal places).

This guidance for net volume measurement almost identically replicated in EN ISO 23953 – however, variation in interpretation can lead to different volumes being calculated.

Cabinets with doors are tested over a 48-hour period where the cabinet door(s) are opened cyclically for 12 h within each 24-hour period. If the cabinet is fitted with lights these were switched on 1 h before the start of the door-opening test and switched off 1 h after the door-opening period.

Start	0 - 12 hours	12 – 24 hours	24 hours	24 – 36 hours	36 – 48 hours
3 min open	each door opened 6 times per hour for 12 seconds(1)	each door closed	3 min open	each door opened 6 times per hour for 12 seconds[1]	each door closed

[1]Door open at an angle of greater than 60° for 10 s. If the cabinet has multiple doors, the doors are opened in sequence within each 10-min period.

The operating characteristics of equipment for testing are defined in the M-package[71] temperature classes and test room climate classes, described below.

Table 1-19: M-package temperature classes

Class	Highest temperature of the warmest M-package less than or equal to	Lowest temperature of the coldest M-package greater than or equal to	Lowest temperature of warmest M-package less than or equal to
	°C		
L1	-15	-	-18
L2	-12	-	18
L3	-12	-	-15
M1	+5	-1	-
M2	+7	-1	-
H1	+10	+1	-
H2	+10	-1	-
S	Special classification		

Table 1-20: Test room climate classes[72]

Test room climate class	Dry bulb temperature (°C)	Relative humidity (%)	Dew point (°C)	Water vapour mass in dry air (g/kg)
0	+20	50	+9.3	7.3
1	+16	80	+12.6	9.1
2	+22	65	+15.2	10.8
3	+25	60	+16.7	12.0
4	+30	55	+20.0	14.8
6	+27	70	+21.1	15.8
5	+40	40	+23.9	18.8
7	+35	75	+30.0	27.3
8	+23.9	55	+14.3	10.2

The water vapour mass in dry air is one of the main points influencing the performance and the energy consumption of the cabinets.

In addition to these product and test parameters, the standard defines requirements for factors such as thermal and air flow characteristics in the test room.

Requirements: In order to calculate the energy consumption, EN ISO 23953 differentiates between plug-in cabinets and remote units. In general, this parameter is given by the TEC in kWh per 24-hour period.

[71] M-packages are test packages fitted with a temperature measuring device

[72] Please see EN ISO 23953 Annex C for further details on the comparison of laboratory and real (in-store) conditions

For the case of remote cabinets, the TEC indicator is the sum of the following:

- DEC in kWh per 24hour period
- REC in kWh per 24-hour period, for remote cabinets

DEC calculation:

$$\mathrm{DEC} = [(\mathrm{P_V}.\mathrm{t_V}) + (\mathrm{P_H}.\mathrm{t_H}) + (\mathrm{P_D}.\mathrm{t_D}) + (\mathrm{P_L}.\mathrm{t_L}) + (\mathrm{P_A}.\mathrm{t_A})]$$

REC calculation:

$$\mathrm{REC} = \mathrm{t_R} \cdot \phi_0 \cdot \frac{(\mathrm{T_c} - \mathrm{T_0})}{(0.34 \cdot \mathrm{T_0})}$$

TEC calculation: $\mathrm{TEC} = \mathrm{DEC} + \mathrm{REC}$ [kWh/24h]

This scope of calculation is very similar to the one in ANSI/AHRI 1200 for the equivalent parameter Calculated Daily Energy Consumption (CDEC) (see §1.3.1.4) in both cases the consumption from the condenser is not included in the consumption of the unit and is calculated separately.

Box 1-1: Definitions and unit of the measured parameters for EN ISO 23953 standard

$P_{V,H,D,L,A}$	respectively fan, heaters, defrost heaters, lighting and accessories power (W)
$t_{V,H,D,L,A}$	respectively fan, heaters, defrost heaters, lighting and accessories running time within 24h
t_R	24h minus defrost period in h
T_C	conventional condensing temperature
T_0	refrigerant evaporating temperature (based on test with 24h lighting)
Φ_0	heat extraction rate in kW (based on test with 24h lighting)

The heat extraction rate Φ_0 is defined by:

$$\phi_0 = \frac{Q_{tot}}{t_R}$$

Q_{tot} represents the total heat extraction in kWh

$$Q_{tot} = \sum_{n=1}^{n=N_{max}} \phi_n \times \Delta t$$

ϕ_n represents the instant heat extraction rate in kWh. It is defined as:

$$\phi_n = q_m \times (h_8 - h_4)$$ (See Figure 1-20)

n	indicates the measuring sample.
N_{max}	is the number of measuring samples in 24 hours
Δt	is the time between two measuring sample
q_m	is the mass flow rate of refrigerant in kg/s
$h_{8,4}$	is the specific enthalpy in kJ/kg at point 8 corresponding to the refrigerant outlet and point 4 corresponding to the refrigerant inlet.

EN ISO 23953 also deals with plug-in units. In this case, the TEC equals the DEC. The TEC includes the compressor energy consumption. For this kind of cabinet, the REC is not defined. This scope is similar to Total Daily Energy Consumption (TDEC) for ANSI/AHRI 1200-2008 (see §1.3.1.4).

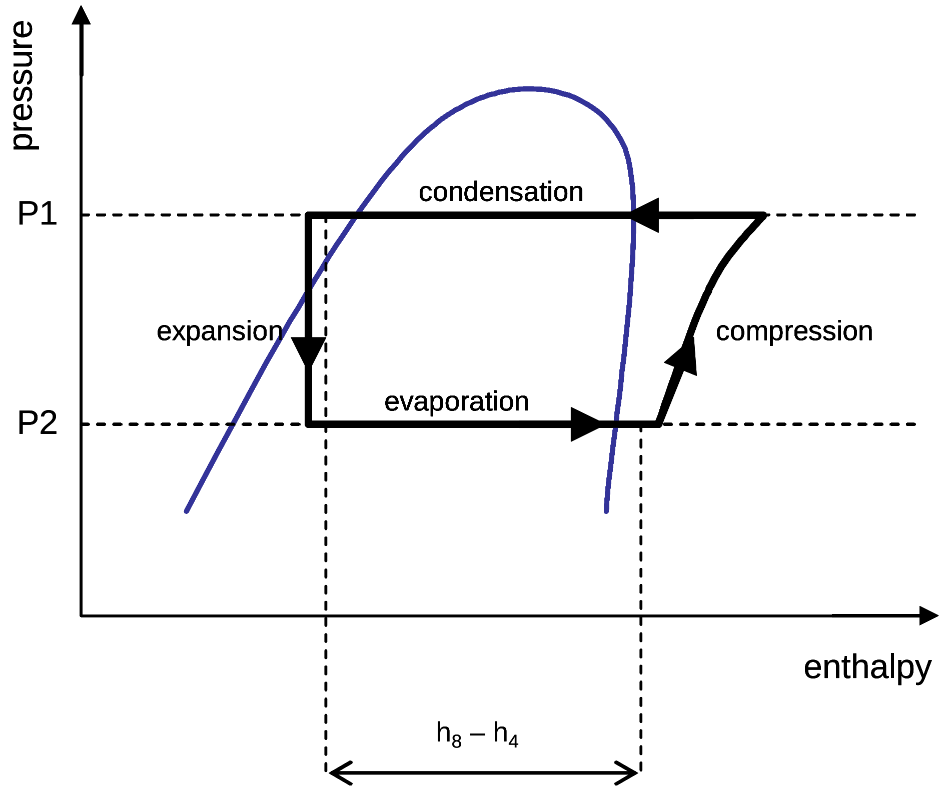


Figure 1-20: Example of a refrigeration system vapour-compression pressure-enthalpy (P-s) diagram showing process stages related to the saturation curve

1.3.1.3 DE DIN 18872 (draft standards in progress)

Part 1: Refrigerators and refrigerated counters (draft standard in progress)

Part 2: Cooling trays (draft standard in progress)

Part 4: Refrigerators and freezers, Requirements and testing

Relevance: Service cabinets

This standard contains requirements for design and function of refrigerators and refrigerated counters for food distribution, including testing, technical safety and hygiene features.

However, no testing requirements are specified for service cabinets.

1.3.1.4 ANSI/AHRI 1200-2008 (US)

Relevance: Service cabinets

The ANSI/AHRI 1200-2008 standard (superseding ANSI/ARI Standard 1200-2006) "Performance Rating of Commercial Refrigerated Display Merchandisers and Storage Cabinets" describes a method for assessing the performance rating of commercial refrigerated display merchandisers and storage cabinets. This standard is voluntary. AHRI presented a certification related to this standard in 2008 which includes both remote and self-contained equipments.

Scope: This standard applies to the following commercial refrigerated display merchandisers and storage cabinets, provided that the cases are equipped and designed to work with electrically driven, direct expansion type systems:

- plug-in and remote commercial refrigerated display merchandisers (already covered in the TREN Lot 12), plug-in and remote commercial refrigerated storage cabinets (ENTR Lot 1), open and closed commercial refrigerated display merchandisers (already covered in the TREN Lot 12).

The standard excludes:

- commercial refrigerated display merchandisers forming the front wall of a refrigerated storage room backed up to a walk-in cooler
- wedge cases (Miter transition display merchandisers) used as a corner section between two refrigerated display merchandisers
- floral merchandisers
- refrigerated vending machines
- ice makers
- ice cream dipping cabinets
- soft serve extruders
- secondary coolant applications

Test requirements: The tests required for this standard should be conducted in accordance with ANSI/ASHRAE Standard 72 (see ASHRAE standards).

Definitions: Box 1-2 provides the definitions of the different parameters used in the ANSI/AHRI 1200 standard.

Box 1-2: Definitions and unit of the measured parameters for ANSI/AHRI 1200 standard (SI units included in square brackets)

A_e =	Projected area from visible product through end walls, ft^2 [m^2]
A_r =	Gross refrigerated area, ft^2 [m^2]
AEC =	Anti-condensate energy consumption, kW·h[kW·h] per day
CDEC =	Calculated Daily Energy Consumption, kW·h [kW·h] per day
CEC =	Compressor Energy Consumption, kW·h [kW·h] per day
COP =	Coefficient of Performance
DEC =	Defrost Energy Consumption, kW·h [kW·h] per day
D_h =	Dimension of projected visible product, ft [m]
E_t =	Total energy measured or calculated for 24-hour period, kW·h [kW·h] per day
EER =	Energy Efficiency Ratio
FEC =	Fan Energy Consumption, kW·h [kW·h] per day
IU =	International Units
LEC =	Light Energy Consumption, kW·h [kW·h] per day
LECR =	Revised Light Energy Consumption, kW·h [kW·h] per day
L =	Length Length of Refrigerated Space, ft [m]
n =	Number of fan motors
P_{ai} =	Power anti-condensate heater input, W [W]
P_c =	Power condensate evaporator pan heater input, W [W]
P_d =	Power defrost heater input, W [W]
P_f =	Power fan, W [W]
P_{fi} =	Power fan input, W [W]
P_{fo} =	Power fan output found on part nameplate, W [W]
P_{li} =	Power light input, W [W]
PEC =	Condensate Evaporator Pan Energy Consumption, kW·h [kW·h] per day
Qrt =	Commercial refrigerated display merchandiser or storage cabinet load, Btu/h [W]
t =	Time unit is tested in 24 h period, h [h]
ta =	Time anti-condensate heaters are on in 24-hour period, h [h]
tc =	Time condensate evaporator pan heaters are on in 24-hour period, h [h]
td =	Time defrost heaters are on in 24-hour period, h [h]
tdt =	Time unit is in defrost, h [h]
tf =	Time fans are on in 24-hour period, h [h]
tl =	Time lights are on in 24-hour period, h [h]
TDA =	Total Display Area, ft^2 [m^2]/Unit of Length, ft [m]
TDEC =	Total Daily Energy Consumption, kW•h [kW•h] per day
Vr =	Refrigerated Volume, ft^3 [m^3]
ηm =	Motor efficiency

Rating requirements: Box 1-3 and Box 1-4 provide the details of the calculation of the CDEC[73] and of the TDEC[74]. The performance rating for remote cabinets calculates the CDEC with an approach similar to what is done in the ISO 23953, i.e. EER and COP values used to calculate the energy consumption of the refrigeration system are conventional values for a typical reciprocating compressor which are provided in the standard (Table 1 of ANSI/AHRI 1200:2008).

[73] CDEC is the value for remote commercial refrigerated service cabinets based upon the requirements of this standard expressed in kW·h [kW·h] per day.
[74] TDEC Is the calculated energy consumption value for plug-in service cabinets based upon the requirements of this standard expressed in kW·h [kW·h] per day.

Box 1-3: Performance rating for remote commercial refrigerated display merchandisers and storage cabinets

CDEC calculation: CDEC=CEC+FEC+LEC+AEC+DEC+PEC

Calculation of CEC $CEC = [(Q_{rt}).(t-t_{dt})]/(EER.1000)$

$CEC = [(Q_{rt}).(t-t_{dt})]/(COP.1000)$ (if IU)

Calculation of FEC $FEC = (P_f.t_f)/(1000)$

$P_f = P_{fi}$ (if measured)

$P_f = (P_{fo}.n)/\eta_m$ (if calculated)

Calculation of LEC $LEC = (P_{li}.t_l)/(1000)$

Calculation of AEC $AEC = (P_{ai}.t_a)/(1000)$

Calculation of DEC $DEC = (P_d.t_d)/(1000)$

Calculation of PEC $PEC = (P_c.t_c)/(1000)$

Other parameters calculation

Refrigerated volume $V_r = A_r.L$

Total display area (display cabinets) $TDA = (D_h.L)+A_e$

Presentation of the data

Informational Item	Data
Commercial Refrigerated Display Merchandiser or Storage Cabinet Model Number	
Adjusted Dew Point, °F [°C]	
Q_{rt}, Load Capacity, Btu/h [kW]	
Length, ft [m]	
Refrigerated Volume, ft^3 [m^3]	
TDA, ft^2 [m^2]	
Commercial Refrigerated Display Merchandiser or Storage Cabinet Test Voltage, V	
Commercial Refrigerated Display Merchandiser or Storage Cabinet Evaporator Dew Point Temperature, °F [°C]	
Integrated Average Temperature of Product Simulators, °F [°C]	
CEC, kW·h [kW·h] per day	
FEC, kW·h [kW·h] per day	
LEC, kW·h [kW·h] per day	
PEC, kW·h [kW·h] per day	
AEC, kW·h [kW·h] per day	
DEC, kW·h [kW·h] per day	
CDEC, kW·h [kW·h] per day	
CDEC/Refrigerated Volume, kW·h/ft^3 [kW·h/m^3] per day	
CDEC/Total Display Area, kW·h/ft^2 [kW·h/m^2] per day	
Other Loads, Notes:	

Box 1-4: Performance rating for self-contained commercial refrigerated display merchandisers and storage cabinets

TDEC calculation: TDEC = E_t/L

Other parameters:

Refrigerated volume $V_r = A_r.L$

Total display area $TDA = (D_h.L)+A_e$

Presentation of the data

Informational Item	Data
Commercial Refrigerated Display Merchandiser or Storage Cabinet Model Number	
Length, ft [m]	
Refrigerated Volume, $ft^3[m^3]$	
TDA, $ft^2[m^2]$	
Commercial Refrigerated Display Merchandiser or Storage Cabinet Test Voltage, V	
Integrated Average Temperature of Product Simulators, °F [°C]	
TDEC, kW·h [kW·h] per day	
TDEC/Refrigerated Volume, kW·h/ft^3 [kW·h/m^3] per day	
TDEC/Total Display Area, kW·h/ft^2 [kW·h/m^2] per day	
Other Loads, Notes:	

1.3.1.5 US ASHRAE Standard 72-2005

Relevance: Service cabinets

ASHRAE Standard 72-2005 *Method of Testing Commercial Refrigerators and Freezers* (ANSI Approved) is the revision of Standard 72-1998. It combines standard 72-1998 for open refrigerators and standard 117-2002 for closed refrigerators. It prescribes a uniform method of testing both remote and self-contained open and closed commercial refrigerators and freezers for rating so that comparative evaluations can be made of energy consumption, product temperature performance, refrigeration load, the suction pressures required and other performance factors. The standard also clarifies door opening requirements, shelf loading and test definitions, and includes requirements that improve the consistency of ambient temperatures.

1.3.1.6 CAN/CSA-C827-98 (R2008)

Relevance: Service cabinet

CAN/CSA-C827-98 (revised in 2008) *Energy Performance Standard for Food Service Refrigerators and Freezers* applies to commercial refrigerators, refrigerator-freezer cabinets that are intended for storing and holding food products and other perishable merchandise. It applies to manufacturers' standard catalogue-type equipment, closed cabinets of the unitary, self-contained type; and commercial refrigerated storage cabinets, regardless of their shape, size or configuration. It does not apply to remote-condensing commercial refrigerators and freezers, walk-in refrigerators and freezers, water coolers, refrigerated vending machines, ice-making machines, soft serve, slush and shake-dispensing freezers and extruders.

The CSA standard contains minimum performance criteria for annual energy consumption that vary with the volume of the refrigerator or freezer (see §1.4.2.1).

1.3.1.7 Comparison of volume measurement methods

Stakeholders commented on their volume measurement methods. There are four volume measurement methods that have been considered as the most important:

- **Method 1**: This method considers the internal vertical distance from the lowest usable shelf to the highest load-line multiplied by the usable shelf area when the door is closed.
- **Method 2**: This methodology considers the space within the equipment with all movable parts removed. It provides a gross volume, from which the space required for the evaporator and air ducts free flow should be deducted.
- **Method 3 (corresponding to EN 441)**: This method measures the equipment with all movable parts installed. The load limits are identified, considering areas where the air channels that should not be blocked at any moment. Volume inferior to 100x100x100mm (cubic testing package) should not be included for the calculation. The measurement should fit primitive geometrical shapes. The volume of the bottom shelf shall not be included in the total volume.
- **Method 4 (corresponding to EN 23953 revision proposal[75]):** Where *n* is the number of shelves, net volume is calculated via: Shelf or drawer base area x (loading height – *n* x thickness of shelf).

Following are some of the issues associated with trying to develop a harmonised and accurate measurement method which reflects the amount of food that the product can store during use[76]:

- In some cabinets, the shelves are recessed and therefore would not actually have food on them.
- Many cabinets are quite poor in terms of load lines and dimensions and so any rule can be interpreted in a variety of ways (hence it would be useful to insist that load lines are marked).
- The number of test packs might be a good method, though loading is only approximately half the shelf height.

Another stakeholder comment noted that the volume of the test packs used in determining the energy consumption should also be used in the energy/volume index calculation (there is an inherent inaccuracy when testing energy with one volume of product and then introducing another volume of product when calculating the energy efficiency index)[77].

Care should be taken when selecting a method considering the trade-off between convenience and accuracy.

---

[75] Source: CECED Italia

[76] Source: London South Bank University

[77] Source: Adande Refrigeration

1.3.1.8 Testing and protocols

There are three main elements of testing for service cabinets, due to their significant impact on energy consumption: ambient temperature and humidity, M-package positioning, and door openings. Climate classes are used to define standard temperatures and humidity, and positioning of M-packages is defined within the standards. The term “protocol” is used to describe the assumed use pattern that is replicated by a specific door opening pattern during the controlled test.

The standards EN ISO 23953, the development of this standard by CECED and the standard EN 441 all have slight protocol variations. These reflect differences in assumed use patterns, in order that the testing method accurately reflects real consumption.

- **EN 441-5:1996**

Cabinets with doors are tested over a 48-hour period where the cabinet door(s) are opened cyclically for 12 h within each 24-hour period. If the cabinet is fitted with lights these are switched on 1 h before the start of the door-opening test and switched off 1 h after the door-opening period.

Start	0 - 12 hours	12 – 24 hours	24 hours	24 – 36 hours	36 – 48 hours
3 min open	each door opened 6 times per hour for 12 seconds(1)	each door closed	3 min open	each door opened 6 times per hour for 12 seconds[1]	each door closed

[1]Door open at an angle of greater than 60° for 10 s. If the cabinet has multiple doors, the doors are opened in sequence within each 10-min period.

- **EN ISO 23953:2005**

The test for closed refrigerated cabinets should always be carried out on a complete cabinet, regardless of the number of doors or lids. The requirements state that the cabinet lighting should be switched on for a period of 12 h; followed by 12 h with the cabinet lighting switched off. With the night covers removed, leave the cabinet lighting switched on for a period of 12 h; followed by 12 h with the night covers on and the cabinet lighting switched off.

Start	0 - 12 hours	12 – 24 hours
3 min open (2)	each door or lid opened 6 times per hour for 6 seconds(3)	each door closed

(2)Where a cabinet is provided with more than one door or lid, each door or lid shall be opened for 3 min consecutively.

(3)Door open at an angle of greater than 60° for 4 s. If the cabinet has multiple doors, the doors are opened in sequence within each 10-min period — where there are two doors, for example, open door no. 1 at 0 min, door no. 2 at 5 min, door no. 1 at 10 min, door no. 2 at 15 min, and so on.

- **CECED Italia EN ISO 23953:2005 revision**

Procedure: during the 24 hours, consumption measurements should be recorded as follows.

- Freezing

Start	0 - 4 hours	4 – 8 hours	8 hours	8 – 12 hours	12 – 24 hours
1 min open	each door opened 6 times per hour for 6 seconds(4)	each door closed	1 min open	each door opened 6 times per hour for 6 seconds(4)	each door closed

- Refrigeration

Start	0 – 12 hours	12 – 24 hours
2 min open cycle	each door opened 6 times per hour for 6 seconds(4)	each door closed

(4)Where more than one door or lid pertains to the cabinet to be tested, the sequence in which the doors and lids are opened shall be staggered.

- **FR NF AC D40-003:2006 (§1.3.6.5)**

1st period	2nd period	3rd period
5 hours	3 hours	1 hour
Door closed: cooling of M-packages to required temperatures	Door openings For high temperature: The door is open to 90°, every 5 min for 10 seconds. In the case of the product having several doors or drawers, they should be opened one at a time, every 5 minutes in turn. For low temperature: The door is open to 90° every 15 min for 30 seconds. In the case where the device has several doors or drawers, they should be open one at a time, every 15 min in turn.	Door closed: cooling of M-packages to required temperatures

Understanding of product use patterns is important when developing testing standards. A field study tested products using different door opening patterns, demonstrating the impact this can have on energy consumption.

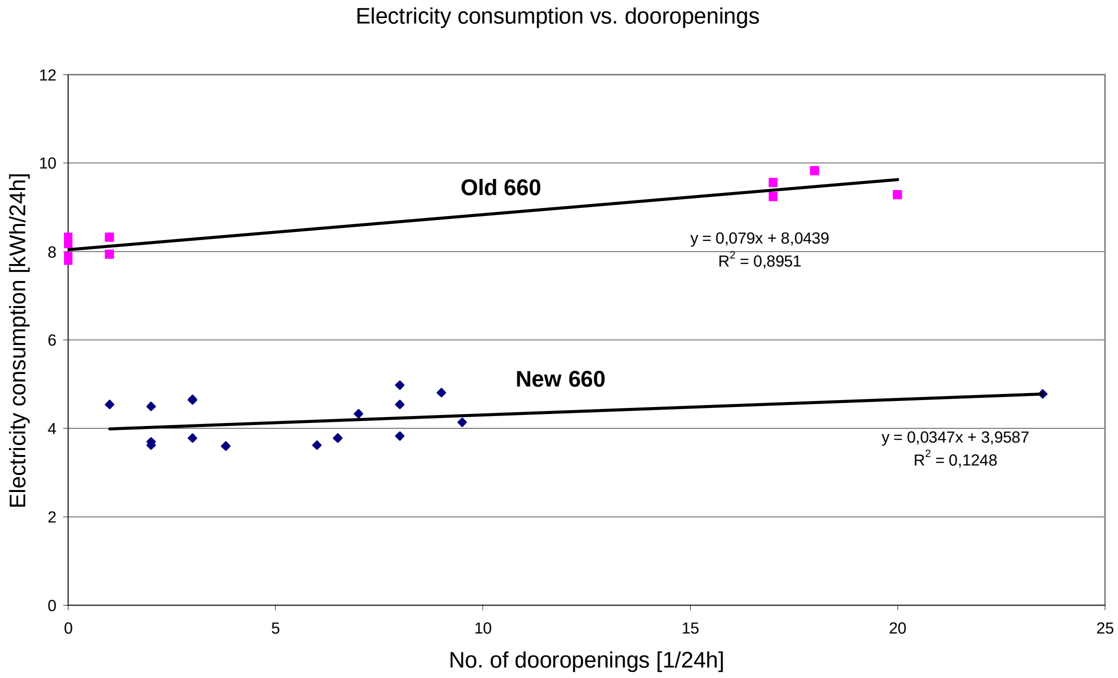


Figure 1-21: Electricity consumption vs. door openings for the freezers[78]

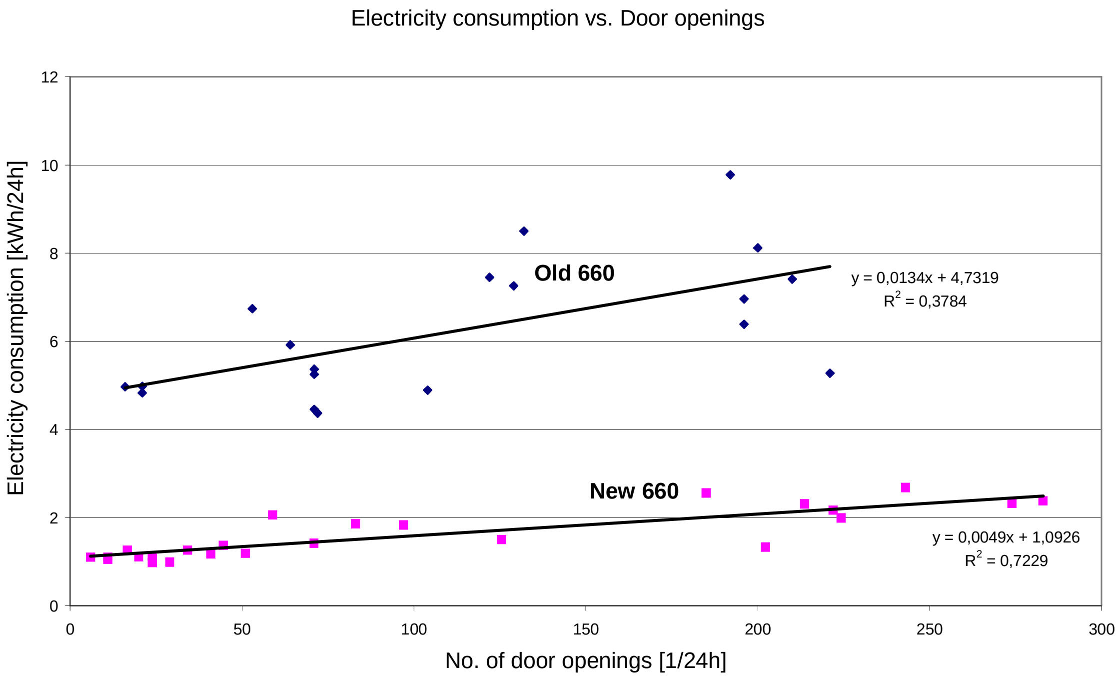


Figure 1-22: Electricity consumption vs. door openings for the refrigerators[78]

[78] Pedersen, P-H., Soe, L. and Jensen, F. *New Generation of Professional Kitchen Appliances with Natural Refrigerants and Reduced Energy Consumption*, Danish Technological Institute and Gram Commercial. Presented at 6th Gustav Lorentzen Natural Working Fluids Conference, Glasgow, UK (2004)

1.3.2. BLAST CABINETS

1.3.2.1 EN 328:1999

Relevance: Blast cabinets, heat exchangers

Heat exchangers. Test procedures for establishing the performance of forced convection unit air coolers for refrigeration. This standard is applied to evaporators in direct dry expansion of refrigerant, liquid feed by means of a pump and machines working with liquids, and includes non-ducted unit air coolers for refrigeration operating.

It is used to evaluate blast cabinet component performance, but not the overall performance of the equipment. It establishes performance evaluation methods. These methods determine the net power of the evaporator, air-flow, and energy consumption.

This standard does not include safety aspects or evaluation of conformity.

1.3.2.2 EN 327:2000

Relevance: Blast cabinets, packaged refrigeration systems

Heat exchangers – Forced convection air cooled refrigerant condensers – Test procedure for establishing performance. This standard applies to remote condensers, air-forced convection condensers where refrigerant change phase is produced.

This is standard is used to determine the functioning of blast cabinet components, but not of blast cabinets by themselves. This standard establishes performance evaluation.

However, it does not provide compliance values, and does not apply to condensers meant to be installed inside machines or cabinets, or condensing units with sub-cooling units.

1.3.2.3 DE DIN 8953/8954

Relevance: Blast cabinets

There is evidence that **DIN 8953/8954** *Household frozen storage cabinets* has been used by the industry to evaluate the performance of blast cabinets. However, it has been phased out.[79]

1.3.3. WALK-IN COLD ROOMS

1.3.3.1 Introduction

This section on test standards for walk-in cold rooms covers methodologies to assess the parameters and performance of both the components that impact on the energy performance of walk-in cold rooms, and the energy performance of the products themselves.

Firstly, methods for testing of the insulation panels and insulated box are described. Subsequently, options for testing of the refrigeration system are

[79] Source: www.gemm-srl.com/ita/images/abbattitorirunner.pdf

discussed. Testing methods for the various individual components are then covered, and lastly methods for testing the energy consumption of the entire product are considered.

For the evaluation of refrigeration systems, standards described within other sections may also be relevant. These include EN 327 for packaged systems (§1.3.2.2), and EN 13771 (§1.3.5.1) and EN 13215 (§1.3.5.2) for remote condensing systems.

1.3.3.2 European Technical Approval Guideline (ETAG) 021 and 016[80]

Relevance: framework for design of cold storage kits

The ETAG 021 *Cold storage premises kits* is divided into two parts: Part 1 "Cold storage room kits" and Part 2 "Cold storage building envelope and building kits" covering specific aspects related to different intended uses. Part 2, covering products that might be constructed outdoors, has additional elements mainly relating to the need to weather-proof the structure.

This guideline was established in the context of Directive 89/106/EEC on construction products (§1.4.8.6). European technical approvals are used to assess the suitability of a product for its intended use in cases where there is no harmonised standard, no recognised national standard and no mandate for a European standard and where the Commission feels, after consulting the Member States within the Standing Committee on Construction, that a standard cannot or cannot yet be prepared. The European Organisation of Technical Approvals (EOTA), which groups together the national approvals bodies, can draw up technical approvals guidelines in respect of a construction product or family of construction products, acting on a mandate from the Commission and after consulting the Standing Committee on Construction[81].

The scope of the guideline covers cold storage kits whose components are pre-designed and prefabricated by one (or various) manufacturer(s) to be produced in series and three-dimensional prefabricated transportable rooms. In the context of the guideline, thermally insulating products are those with a declared thermal conductivity of less than 0.06W/m.K at +10°C. Components put on the market separately are not covered by ETAG 021, although much of the data on technical characteristics is provided on a component basis.

Cold storage building kits contain at least the load bearing structure and wall and roof panels, or wall panels and roof (with ceiling panels). Some important points to note:

- The technical equipment (e.g. cooling systems and other electrical equipment) is excluded from the guidelines in both cases.
- The enclosure[82] is made out of sandwich panels with insulating cores.
- The kits follow pre-designed technical solutions for joints and assembly.
- For all premises, floors may be included depending on its characteristics.

[80] European Technical Approval Guideline 021. *Cold storage premises kits.* Draft Edition 2004.
[81] ec.europa.eu/enterprise/sectors/construction/documents/legislation/cpd/index_en.htm
[82] The term "envelope" in this guideline refers to the waterproof layer and not to a structural part of the building.

- The guidelines cover cold stores intended to store products at temperatures below +15°C and above -40°C.
- As the rooms are designed for specific internal temperature intervals, these must be specified by the ETA applicant and declared in the ETA (although specific component characteristics such as thermal performance are not linked to temperatures).

During the approval issuing process, the approval bodies will assess whether the kit design, the components and the installation and maintenance foreseen by the European Technical Approval (ETA) applicant lead to an overall favourable assessment of the kit for that (or those) intended use (or uses). Kits that conform to the ETA can be CE marked, all others cannot, and if a kit manufacturer wants to use a previously CE-marked kit for another intended use, they must therefore have the ETA revised or apply for a new ETA.

Components put on the market separately are not covered by ETAG 021. Contractors that assemble components of cold store kits and place them on the market are not obliged to apply for an ETA, however applying for one will provide the advantage that their component has been proved fit for intended use (whereas fitness for purpose of combinations of components placed on the market separately will need to be tested onsite).

The ETA alone is not sufficient to enable placing of the product on the market. In addition to the technical specification, an attestation of conformity, resulting in an EC Declaration of conformity, is required before CE marking is possible.

Figure 1-23 presents a number of possibilities that exist for placing cold storage premises kits on the market:

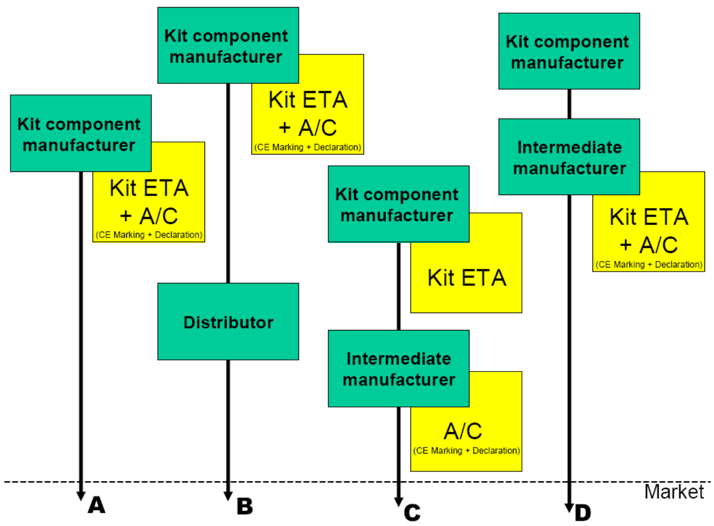


Figure 1-23: Placing cold storage kits on the market

Case A is the "normal" case. The ETA-holder is also the party that also performs the attestation of conformity tasks and signs the EC Declaration of conformity. The kits go directly from the ETA-holder to the market.

In Case B, the products are stored by a distributor who places the kits on the market. Because the latter does not modify (in any way) the kit, the kit manufacturer (ETA-holder) can also perform all A/C tasks. In this case, it is possible that the distributor benefits from a "duplicate" ETA and that the kits bear the distributor's name.

Case C represents the possibility that the kit manufacturer has an ETA that covers a number of possible kits, where an intermediate manufacturer places on the market some or all of them. The choice of the components and therefore also the performance of the kit is determined by the intermediate manufacturer and he becomes responsible for signing the EC Declaration of conformity and CE Marking of the kit.

Case D is the case where the kit manufacturer does not obtain his ETA and does not put the kit on the market. His responsibility is reduced to that of a supplier. The intermediate manufacturer obtains the ETA and also performs the attestation of conformity tasks. There must be a technical and legal link between the manufacturer(s) or supplier(s) and the party signing the EC Declaration of conformity.

ETAG 021 specifies standardised methods to evaluate the characteristics of the product and its fitness, judging methods and assumptions, and makes other recommendations (see Table 1-21). As ETAG 021 covers required evaluation to comply with the Directive on construction products (89/106/EEC), the EC Foodstuff Directive (91/43/ECC), and the EC food contact material Directives (the Framework Directive 89/109/It), many requirements link to associated characteristics of structural integrity and health and safety compliance, and also characteristics pertaining to energy economy and heat retention are covered.

Some of them apply to both cold room kits and cold room building kits, while others are relevant only to one type of them:

Table 1-21: Aspects considered in ETAG 021 scope to evaluate Cold rooms kits and Cold rooms building kits[83]

Aspect		CRK*	CRBK**
Mechanical resistance		x	x
Safety in case of fire			
	Reaction to fire	x	x
	Resistance to fire	x	x
	External fire performance		x
Hygiene, health and environment			
	Dangerous substances release	x	x
	Vapour permeability	x	x
	Moisture resistance	x	x
	Fitness for contact with food and feedstuff	x	x
	Water tightness		x
	Air tightness	x	x
Safety in use			

[83] Source: European Technical Approval Guideline 021. *"Cold storage premises kits"*. Draft Edition 2004.

Aspect			CRK*	CRBK**
	Impact resistance		x	x
	Mechanical resistance			
		Fixing resistance	x	x
		Mechanical resistance of wall, ceiling and floor panels	x	x
		Mechanical resistance of the cold storage building enclosures	x	x
	Eccentric loads resistance		x	x
	Slipperiness		x	x
	Safety against personal injuries by contact		x	x
	Safety against entrapment		x	x
	Safety against collapse (due to air pressure differences)		x	x
	Resistance to horizontal and provisions preventing falling due to changes in level or sudden drops			x
Protection against noise				
	Airborne sound insulation			x
	Impact sound insulation			x
	Sound absorption			x
Energy economy and heat retention				
	Thermal performance		x	
	Thermal resistance			x
	Air permeability		x	x
	Water vapour permeability		x	x
	Thermal inertia			x
Durability, serviceability and identification				
	Durability		x	x
	Serviceability		x	x
	Identification		x	x

* Cold rooms kits ** Cold rooms building kits

Within the documentation, it states methods and calculation to assess the kit and components.

For thermal performance, the guideline proposes means to evaluate the product at component level. For example, the hot box method is proposed as a means of evaluating doors, gates and windows.

Assessment of the panels which are main components of cold storage rooms, i.e. composite panels with insulating cores, is primarily based on the draft harmonised technical specifications EN 14509 "Double metal faced insulated sandwich panels" (§1.3.3.3) or ETA-Guideline 016 "Self supporting light weight composite panels". Both of these refer to other standards for the thermal conductivity and aged thermal conductivity, including laboratory test methods such as EN 12939, EN 12667, EN 12664 (§1.3.3.5) for measurement of thermal conductivity, and statistical calculation methods in EN 13162 to EN 13167 (EN 13164 and EN 13165 are discussed in §1.3.3.4) and EN ISO 10456 for aged thermal conductivity. Thermal resistance and the corresponding thermal transmittance (U-value) of the panels shall be calculated according to EN ISO 6946 (a calculation method) (§1.3.3.7) or a hot box procedure under ETAG016, and under EN 14509 thermal transmittance is calculated under a formula.

For doors, gates and windows, ETAG021 states that the thermal resistance of panels can be used. Alternatively, the hot-box test method (EN ISO 12567-1:2010 as described in §1.3.3.6) can be offered. Other component methods are calculations, and use standard data from tables.

For air permeability, test standards are proposed for the kit, doors and gate and composite panels. These are:

- ISO 12569:2000 Thermal performance of buildings -- Determination of air change in buildings -- Tracer gas dilution method
- EN 13829:2001 Thermal performance of buildings. Determination of air permeability of buildings. Fan pressurization method
- EN 12114:2000 Thermal performance of buildings. Air permeability of building components and building elements. Laboratory test methods (as set out in EN 14509:2006 and ETA-Guideline 016)
- BS EN 1026:2000 Windows and doors. Air permeability. Test method (with EN 12207:2000 Windows and doors. Air permeability. Classification)

1.3.3.3 EN 14509:2006

Relevance: to assess insulation properties of sandwich panels

This standard includes the specifications, evaluation and monitoring of factory-made, self-supporting, double skin metal faced insulating panels. Due to the great variety of sandwich panel applications, profiles, adhesives, insulation core materials and production lines, different levels of mechanical performance can be achieved.

The main parameters of interest measured in respect to energy performance of the cold rooms is the thermal conductivity, λ, and thermal transmission, U-value, as described.

The standard references EN 13162 to EN 13167, for specifications of testing aged thermal conductivity of different insulation materials and it proposes a calculation method for the thermal transmittance of the panel.

Since October 2010, CE marking has been compulsory for all sandwich panels sold in the EU[84].

1.3.3.4 EN 13164:2009-02 and EN 13165:2009-02

Relevance: to assess insulation properties of panel core material

Thermal insulation products for buildings. EN 13164:2009-02 *Factory made products of extruded polystyrene foam (XPS)* and EN 13165:2009-02 *Factory made rigid polyurethane foam (PUR) products.* With the introduction of harmonized European standards for evaluating the characteristics of insulation foam, a new

[84] Source: www.rockwool-sandwichpanel.com/solutions/en+14509

method of measurement and declaration of aged thermal conductivity (λ) and thermal resistance was implemented to create a level playing field for insulation materials where permanent blowing agents are used. Hence, manufacturers of insulating panels must now declare the aged λ value. The aged λ is test is described in Annex C, and is performed at +10°C.

1.3.3.5 EN 12664:2001, EN 12667:2001 and EN 12939:2001

Relevance: to assess thermal performance of insulating panels

Thermal performance of building materials and products. Determination of thermal resistance by means of guarded hot plate and heat flow meter methods. Dry and moist products of medium and low thermal resistance - EN 12664:2001 medium and low thermal resistance, EN 12667:2001 high and medium thermal resistance, EN 12939:2001 thick products of high and medium thermal resistance.

The guarded hot plate consists of a two specimen around a heated plate, which is sandwiched between two cooling plates. With the Heat Flow Meter, samples are tested between two heat flux sensors in fixed or adjustable temperature gradients. After a few minutes for the system to reach equilibrium, the built-in PC or external computer determines the thermal conductivity and thermal resistance of the sample, hence the steady-state heat flow through the specimen is measured.

1.3.3.6 ISO 12567-1:2010

Relevance: to assess thermal performance of insulating panels, doors and windows

Thermal performance of windows and doors -- Determination of thermal transmittance by the hot-box method -- Part 1: Complete windows and doors

ISO 12567-1:2010 specifies a method to measure the thermal transmittance of a door or window system. It is applicable to all effects of frames, sashes, shutters, blinds, screens, panels, door leaves and fittings.

For the “hot box” method, the insulation product is installed in a dividing wall between two rooms with different temperatures. A “hot box” consisting in a five-sided box is installed in the warm room, with the open side facing the insulation product to be tested. The temperature inside and outside the box has to be the same, so the transmittance is made through the insulation product into the cold room. Simultaneous measurement of the temperature difference across the item tested enables to calculate the thermal resistance.

The U-value can also be tested directly by measuring the different air temperatures in both rooms, using calibrated testing equipment.

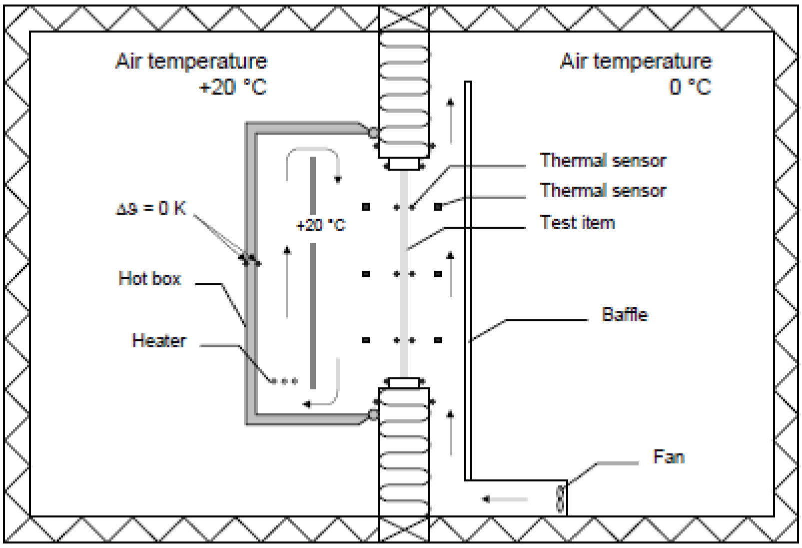


Figure 24: Diagram of thermal resistance test method[85]

1.3.3.7 EN ISO 6946:2007

Relevance: to assess thermal performance of insulation panels

Building components and building elements -- Thermal resistance and thermal transmittance -- Calculation method

This standard provides the method of calculation of the thermal resistance and thermal transmittance of building components and building elements, excluding doors, windows and other glazed units, curtain walling, components which involve heat transfer to the ground, and components through which air is designed to permeate.

The calculation method is based on the appropriate design thermal conductivities or design thermal resistances of the materials and products for the application concerned.

The method applies to components and elements consisting of thermally homogeneous layers (which can include air layers).

ISO 6946:2007 also provides an approximate method that can be used for elements containing inhomogeneous layers, including the effect of metal fasteners, by means of a correction term given in Annex D. Other cases where insulation is bridged by metal are outside the scope of ISO 6946:2007.

1.3.3.8 EN 12114:2000

Relevance: to assess air permeability of insulation panels

Thermal performance of buildings. Air permeability of building components and building elements. Laboratory test methods

[85] Source: SP Technical Research Institute of Sweden, available online at: www.sp.se/sv/units/energy/Documents/ETi/SP%20INFO%202000_17%20E%20eng%20-%20Thermal%20transmittance%20by%20hot%20box%20method.pdf

Under EN 14509, the following specifications are made for this standard, when testing panels.

The dimensions of the test assembly shall be as large as necessary to be representative of the intended use. The assembly shall not be less than 1,200mm x 2,400mm. The joints of the modules comprising the test assembly shall be representative, i.e. the same length per m^2 as in end use. Both horizontal and vertical joints shall be incorporated where these are an intrinsic part of the panel assembly.

The air permeability shall be measured with a pressure difference of 50 Pa between the inside and outside of the test assembly. The air permeability (air loss) shall be determined in terms of m^3/m^2.h at 50 Pa.

1.3.3.9 BS EN 4376-1:1991

Relevance: to assess performance of insulating box

BS EN 4376-1 *Electrically operated blood storage refrigerators* defines standards for closed reach-in type refrigerators designed and equipped for the storage of whole blood and red cell components that need to be kept within specified limits of temperature. The refrigerators are intended for use in hospitals and blood collecting centres. Facilities for the storage of frozen blood products are excluded.

The standard specifies that the insulation shall have a thermal transfer coefficient not greater than 0.35 $W/(m^2 \cdot K)$ and should be vapour sealed. The preferred type of insulation is “foamed in place”, and the standard requires that if “slab type” insulation (blocks of pre-foamed insulation) is used, it should be bonded at joints and to both external and internal linings with a thermal break (for fire protection) between the inner and outer surfaces. Doors should be self-closing type with inner doors or flaps to reduce entry of ambient air to the compartment.

A method of testing for temperature within the net storage volume of the cabinet on failure of the air recirculating fan to verify that either:

a) the air temperature within the storage volume remains within the limits of 0 °C to 8 °C; or

b) an audible and visual alarm operates.

The temperature should be measured at the bottom and top of the storage volume using a calibrated recording device during the duration of the test. The operator should set the mean air temperature within the storage volume to maintain the temperature between +1°C and +7°C, and once reached, stop the air recirculating fan, continuing until whichever occurs first:

a) until an audible and visual alarm is operated; or

b) 24h passes.

This test is known in the trade as the “holdover” test.

1.3.3.10 Agreement on the international carriage of perishable foodstuffs (ATP)

Relevance: test method to assess insulation performance of the insulated box and refrigeration system, either as a whole system or individually

ATP is the multi-lateral agreement between Signatory Countries (Contracting Parties) for overland cross border carriage of perishable foodstuffs. It ensures that vehicles used for this carriage meet agreed international standards. The standards apply to the bodywork (insulating box) and refrigeration units.

The agreement also details the following aspects of interest:

- Classifications of equipment, based on operation storage temperature ranges (with a mean outside temperature of + 30 °C and maintaining continuously temperature T_i inside the empty insulated box):
    - Class A: T_i may be chosen between + 12 °C and 0 °C inclusive;
    - Class B: T_i may be chosen between + 12 °C and - 10 °C inclusive;
    - Class C: T_i may be chosen between + 12 °C and - 20 °C inclusive.
    - Class D: T_i is equal to or less than 0 °C;
    - Class E: T_i is equal to or less than - 10 °C;
    - Class F: T_i is equal to or less than - 20 °C.

  In the case of classes A, B and C, any desired practically constant T_i (in conformity with the standards defined above), while in the case of classes D, E and F a fixed practically constant T_i (in conformity with the standards defined above).
- Procedures for testing the insulated enclosure and refrigeration equipment, either combined (within an insulated testing laboratory) or separately (insulated box tested within insulated laboratory, refrigeration unit measured under other accepted standard conditions). Hence refrigerating capacity of the refrigeration system can be calculated by attachment to a calorimeter box, and the cooling capacity matched to the heat load requirement of the insulated box (as measured under the test conditions). Specifications of the test include:
    - K coefficient measured either by the internal cooling method or by the internal heating method;
    - conditions in the testing laboratory (such as air flow;
    - temperature measuring points;
    - period of test; and
    - parameter variances permitted.

For test procedure details, please see Annex 1-1, §1.14.4.

1.3.3.11 PAS 57:2003

Relevance: to assess performance of refrigeration system

PAS 57:2003 *Cellar cooling equipment — Procedure for determining performance and calculating energy efficiency* defines procedures and conditions for measuring the performance of cellar cooling equipment and calculating the energy efficiency, expressed as a COP, providing a means for comparing product energy efficiency. Cellar cooling equipment is a refrigeration system designed to maintain an indoor environment at a condition suitable for the storage of chilled beverages, typically +10°C to +12°C.

The standard specifies procedures for determining the performance and energy efficiency of cellar cooling equipment with a capacity between 2 kW and 12 kW, at a standard rating condition of +10°C air onto the evaporator and +32°C air onto the condenser, using air-cooled condensers categorized as either:

a) a packaged system, comprising all components mounted on one base for "through the wall" installation; or

b) a split system, with the equipment supplied in two parts (evaporator and condensing unit) to be connected on site; or

c) a remote system, with equipment supplied in three parts (evaporator, compressor/receiver unit and condenser) to be connected on site.

All components supplied as part of the equipment shall be included in the evaluation. The standard specifies the conditions to be maintained in two rooms, Test room A which will contain the condensing unit, consisting of the compressor, condenser, liquid receiver (where fitted), filter drier, or compressor/receiver set plus air cooled condenser or outdoor part of the packaged system, and Test room B (calorimeter room) which will contain the evaporator and expansion valve (where fitted to the evaporator). In addition, piping lengths and dimensions are specified for the split and remote system types.

The system cooling capacity and energy consumption are measured to provide the COP, and the requirements for an evaluation report are set out.

The temperature and humidity is controlled in test room A, which shall have sufficient volume for unrestricted airflow through the condenser. The test room B shall be an insulated chamber with a heat load to simulate cellar conditions, and shall have a thermal mass such that during the system efficiency test, the room temperature increases at a rate less than 1°C in 5 min when the cellar cooling equipment is turned off. The size of the room B is also specified so that no obstacles are positioned at a specific distance to the evaporators and the volume of the room is according to the air flow generated by the evaporator.

The cooling capacity shall be measured under the following conditions:

- The relative humidity of the test room B shall be of (80±5)%
- Single phase equipment shall be tested at (230±5) V and (50±0.5) Hz
- Three phase equipment shall be tested at (400±8) V and (50±0.5) Hz
- Air onto the condenser at (32±0.5)°C
- Test room B temperature at (10±0.5)°C, with the average temperature during the 1 h period being between 9.8°C and 10.2°C.
- Cellar unit operating continuously
- The cooling capacity shall be measured at steady state conditions (specified above), achieved at least 30 min prior to evaluation and maintained for 1 h.

The energy consumption shall be measured under the following conditions:

- Cooling capacity measured as explained above
- Air onto the condenser at (20±0.5)°C
- Test room B temperature at (10±0.5)°C
- Cellar unit cycling on its thermostat

- The energy consumption shall be measured at steady state conditions (specified above), achieved at least 30 min prior to evaluation and maintained for 2 h.

The coefficient of performance (COP) shall be calculated by dividing the system cooling capacity (in kW) by the system energy consumption (in kW). In order to calculate the system energy consumption in kW, the energy consumption measured in kWh is divided by the duration of the test in hours.

1.3.3.12 AHRI 1251 (SI) (and AHRI 1250 (I-P))

Relevance: to assess energy consumption of whole product

AHRI 1251 (SI units) *Performance rating of Walk-In Coolers and Freezers* applies to walk-in coolers and freezers with refrigeration system configurations:

- integrated, comprising a single package;
- matched system, with evaporator unit ("unit cooler") integral, and condensing unit is separated and located either indoor or outdoor;
- unit cooler integral, connected to a central, shared condensing unit.

The control system may be integral, but if this is not the case the performance of the control system should be tested as well (normally by a separate party). The standard defines a method that evaluates the refrigeration system and the walk-in "box" heat load separately.

This standard does not apply to:

- rooms for telecommunication switch gear or other equipments that need to be cooled;
- enclosures for medical, scientific or research purposes;
- performance testing of large parallel rack refrigeration systems (condensing units).

Conditions for evaluation under specified test procedures to provide Standard Ratings for the refrigeration system are defined for different product configurations (indoor/outdoor condensing unit; fixed capacity matched, two capacity matched and variable capacity matched refrigeration systems), and there is a requirement to calculate the Application Rating, consisting of a Capacity Rating plus the associated power input and COP. Measured test results for cooling capacity and COP shall be no less than 95% of the published rating.

The standard then sets out equations to calculate the box heat load for various product configurations (indoor/outdoor condensing unit; fixed capacity matched, two capacity matched and variable capacity matched refrigeration systems).

The walk-in box load is comprised of a high load period (BLH) of the day corresponding to frequent door openings, product loading events, and other design load factors, and a low load period of the day (BLL) corresponding to the minimum load resulting from conduction, internal heat gains from equipment that is not related to the refrigeration system, and infiltration when the door is closed. Both the BLH and BLL are defined as a linear relationship with outdoor ambient temperature. This relationship accounts for the influence of outdoor ambient on the conduction and infiltration loads for a "typical" walk-in box.[86]

BLH and BLL are functions of the cooling capacity of the refrigeration system at specific temperatures, as set out in section 6 of the standard. For example BLH being 0.7 times, and BLL 0.1 times, the cooling capacity for a cooler at +32°C ambient, and BLH being 0.8 times, and BLL 0.4 times cooling capacity for a freezer at +32°C ambient.

The standard then sets equations that allow the calculation of the Annual Walk-in Energy Factor (AWEF), a factor indicating efficiency.

"Annual Walk-in Energy Factor (AWEF). A ratio of the total heat, not including the heat generated by the operation of refrigeration systems, removed, in watt-hours, from a walk-in box during one year period of usage for refrigeration to the total energy input of refrigeration systems, in watt-hours, during the same period."[86]

1.3.3.13 US test procedures for walk-in coolers and freezers

Relevance: minimum insulation standards for product components

Test methods prescribed to confirm achievement of minimum standards (see §1.4.3.1):

- The R-value shall be the 1/K factor multiplied by the thickness of the panel.
- The K factor shall be based on ASTM test procedure C518-2004.
- For calculating the R-value for freezers, the K factor of the foam at 20°F (-6.7°C) (average foam temperature) shall be used.
- For calculating the R-value for coolers, the K factor of the foam at 55°F (+12.8 °C) (average foam temperature) shall be used.

1.3.3.14 US DOE proposed test procedures for walk-in coolers and freezers

Relevance: component approach to testing and standards

The US Energy Independence and Security Act of 2007 enacted on December 19, 2007, establishes energy conservation standards for certain consumer products and commercial and industrial equipment, including walk-in cold rooms and walk-in freezers. The DOE's Building Technologies Program has been developing proposals for testing energy consumption of walk-in cooler and freezer rooms. A Notice of Proposed Rulemaking was published in January 2010, and a public meeting held in March 2010 to discuss the options.

The US DOE published on April 15th 2011 a final rule establishing test procedures for measuring the energy efficiency of certain walk-in cold room components, including panels, doors and refrigeration systems, which will be used for the process of evaluation of potential minimum performance standards in a concurrent study. Representations on product performance to this concurrent study must therefore use the test methods outlined in the final rule. In addition, a certification, compliance and enforcement (CEE) final rule was published March 7, 2011.

The US DOE notes that the component approach addresses the unique challenges posed by regulation of walk-in cold rooms, including the facts that the products

[86] AHRI. *2009 Standard for Performance Rating of Walk-In Coolers and Freezers*.2009

are frequently assembled using components produced by several manufacturers, and that installers of walk-in cold rooms may not be equipped to test all of the components that comprise a walk-in cold room.

Summary of DOE approach

Walk-in cold rooms are categorised as walk-in “coolers” or walk-in “freezers”.

The final **rule references US and EU test standards**, including:

- AHRI 1250 (I–P)–2009, ‘‘2009 Standard for Performance Rating of Walk-In Coolers and Freezers”
- ASTM C1363–05, ‘‘Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus”
- DIN EN 13164:2009–02, ‘‘Thermal insulation products for buildings—Factory made products of extruded polystyrene foam (XPS)—Specification”
- DIN EN 13165:2009–02, ‘‘Thermal insulation products for buildings—Factory made rigid polyurethane foam (PUR) products—Specification”
- NFRC 100–2010[E0A1], ‘‘Procedure for Determining Fenestration Product U-factors”

In addition, the final rule refers to the test standard ASTM C518-04 “Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus”, which is used to measure characteristics required to meet minimum standards specified in EPCA, and the result of this test is also required to provide an input to the calculations in the final rule.

Overview of test procedures and energy consumption and efficiency calculations

The energy consumption of components is calculated, including for refrigeration system, panels, doors and electronic equipment.

AHRI 1250 is used to calculate the refrigeration system daily energy consumption and an overall efficiency factor, the annual walk-in efficiency factor (AWEF), test condition adapted for the relevant operation temperature (cooler or freezer). This standard includes methods for testing of the refrigeration system to evaluate cooling capacity and energy consumption, hence refrigeration system COP.

Daily energy consumption of the walk-in cold room surfaces (panels and doors) are calculated separately. Firstly U-factors for panels and doors are evaluated through test procedures, test condition adapted for the relevant operation temperature (cooler or freezer). The U-factor takes into account composite panel or door characteristics, such as insulation type, structural members, and transparent material (e.g. glass) and panel thickness. The U-factor is then multiplied with nominal refrigeration system performance characteristics for the relevant operation temperature (cooler or freezer), to calculate energy consumption (total energy consumption is calculated as an effect of the door’s thermal load on a “nominal” refrigeration system and hence the energy consumed by the refrigeration system to meet this load).

The nominal efficiency is described using an energy efficiency ratio (EER), with values proposed for coolers and freezers being 12.4 Btu/W-h (COP of 3.63) and 6.3

Btu/W-h (COP of 1.85)[87] respectively (these values correspond to the nominal EER values for the refrigeration test procedure for unit coolers connected to central condensing units under AHRI 1250–2009 in respect to assumed adjusted dewpoint temperature of -7°C and -32°C respectively for coolers and freezers), and the US DOE highlights that these are only for comparative purposes and are not intended to represent the efficiency of the refrigeration system that would be paired with the components.

Finally, daily energy consumption of any integrated electronic devices, and the effect of their heat load on the nominal refrigeration system, are added.

Test procedure for doors

Doors can be display (integrating a transparent section) or non-display type, and are tested in through the same procedure. NFRC 100-2010[E0A1] is used to evaluate the U-factor (thermal transmittance measured in Btu/h-ft^2-°F) through the door. NFRC 100-2010[E0A1] also allows verified computer models to simulate performance to reduce testing burden.

This energy consumption of the nominal refrigeration system due to thermal transmittance is then combined with the energy consumption of any electrical components integrated into the door, in kWh/day. Assumptions on the nominal refrigeration system are the same for all doors tested, depending if the door is to be used for walk-in coolers or walk-in freezers, to enable direct comparison within the temperature categories.

Direct electricity consumption of the door will be the sum of the rated power of the component multiplied by the assumed operation time. To facilitate the calculation of electricity consumption, fixed assumptions for the percentage time off (PTO) of common electrical devices used in doors are specified in sections 4.4.2 and 4.5.2 of Appendix A of the final rule for display and non-display door types respectively. For any electrical device not covered in the assumptions provided in the final rule, then a PTO of 25% can be used where a manufacturer demonstrates that the device is controlled by a preinstalled control system, timer, or other auto-shut-down system. The test procedure also provides the method of calculating the added energy consumption due to the heat load placed on the refrigeration system by any electrical device(s) installed in the door.

A formula is provided in the final rule to produce a energy consumption of the door. The calculations are described in the final rule, sections 4.4 and 4.5 of Appendix A.

Test procedures for panels

In the final rule, a panel is described as the fully manufactured product containing, but not limited to the insulation, skin, framing material, other structural members, or any combination of these, as opposed to just the "insulation", which is synonymous with "foam". A display panel is a panel that is partially or entirely comprised of glass, a transparent material, or both, and is used for display purposes. A non-display panel can be either a floor or non-floor panel, and since these are typically formed in the same way from a composite of insulation, framing and facer material, they will be measured in the same way. The US DOE is adopting a separate approach depending on whether a panel is a display or non-

[87] 1 Btu = 0.293 W.h, hence COP = EER / 3.412

display type, hence display panels are tested under a different regime, specified in section 4.1 in Appendix A of the final rule (similar to that of the test procedure for doors as described above).

For non-display (floor, wall and ceiling) panels, US DOE specifies that ASTM C518-04 must still be used to determine the K-factor of the insulation (R-value is equal to 1/K-factor multiplied by thickness of the panel) as required by EPCA. The US DOE emphasises that the current final rule does not prevent adherence to the existing EPCA regulation on R-value of the insulation, which will remain a requirement, and highlights that this R-value is not related to the structural members that may be included in the panel. The use of ASTM C1363-05 allows more accurate testing of the energy performance of the panels, and captures the effects of the structural members.

To account for insulation aging and, by extension, to the increased energy consumption due to reduced performance of the insulation over lifetime, the US DOE has adopted the test methods set out in Annex C of EN 13164:2009–02 or EN 13165:2009–02, to measure long term thermal resistance (LTTR), thereby eliminating time as a variable that could affect the measured performance of the insulation. One change to the EN standards used to determine the LTTR is the mean temperatures for testing conditions – these are changed to follow the ASTM C518-04 mean temperatures of 55°F (+12.8 °C) and 20°F (-6.7°C) respectively for a cooler and a freezer under either EN 13164:2009–02 or EN 13165:2009–02, in place of the +10°C specified in the standards. The LTTR R-value is divided by the initial R-value (measured under ASTM C518-04), to provide a degradation factor. The degradation factor (unitless) is then applied to the U-factor of the panel (this calculation is provided in sections 4.2 and 4.3 of Appendix A), increasing the thermal transmission of the panel to account for future insulation aging effects, the U-factor having been measured under ASTM C1363-05 (as described below). Appendix A also sets out the requirements of the sample used to assess LTTR.

The final rule specifies that manufacturers use the ASTM C1363-05 procedure to test a pair of 4 ft by 8 ft (1.22m by 2.43m)[88] test panels, with tolerance of +/- 1 ft (0.3m), joined with the same fastening system and materials that would be used during use, to obtain a core U-factor and an edge U-factor. The weighted percentage of edge U-factor and core U-factor is used to calculate total U-factor when applying the results of the test panels to other floor and non-floor panels of the same thickness, construction and materials (i.e. to use a “basic model” approach that reduces testing burden). The final rule provides an example of such a calculation in section III.B.2.a.

The US DOE notes that the aging test is only applied to foams incorporating low conductivity blowing agents, but as expanded polystyrene is not affected by the issue it does not need to be tested for aging. In addition, polyisocyanurate (PIR) insulation is covered under the test for polyurethane (PUR) insulation in EN 13165:2009–02.

A formula is provided in the final rule to produce a energy consumption of the door. The calculations are described in the final rule, sections 4.2 and 4.3 of Appendix A.

Test procedure for refrigeration system

[88] 1 ft = 0.304 m

The US DOE considered the refrigeration system as an individual component of the walk-in cold room. It therefore establishes a test procedure to assess performance of the refrigeration system itself, assuming nominal envelope characteristics. There is discussion on the options for classification of refrigeration system types, which are categorised as dedicated single-package systems containing condensing and evaporating units, split systems containing an evaporator unit (or "unit cooler") and dedicated condensing unit, and unit coolers that receive refrigerant from a central condensing system that is shared with other equipment. For the last type, those connected to shared, central refrigeration systems, the compressor and condenser are considered out of scope.

AHRI 1250–2009 is the basis for testing of the refrigeration systems, covering all three system types, and this includes a method for measuring the refrigeration capacity and electrical energy consumption for the condensing unit and the unit cooler, as well as off-cycle fan energy and the defrost subsystem under specified conditions, the conditions being different for indoor and outdoor locations for the condensing unit, and also for cooler or freezers.

The AHRI standard also specifies a calculation methodology to compute the AWEF for the refrigeration system under a specified load profile, and the procedure allows for testing of components individually and calculating the AWEF from the component test results. This flexibility enables manufacturers to test unit coolers and condensing units separately, and used them together in new refrigeration systems (test results are independent of the matched unit cooler or condensing unit attached to the respective condensing unit or unit cooler for the purposes of the test).

In contrast, test results of individual components produced by different manufacturers are in the form of a performance curve to facilitate calculation of matched performance, which creates some limitation as meaningful comparison between unit coolers is therefore not possible without matching of the tested unit coolers to the same condensing unit. However, if unit coolers are tested and rated as if matched to a central condensing unit, they can be compared, hence it is relatively simple for manufacturers of cooling units to provide both matched performance data, to allow assessment of design performance, and performance relative to the use of a nominal central condensing unit, for cross-market comparative purposes.

For the calculation of energy use of central refrigeration systems, a nominal efficiency that accounts for the type of system's ability to reject heat is used (i.e. depending on indoor or outdoor).

Formulae for calculation of the annual energy consumption are provided in the revisions to §431.304, part (8)(i) to (iii), in Appendix A of the final rule.

The US DOE has also left open the option of manufacturers (particularly those manufacturers producing low-volume customised equipment) using their own methods to calculate refrigeration system energy consumption, whether calculation or computer simulation, after substantiation of the method with test data and acceptance of the method from the US DOE, in order to reduce testing burden. These can be in the form of alternate rating methods (ARMs) or alternate efficiency determination methods (AEDMs).

Temperature conditions

For the calculation of thermal transmittance across the insulation panels (sections 4.1 to 4.5 in Appendix A to the final rule), the following temperatures are used:

- Internal cooled space for cooler: 35°F (+1.7°C)
- Internal cooled space for freezer: -10°F (-23.3°C)
- External space for cooler and freezer: 75°F (+23.9°C)
- Subfloor temperature for cooler and freezer: 55°F (+12.8 °C)

Following this, the final rule specifies that for the ASTM C1363-05 procedure, the "hot side" for non-floor panel is 75°F (+23.9°C) and for floor panel is 55°F (+12.8 °C), and on the "cold side", 35°F (+1.7°C) for the cooler and -10°F (-23.3°C) for the freezer. This is also the case for NFRC 100-2010[E0A1].

The final rule specifies a change to the EN 13164:2009–02 and EN 13165:2009–02 standards used to determine the LTTR in section 5.3 in Appendix A. The mean temperatures for testing conditions are changed to 55°F (+12.8 °C) and 20°F (-6.7°C) respectively for a cooler and a freezer (to follow the ASTM C518-04).

Temperatures used in AHRI 1250–2009 for nominal evaporation temperature are unchanged, at -7°C and -32°C respectively for coolers and freezers, and condensing air temperatures are assumed to be +32°C indoors, and up to +35°C outdoors.

Responsibility for testing and information requirements

These are described in full in the CEE final rule. In summary, the responsibility for compliance extends to both component manufacturer and assembler. Component manufacturers are responsible for certifying compliance of the components to be used for walk-in cold rooms, while assemblers of the complete walk-in cold room are required to use only certified components (the component manufacturer is not responsible for the end-users implementation of the component – only of the components compliance as designed).

Regarding the **basic model approach**, the US DOE has decided that this approach should be used for each key component within the walk-in cold rooms, rather than the product overall, and as long as the basic model covers equipment with characteristics that are essentially the same with respect to energy consumption or energy efficiency the CCE final rule allows for use of basic models at the discretion of the manufacturer (in other words a component may be grouped with others as long as its tested performance is at least as good as the certified rating). However, the concept is applied slightly differently to panels, doors and refrigeration systems, due to their different characteristics.

- **Panels:** smaller panels may have higher proportion of framing material to non-framing material, or the use of different framing material, which may increase heat transmission and affect the overall U-factor, hence would need separate testing and certification – however, increases in width and height would not be expected to detrimentally affect the U-value if all other characteristics were equal.
- **Doors:** as with panels, those with essentially identical energy consumption levels can be grouped into a basic model and rated conservatively.
- **Refrigeration system:** models may be grouped, if they have essentially identical electrical, physical and functional characteristics that affect

energy consumption or efficiency, hence the tested performance must be at least as good as the certified rating.

Information requirements

The requirements for information provision are set out in § 429.12 and § 429.53. The certification report needs to include the following: door type, the R-value of the wall, ceiling and door insulation (except for glazed portions of the doors or structural members), the R-value of the floor insulation (for freezers only), the evaporator fan motor type, the efficacy of the lighting including ballast losses, and a declaration that the manufacturer has incorporated the applicable design requirements. In addition, for those walk-in coolers and freezers with transparent reach-in doors and windows: the glass type of the doors and windows (e.g., double-pane with heat reflective treatment, triple-pane glass with gas fill), and the power draw of the antisweat heater in watts.

Any calculations to support the certified ratings must be retained along with the test data of the test panels for maintaining records of all models covered under that “basic model”.

Areas not taken forward

The US DOE has in addition described in its final rule the areas of investigation that have not been taken forward into the requirements for testing and subsequent minimum standards.

Infiltration is no longer considered, due to the shift to a component approach, and the US DOE considers that this issue is most likely negligible compared to other energy consumption pathways. In addition, the US DOE states that this issue relies heavily on on-site construction practice rather than component performance, and notes that door opening infiltration reduction devices are already mandated through EPCA. However, the issue of infiltration may be re-examined by the US DOE in future rulemaking.

The US DOE sets outs reasons for exclusion of testing of moisture absorption or vapour permeance in foam at the time of the final rule, but states that one of its laboratories is currently testing methods to evaluate moisture absorption on R-value.

Since the approach is component-based, electrical components not part of one of the components (door, display panel or refrigeration system) are not covered, but the US DOE highlights that EPCA requirements on lighting efficacy standards must still be maintained.

Regarding the effect of structural members on LTTR, the US DOE states that due to no known tests for edge sealing of panels, this issue is not considered, although it is highlighted as a potential factor to consider in future rulemaking.

Open areas included in walk-in cold rooms are excluded from the US DOE final rule.

Appendix A of the final rule

As described at several points, the final rule contains an Appendix A which lists aspects such as amendments to existing test standard operating conditions, procedures, calculations, and other calculations.

1.3.4. PROCESS CHILLERS

1.3.4.1 EN 14511:2007

Relevance: Industrial process chillers

The EN 14511 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Terms and definitions, test conditions, test methods and requirements,* specifies the terms, definitions, test conditions, methods and requirements for the rating and performance of air- and water-cooled air conditioners, liquid chilling packages, air-to-air, water-to-air, air-to-water and water-to-water heat pumps with electrically driven compressors when used for space heating and/or cooling. **Liquid chilling packages are typically tested with this standard, being not restricted to comfort equipment.** It was stated by stakeholders that the conditions specified within this standard for testing are extreme, and sometimes not a realistic representation of actual working conditions.

The scope of this standard covers:

- Factory-made units that can be ducted.
- Factory-made liquid chilling packages with integral condensers or for use with remote condensers.
- Factory-made units of either fixed capacity or variable capacity by any means.
- Packaged units, single split and multisplit systems are covered by this standard. Single duct and double duct units are covered by the standard.
- In the case of units consisting of several parts, this standard applies only to those designed and supplied as a complete package, except for liquid chilling packages with remote condenser.
- This standard is primarily intended for water and brine chilling packages but can be used for other liquid subject to agreement.
- Air-to-air air conditioners which evaporate the condensate on the condenser side.
- The units having their condenser cooled by air and by the evaporation of external additional water are not covered by this standard.
- This standard does not apply to units using transcritical cycles, e.g. with CO_2 as refrigerant.
- Installations used for heating and/or cooling of industrial processes are not within the scope of this standard.

The standard EN 14511 part 2 provides the ambient conditions for performance testing and rating for the following configurations:

- Outdoor units
- Indoor units
- Air-to-air units in heating mode
- Air-to-air units in cooling mode

- Water-to-air units in heating mode
- Water-to-air units in cooling mode
- Water-to-water units in heating mode
- Water-to-water units in cooling mode
- Air-to-water in heating mode
- Air-to-water in cooling mode
- Liquid chilling packages with remote condenser
- Liquid chilling packages for heat recovery condenser
- Basic, multiple circuit and modular air-cooled multisplit systems in the heating mode
- Basic, multiple circuit and modular air-cooled multisplit systems in the cooling mode
- Modular heat recovery air-cooled multisplit systems
- Basic, multiple circuit and modular water-cooled multisplit systems in the heating mode
- Basic, multiple circuit and modular water-cooled multisplit systems in the cooling mode

The tolerances permitted in the declared values are the following:

Table 1-22: Tolerances permitted in EN 14511

Parameter	Tolerance
Tested cooling and heating capacity	0.88*declared capacity
Tested EER (cooling mode)	0.85*declared EER
Tested COP (heating mode)	0.85*declared COP

EN 14511 part 3 provides the test procedures (measurements, apparatus, data required, calculations) and EN 14511 part 4 specifies the minimum requirements for chilling packages to ensure a proper functioning of the machines. The performance data required should be tested as per EN 14511 parts 2 and 3.

1.3.4.2 EN 15218:2006

Relevance: Air conditioning and liquid chillers

EN 15218:2006 "*Air conditioners and liquid chilling packages with evaporatively cooled condenser and with electrically driven compressors for space cooling. Terms, definitions, test conditions, test methods and requirements*". is also of relevance.

1.3.4.3 prEN 14825

The prEN 14825:2009 *Air conditioners, liquid chilling packages and heat pumps, with electrically compressors, for space heating and cooling- Testing and rating at part load conditions and calculation of seasonal performance* provides testing methods for refrigeration and air-conditioning equipment considering part-load conditions and seasonal performance.

The scope of this standard covers "*air conditioners, heat pumps and liquid chilling packages in part load conditions*". The standard applies to factory made units as defined in EN14511-1, except single duct, control cabinet and close control units.

The standard provides the calculation methods for the determination of reference seasonal energy efficiency (SEER and SEERon) and reference seasonal coefficient of performance (SCOP , SCOPon and SCOPnet).

The standard provides testing conditions and calculation methods for efficiency at part load for:

- Air-to-air units in the cooling mode
- Water-to-air units and brine-to-air units in the cooling mode
- Air-to-water units in the cooling mode
- Water-to-water units and brine-to-water units in the cooling mode
- Air-to-air units in the heating mode
- Water-to-air units and brine-to-air units in the heating mode
- Air-to-water units in the heating mode (low/medium/high temperature application)
- Water-to-water units and brine-to-water units in the heating mode (low/medium/high temperature application)

This standard is only available in draft version (draft by the CEN TC 113 WG 7) and it is still not approved at the time of writing this report.

1.3.4.4 AHRI 550/590-2003

Relevance: Industrial process chillers (vapour compression)

The **AHRI 550/590-2003** *Standard for performance rating of water-chilling packages using the vapor compression cycle* establishes definitions, test requirements, rating requirements and minimum data requirements for published ratings, marking and nameplate data; and conformance conditions.

Scope: "This standard applies to factory-made vapour compression refrigeration water-chilling packages, including one or more hermetic or open drive compressors"[89]. These equipments include:

- water-, air- or evaporatively-cooled condensers
- air-, water-cooled heat reclaim condensers
- packages supplied without a condenser

Test requirements: The tests required for this standard shall be conducted in accordance with Appendix C of the AHRI 550/590-2003 standard.

Rating conditions: Table 1-23 specifies standard rating conditions for all water-chilling packages.

[89] AHRI Standard 550/590-2003. *Standard for performance rating of water-chilling packages using the vapor compression cycle*. 2003

Table 1-24 presents part-load rating conditions defined by ANSI/AHRI 550/590-2003 to permit the development of part-load performance over a range of operating conditions.

Rating requirements:

The minimum rating requirements include the following:

- Net refrigerating capacity, refrigeration tons (RT) [kW]
- Total power input to chiller, bhp or kW, as applicable
- Energy efficiency, expressed as EER, *COP* or kW/ton
- Evaporator Fouling Factor
- Chilled water entering and leaving temperatures, °F [°C], or leaving water temperature and temperature difference, °F [°C]
- Evaporator water pressure drop (inlet to outlet), psi or ft H_2O [kPa]
- Chilled water flow rate, gpm [L/s]
- Nominal voltage, V, and frequency, Hz, for which ratings are valid

Table 1-23: Standard rating conditions of water chilling packages

	Water-cooled		Evaporatively-cooled		Air-cooled	
Condenser water						
Entering	+85°F	+29.4°C				
Flow rate	3.0 gpm/tonne	0.054 L/s per kW				
Condenser fouling factor allowance						
Water-side	0.00025 h*ft^2*°F/Btu	0.000044 m^2*°C/W				
Air-side			0.0 ft^2*°F/Btu	0.0 m^2*°C/W	0.0 h*ft^2*°F/Btu	0.0 m^2*°C/W
Entering air						
Dry-bulb					+95.0°F	+35.0°C
Wet-bulb			+75°F	+23.9°C		
Evaporator water						
Leaving	+44.0°F	+6.7°C	+44.0°F	+6.7°C	+44.0°F	+6.7°C
Flow rate	2.4 gpm/tonne	0.043 L/s per kW	2.4 gpm/tonne	0.043 L/s per kW	2.4 gpm/tonne	0.043 L/s per kW
Evaporator fouling factor allowance						
Water-side	0.0001 h*ft^2*°F/Btu	0.000018 m^2*°C/W	0.0001 h*ft^2*°F/Btu	0.000018 m^2*°C/W	0.0001 h*ft^2*°F/Btu	0.000018 m^2*°C/W
Evaporator fouling factor allowance						
Saturated discharge	+105.0°F	+40.6°C	+105.0°F	+40.6°C	+125.0°F	+51.7°C
Liquid refrigerant	+98.0°F	+36.7°C	+98.0°F	+36.7°C	+105.0°F	+40.6°C
Barometic pressure	29.92 in Hg	101.3 kPa	29.92 in Hg	101.3 kPa	29.92 in Hg	101.3 kPa

Table 1-24: Part-load conditions for rating

	IPLV		NPLV	
Evaporator (All Types)				
100% load LWT	[2]44.0 °F	6.7 °C	[2]Selected LWT	[2]Selected LWT
0% load LWT	44.0 °F	6.7 °C	Same as 100% load	Same as 100% load
Flow Rate (gpm)	[3]2.4 gpm/ton	0.043 L/s per kW	[3]Selected gpm/ton	[3][L/s per kW]
F.F.A.	0.0001 h · ft2 · °F/Btu	0.000018 m² · °C/ W	As Specified	As Specified
[1]*Water-Cooled Condenser*				
100% load EWT	[2]85.0°F	29.4 °C	[2]Selected EWT	[2]Selected EWT
75% load EWT	75.0 °F	23.9 °C	[4]	[4]
50% load EWT	65.0 °F	18.3 °C	[4]	[4]
25% load EWT	65.0 °F	18.3 °C	[4]	[4]
0% load EWT	65.0 °F	18.3 °C	65.0 °F	18.3 °C
Flow rate (gpm) [L/s]	[3]3.0 gpm/ton	0.054 L/s per kW	[3]Selected gpm/ton	[3]L/s per kW
F.F.A.	0.00025 h · ft2 · °F/Btu	0.000044 m² · °C/ W	As Specified	As Specified
[1]*Air-Cooled Condenser* (Use Figure 2)			No Rating Requirements	
100% load EDB	95.0 °F	35.0 °C		
75% load EDB	80.0 °F	26.7 °C		
50% load EDB	65.0 °F	18.3 °C		
25% load EDB	55.0 °F	12.8 °C		
0% load EDB	55.0 °F	12.8 °C		
F.F.A.	0.0 h·ft²·°F/Btu	0.0 m²·°C/W		
[1]*Evaporatively-Cooled Condenser*			No Rating Requirements	
100% load EWB	75.0 °F	23.9 °C		
0% load EWB	50.0 °F	10.0 °C		
F.F.A.	0.0 h·ft²·°F/Btu	0.0 m²·°C/W		
Air-Cooled Without Condenser			No Rating Requirements	
100% load SDT	125.0 °F	51.7 °C		
0% load SDT	55.0 °F	12.8 °C		
Water and Evaporatively-Cooled Without Condenser			No Rating Requirements	
100% load SDT	105.0 °F	40.6 °C		
0% load SDT	65.0 °F	18.3 °C		

1 If the unit Manufacturer's recommended minimum temperatures are greater than those specified in Table 3, then those may be used in lieu of the specified temperatures.
2 Corrected for Fouling Factor Allowance by using the calculation method described in C6.3
3 The flow rates are to be held constant at full load values for all part-load conditions.
4 For part-load entering condenser water temperatures, the temperature should vary linearly from the selected EWT at 100% load to 65.0 °F at 50% loads, and fixed at 65.0°F for 50% to 0% loads.

SDT - saturated discharge temperature
LWT - leaving water (liquid) temperature
EWT - entering water (liquid) temperature
EDB - entering air dry-bulb temperature
EWB - entering air wet-bulb temperature
F.F.A. - Fouling Factor Allowance

1.3.4.5 ANSI/AHRI 560-2000

Relevance: Industrial process chillers (absorption)

The **ANSI/AHRI 560-2000** *Absorption water chilling and water heating packages* establishes: definitions; test requirements; rating requirements; minimum data requirements for published ratings; marking and nameplate data; and conformity conditions.

Scope: This standard applies to water-cooled single effect steam and hot water operated water chilling units, water-cooled double-effect steam and hot water operated water chilling units, and double-effect direct-fired (natural gas, oil, LP gas) water chilling/heating units. Water is the refrigerant and LiBr (lithium bromide) the absorbent. This standard does not apply to air-cooled applications, heat pump applications, exhaust gas fired applications and non-standard units.

Test requirements: The tests required for this standard shall be conducted in accordance with Appendix C of ANSI/AHRI 560-2000 standard.

Rating conditions: Table 1-25 specifies standard rating conditions of absorption water chilling and water heating packages.

Table 1-26 presents part-load rating conditions defined by ANSI/AHRI 560-2000 to permit the development of part-load performance over a range of operating conditions.

Rating requirements:

The minimum rating requirements include the following:

- Net refrigerating capacity, tons [kW]
- Total Energy Input to the chiller in MBH[90] [kW], as applicable
- Direct Fired, MBH [kW] based on Higher Heating Value
- Indirect Fired, MBH [kW]
- Chiller Efficiency, expressed as COP or MBH/ton
- Evaporator Fouling Factor, as stated in Table 1 of the standard
- Chilled water entering and leaving temperatures, °F [°C] (as stated in Table 1 of the standard), or leaving water temperature and temperature difference, °F [°C]
- Evaporator water pressure drop (inlet to outlet), psi or ft H_2O [kPa]
- Chilled water flow rate, gpm [L/s]
- Average electrical power consumption, kW [kW] for all auxiliary components including solution and refrigerant pumps, purge, control panel, burner fan, burner controls, etc. Power required by system water pumps shall be excluded.
- Absorber/condenser water pressure drop (inlet to outlet), psi or ft H_2O [kPa]
- Any two of the following:
    - Entering absorber/condenser water temperature, °F [°C]
    - Leaving absorber/condenser water temperature, °F [°C]
    - Water temperature rise through the absorber/condenser, °F [°C]
- Absorber/condenser water flow rate, gpm [L/s].
- Fouling Factors, as stated in Table 1-25.

[90] MBH is the expression of BTU's (British Thermal Units) in thousands.

Table 1-25: Standard rating conditions of absorption water chilling packages

	Single Stage Indirect Fired	Two-Stage Indirect Fired	Two-Stage Direct Fired
Absorber / Condenser Water			
Entering Water Temperature	85.0EF [29.4EC]	85.0EF [29.4EC]	85.0EF [29.4EC]
Water Flow Rate	3.6 gpm/ton [0.065 L/s per kW]	4.0 gpm/ton [0.072 L/s per kW]	4.0 gpm/ton [0.072 L/s per kW]
Water-Side Fouling Factor	0.00025 hAft^2 AEF/Btu [0.000044 m^2 AEC/W]	0.00025 hAft^2 AEF/Btu [0.000044 m^2 AEC/W]	0.00025 hAft^2 AEF/Btu [0.000044 m^2 AEC/W]
Evaporator			
Leaving Water Temperature	44EF [6.7EC]	44EF [6.7EC]	44EF [6.7EC]
Water Flow Rate	2.4 gpm/ton [0.043 L/s per kW]	2.4 gpm/ton [0.043 L/s per kW]	2.4 gpm/ton [0.043 L/s per kW]
Water-Side Fouling Factor	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]
Energy Input			
Fuel Heat Content	N/A	N/A	HHV[c]
Steam Pressure[b]	[a]	[a]	N/A
Tube-Side Fouling Factor (Steam)	0.000 hAft^2 AEF/Btu [0.0000 m^2 AEC/W]	0.000 hAft^2 AEF/Btu [0.0000 m^2 AEC/W]	N/A
Hot Water Entering Temperature	[a]	[a]	N/A
Hot Water Leaving Temperature	[a]	[a]	N/A
Hot Water Flow Rate	[a]	[a]	N/A
Tube-Side Fouling Factor (Hot Water)	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	N/A
Energy Output (Hot Water)			
Hot Water Leaving Temperature	N/A	N/A	[a]
Hot Water Entering Temperature	N/A	N/A	[a]
Hot Water Flow Rate	N/A	N/A	[a]
Tube-Side Fouling Factor	N/A	N/A	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]

[a] Manufacturer specified conditions.
[b] After energy control valve at inlet flange of chiller
[c] Higher Heating Value

Table 1-26: Part-load Rating conditions of absorption water chilling packages

	Single Stage Indirect Fired	Two-Stage Indirect Fired	Two-Stage Direct Fired
Absorber / Condenser Water			
Entering Water Temperature	85.0EF [29.4EC]	85.0EF [29.4EC]	85.0EF [29.4EC]
Water Flow Rate	3.6 gpm/ton [0.065 L/s per kW]	4.0 gpm/ton [0.072 L/s per kW]	4.0 gpm/ton [0.072 L/s per kW]
Water-Side Fouling Factor	0.00025 hAft^2 AEF/Btu [0.000044 m^2 AEC/W]	0.00025 hAft^2 AEF/Btu [0.000044 m^2 AEC/W]	0.00025 hAft^2 AEF/Btu [0.000044 m^2 AEC/W]
Evaporator			
Leaving Water Temperature	44EF [6.7EC]	44EF [6.7EC]	44EF [6.7EC]
Water Flow Rate	2.4 gpm/ton [0.043 L/s per kW]	2.4 gpm/ton [0.043 L/s per kW]	2.4 gpm/ton [0.043 L/s per kW]
Water-Side Fouling Factor	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]
Energy Input			
Fuel Heat Content	N/A	N/A	HHV[c]
Steam Pressure[b]	[a]	[a]	N/A
Tube-Side Fouling Factor (Steam)	0.000 hAft^2 AEF/Btu [0.0000 m^2 AEC/W]	0.000 hAft^2 AEF/Btu [0.0000 m^2 AEC/W]	N/A
Hot Water Entering Temperature	[a]	[a]	N/A
Hot Water Leaving Temperature	[a]	[a]	N/A
Hot Water Flow Rate	[a]	[a]	N/A
Tube-Side Fouling Factor (Hot Water)	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]	N/A
Energy Output (Hot Water)			
Hot Water Leaving Temperature	N/A	N/A	[a]
Hot Water Entering Temperature	N/A	N/A	[a]
Hot Water Flow Rate	N/A	N/A	[a]
Tube-Side Fouling Factor	N/A	N/A	0.0001 hAft^2 AEF/Btu [0.000018 m^2 AEC/W]

[a] Manufacturer specified conditions.
[b] After energy control valve at inlet flange of chiller
[c] Higher Heating Value

1.3.4.6 CAN/CSA-C743-09

Relevance: Industrial process chillers

The **CAN/CSA-C743-09** *Performance Standard for Rating Packaged Water Chillers* applies to factory-designed and prefabricated water-cooled chiller/heater units, single-effect indirect-fired by steam or hot water, and double-effect, both indirect-fired by steam or hot water and direct-fired by oil, natural gas or LP gas; water is the refrigerant and lithium bromide is the absorbent. This standard does not apply to absorption chiller/heater units with air-cooled condensers, nor to applications employing heat pumping or exhaust gas firing.

1.3.4.7 AS/NZS 4776: 2008[91]

Relevance: Industrial water chillers

The **AS/NZS 4776:2008** *Liquid-chilling packages using the vapour compression cycle* standard aims to establish a method to rate the performance of factory-made liquid chilling packages using the vapour compression cycle. The scope of the standard includes: air- and water-cooled liquid-chilling packages of cooling capacity 350kW and above.

The AS/NZS 4776.1 does not cover:

- liquid-chilling packages driven by other than electrical motors;
- air-cooled liquid-chilling packages with centrifugal fans;
- liquid-chilling packages with remote condensers; and
- liquid-chilling packages for fluids other than water.

This standard is linked to a MEPS (see §1.3.4.7)

1.3.5. Remote condensing units

1.3.5.1 EN 13771:2003/ EN 13771:2007

Relevance: Remote condensing unit, compressor and condenser

EN 13771-1:2003 *Compressor and condensing units for refrigeration – performance testing and test methods for refrigerant compressors* applies to refrigerant compressors and describes a number of selected performance test methods. These methods provide sufficiently accurate results for the determination of the refrigerating capacity, power absorbed, refrigerant mass flow, isentropic efficiency and the coefficient of performance. This European Standard applies only to performance tests conducted at the manufacturer's works.

EN13771-2: 2007 *Compressor and condensing units for refrigeration. Performance testing and test methods. Part 2: Condensing units*. This part of EN 13771 applies only to condensing units for refrigeration and describes a number of selected performance test methods. These methods provide sufficiently accurate results for the determination of the refrigerating capacity, power absorbed, refrigerant mass flow and the coefficient of performance.

1.3.5.2 EN 13215:2000

Relevance: Remote condensing unit

EN 13215:2000 (ISO 917:1989) *Condensing units for refrigeration. Rating conditions, tolerance and presentation of manufacturer's performance.* This standard is applicable to equipments with positive-displacement compressors and it aims to specify rating conditions, tolerances and presentation of manufacturer's performance data, usable for comparison of different units. The performance of

[91] Source: Standard Australia/Standard New Zealand. 4776.1:2008. "*Liquid-chilling packages using the vapour compression cycle*". 2008

the units (related to the refrigeration capacity) includes correction factors and based on full load operation[92].

Table 1-27 Standard reference points specified in EN 13215:2000

Reference points	Condensing unit applications			
	High evaporating temperature	Medium evaporating temperature	Low evaporating temperature	Household and similar refrigerators/ freezers
Evaporating temperature (°C) – suction dew point	+ 5	- 10	- 35	- 25
Suction temperature (°C) or superheat (K)	+ 20 10 or 5[1)]	+ 20 10 or 5[1)]	+ 20 10 or 5[1)]	+ 32
[1)] For R717.				

The tolerances permitted in the data presented by the manufacturers shall not be higher than:

- -10.0% in the refrigerating capacity for medium evaporating temperature
- +10.0% in the power absorbed for medium evaporating temperature
- -12.5% in the refrigerating capacity for low evaporating temperature
- -12.5% in the power absorbed for low evaporating temperature

In no case, the tolerance on COP be higher than 10%.

1.3.5.3 ASHRAE Standard 23-2005

Relevance: Packaging condensing unit, compressor and condenser

The **ASHRAE 23-2005** *Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units* (ANSI approved) applies to the methods of testing for rating single-stage positive-displacement refrigerant compressors and condensing units that do not have liquid injection and are operated at subcritical (saturated) temperatures of the refrigerant. It also applies to the methods of testing for rating single-stage positive-displacement refrigerant compressors and condensing units that incorporate liquid injection that is controlled by a steady flow rate method and are operated at subcritical (saturated) temperatures of the refrigerant.

1.3.5.4 ISO/R 916:1968

Covers the determination of the technical performance of a refrigerating system, but not the functional duty of a complete installation or the performance of its individual components. The term "refrigerating system" implies the conventional vapour compression type consisting of compressing, condensing and evaporating apparatus, together with the interconnecting piping and the accessories necessary to complete the refrigerant circuit.

[92] Source: http://necis.ihs.com/document/abstract/OWZNHBAAAAAAAAAA

1.3.6. STANDARDS RELATED TO THE DESIGN, USE AND SAFETY OF PRODUCTS

1.3.6.1 EU EN 631-1:1993 – Gastronorm

Relevance: Blast cabinets, service cabinets

The size of refrigeration equipment used for catering is normally standardised according to Gastronorm format. This is used by the European Committee of Standardization under the reference EN 631-1:1993 *Materials and articles in contact with foodstuffs. Catering containers. Dimensions of accessories and supports*. According to this, the trays can be used for storage, transportation, handling, service, etc. The basic size is the GN1/1 with a capacity equal to 530mm x 325mm. However there is a big range of sizes as per the following table.

Table 1-28 Gastronorm standardised size for kitchen related equipment according to EN 631-1:1993

Format	Surface area (mm)
GN 2/1	530 x 650
GN 1/1	530 x 325
GN 2/3	352 x 325
GN 1/2	265 x 325
GN 1/3	176 x 325
GN 2/8	132 x 325
GN 2/4	530 x 162
GN 1/4	265 x 162
GN 1/6	176 x 162
GN 1/12	88 x 162
GN 1/9	176 x 108
GN 2/24	132 x 108
GN 1/18	88 x 108

1.3.6.2 EN 1672:1997 Food processing machinery hygiene requirements

Part 2: Hygiene requirements

Relevance: Service cabinets, blast cabinets, walk-in cold rooms

Provides details on verification tests and on what user instructions (provided by manufacturers) need to cover, specifying the cleaning regimes and materials and safe methods of dismantling, cleaning (disinfecting) and rinsing the machine, including any internal pipework.

1.3.6.3 EN ISO 14159:2002

Relevance: Service cabinets, blast cabinets, walk-in cold rooms

The standard specifies hygiene requirements, both for the equipment and the information to be provided by the manufacturer regarding the intended use. It applies to all types of machines and associated equipment used in applications where hygiene risks to the consumer of the product can occur.

1.3.6.4 EN 60335-2-24:2010

Relevance: Service cabinets, blast cabinets, ice-makers, and beverage and dessert appliances

The international safety standard **EN IEC 60335** *Household and similar electrical appliances – Safety* is composed of two distinct sections. Part 1 "General requirements", describes general requirements common to all the electric motor appliances. Part 2 addresses various specific products. Those applicable to ENTR Lot 1 are described in the following paragraphs.

The **EN IEC 60335-2-24:2006** *Household and similar electrical appliances – safety – part 2-24: particular requirements for refrigerating appliances, ice cream appliances and ice-makers* deals with the safety of refrigerating appliances for household or similar use, ice-makers incorporating a motor-compressor, ice-makers intended to be incorporated in frozen food compartments, refrigerating appliances and ice-makers for use in camping, touring caravans and boats for leisure purposes. Appliances intended to be used in shops are within the scope of this standard.

The **EN IEC 60335-2-34:2004** *Household and similar electrical appliances – safety – part 2-34: particular requirements for motor compressors* deals with the safety of sealed motor-compressors (hermetic and semi-hermetic types), their protection and control systems. They are intended for use in equipment for household and similar purposes and conform with the standards applicable to such equipment. Examples of equipment which contain motor compressors are refrigerators, food freezers and ice-makers.

The **EN IEC 60335-2-89:2005** *Household and similar electrical appliances – safety – part 2-89: particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor* specifies safety requirements for electrically-operated commercial refrigerating appliances that have an incorporated compressor or that are supplied in two units for assembly as a single appliance in accordance with the manufacturer's instructions (split system).

Scope: Appliances that are within the scope of this standard are: refrigerated service cabinets, blast chillers and blast freezers (refrigerated display cabinets - covered in the preparatory study TREN Lot 12, service counters and self-service counters are also covered)[93].

This standard does not apply to: commercial ice-cream appliances, commercial ice-makers, cold rooms, domestic refrigerating appliances, industrial refrigerating systems, motor-compressors (IEC 60335-2-34 described previously), commercial dispensing appliances and vending machines (IEC 60335-2-75), and multiple refrigerated chambers with a remote compressor. Appliances with a charge of more than 150 g of flammable refrigerant in each separate refrigerant circuit are not covered by this standard. For appliances with a charge greater than 150 g of

[93] IEC Website: www.iec-normen.de/previewpdf/info_iec60335-2-89%7Bed1.2%7Db.pdf

flammable refrigerant in each refrigerant circuit and for the installation, **ISO 5149:1993** may be applied.

Requirements: As far as is practicable, this standard deals with the common hazards presented by appliances within the scope of **EN IEC 60335-2-89:2005.**

1.3.6.5 EN 12464-1:2004

Relevance: Walk-in cold rooms

The standard specifies lighting requirements for indoor work places which meet the needs for visual comfort and performance. All usual visual tasks are considered, including display screen equipment (DSE). It covers lighting design criteria, schedule of lighting requirements and verification procedures. It does not specify lighting requirements with respect to the safety and health of workers at work, although the lighting requirements as specified in this standard usually fulfill safety needs, and is not applicable for the lighting of outdoor work places and underground mining.

1.3.6.6 FR NF AC D40-003:2006

Relevance: Blast cabinets, service cabinets

NF AC D40-003:2006 "Equipment for collective restaurant – refrigerating equipment. General design and construction rules for ensuring hygiene in use". This document establishes some manufacturing rules to decrease hygiene-related risks associated with restaurant equipment, including blast and service cabinets.

The conditions expressed in the original text are summarised below:

Environment

- Mean temperature: > +24°C,
- Instant temperature: +25°C (± 4K)

Testing conditions (performance testing): cabinets

- Testing load
  - Foodstuff type: smashed potatoes: potatoes paste flakes (11.5%), water (87.7%) and salt (0.8%). Percentages are expressed in mass. The salted water is heated up to 75 to 80°C. The potatoes are added and mixed. This mixture is added to package type trays and lidded. This preparation can be used only once.
  - Package type tray: the disposable trays made of carton with polypropylene weight 1.8kg. Their size corresponds to GN ½. The tray lid is the material as the tray itself.
  - M-package: package type including fixed temperature measuring equipment.
  - Weight: the testing weight shall be the one declared by the equipment manufacturer according to the cycle with a tolerance of 5%.
  - Number of trays and distribution: the packages or testing material are placed in the trays corresponding to the nominal load. At least 10 temperature probes shall be in use. There shall be at least one

package per tray. They shall be arranged alternately from front to back or from right to left.

- The temperature of the load shall be between +63°C to +80°C.

- Refrigerant charge
  - The remote condensing unit should be located outside the testing room. The distance between the equipment and the condensing unit shall be registered. The same rule applies to equipment using cryogenic material. The conditions for evaluation of remote blast cabinets are described in section 0.
- Loading
  - The temperature inside the equipment shall be in the same as the room conditions. The loading shall be done as fast as possible.
- Temperature registration
  - The room temperature and the temperature of the packages shall be registered every 5 minutes.
  - To determine the initial and final temperature, the data collection shall be done every minute is possible.
- Reference temperature
  - Initial temperature: +63°C.
  - Final temperature: +10°C for chilling equipment, -18°C for freezing equipment.
- Required results
  - Testing period of time: the initial time is the time when the package's mean temperature is equal to the initial reference temperature. While, the final time shall correspond to the instant when the package's mean temperature correspond to the final reference temperature.
  - In the case of blast chilling equipment, the tolerance will be of 1.5°C. The test will be satisfactory if:

    - The testing material temperature decreases from +64.5°C to +8.5°C in 120 min (+5%) or less.

    - The temperature of the coldest package shall be greater than -1°C.
  - In the case of blast freezing equipment, the test will be satisfactory if:

- The testing material temperature decreases from +64.5°C to -19.5°C in 4.5 hours (+5%) or less.

  - In the case of combined blast equipment, the test will consist of:

- 2 tests conducted with the appropriate conditions according to the type of cycle.

- the required results are from the chilling and freezing cycles.

Performance Testing: vacuum test (remote condensing units)

This section describes the procedure of remote blast cabinets testing. The test can be performed either in a testing room or in-site.

- Temperature:
  - for vapour compression cycles: the test is done under 2 room temperature conditions: +20°C (±4K) and +35°C (±4K).
  - for cryogenic systems: the test is done under the room temperature. This temperature has to be registered.
- Relative humidity: not considered.
- Test procedure: 3 temperature probes shall be used to measure the temperature of the condensing unit and of the room. The measurement shall be done every 5 minutes.
- Reference temperature:
  - Initial: +20°C and +35°C or the room temperature in-site.
  - Final: +20°C for blast chilling, +35°C for blast freezing and 40°C for cryogenic cabinets.
- Testing time, the test will end once the probe temperature measures correspond to the final reference temperature. The time in testing room conditions will be used as reference for the in-site testing time.

Further information on protocol for service cabinets is expressed in section §1.3.1.8.

1.3.6.7 DE VDMA 11499 Operation and use of refrigerated display cabinets

Relevance: Service cabinets, walk-in cold rooms, blast cabinets

Relates to the operation and use of refrigerated cabinets and the corresponding refrigeration devices, and details possible measures for maintaining the safety temperatures for refrigerated cabinets, and the optimum conditions for energy-efficient operation.

1.3.6.8 DE VDMA 24247 Energy efficiency of refrigerating systems

Part 1: Contribution of refrigerating and air conditioning systems to climate protection – Improvement of energy efficiency – Reducing greenhouse-related emissions
Part 2: Requirements for system design and components
Part 3: Guideline for an improved energy efficiency in cold storages
Part 4: Supermarket refrigeration
Part 5: Industrial refrigeration
Part 6: Refrigeration in air conditioning systems
Part 7: Control and energy management
Part 8: Components – Heat Exchangers

These standards describe means to improve refrigeration system efficiency and reduce environmental impacts, both in respect to overall system design and selection of components, as well as more in-depth analysis and recommendations for specific industrial sectors.

1.3.6.9 US NSF/ANSI 7:2009

Relevance: Blast cabinets, service cabinets, walk-in cold rooms

NSF/ANSI Standard 7:2001 Commercial Refrigerators and Freezers provides requirements for minimum food protection and sanitation requirements for the materials, design, manufacture, construction and performance of foodstuff storage equipments for refrigeration and freezing, not limited to service cabinets, walk-in cold rooms, and blast cabinets, among others. This standard does not provide installation requirements.

1.3.7. Standards affecting the use of refrigerants

1.3.7.1 EU EN 378:2009

Relevance: Refrigerating systems, refrigerants

The EN 378:2009 *Refrigerating systems and heat pumps. Safety and environmental requirements. Design, construction, testing, marking and documentation* includes within its scope piping, components and materials and additional equipment in direct association with those systems. It also states requirements for testing, commissioning, marking and documentation.

If the heat transfer fluid is liquid at atmospheric pressure, the requirements for its circuits are excluded from this standard but not for those belonging to safety devices associated with the refrigerant system. This standard does not concern water, air refrigerant systems or systems to be used in potentially explosive atmospheres. It also specifies the requirements for stationary and mobile refrigerating systems, including heat pumps. EN 378:2009 only includes systems whose refrigerants are listed in the Annex of EN 378-1:2008 as long as a safety class is not assigned. EN 378-1 defines some basic safety standards for refrigerating systems, such as limits for refrigerant charge depending on the size of the room, due to the flammability or toxicity of the substances.

Part 1, "basic requirements, definitions, classification and selection criteria" provides definitions of certain terms used in the standard. It also provides a classification system according to:

- Usage of the premises:
  - category A: rooms, parts of building or buildings in which persons may sleep or may not have total freedom of movement and where persons are not aware of the safety measures to be applied. Such premises include hospitals, courthouses and prisons, supermarkets, schools, railway stations, etc. and thus are public buildings;
  - category B: rooms, parts of building or buildings in which certain persons may be aware of the general safety measures to be applied. Such premises include production plants, commercial premises, etc;
  - category C: rooms, parts of building or buildings in which all persons present are trained in the general and specific safety measures to be applied. Such premises include specific production plants, cold stores, etc.
- Refrigerants are classified according to their flammability and toxicity:

- o group L1 (non-toxic, non-flammable refrigerants) forming category A1;
- o group L2 (slightly flammable refrigerants) comprising the categories A2, B1 and B2;
- o group L3 (toxic, flammable refrigerants) comprising the categories A3 and B3.

Annex E contains information on refrigerants and indicates their characteristics (molecular mass, flammability limits, GWP, ODP, etc.).

1.3.7.2 DE VDMA 24020 Operational requirements for refrigerating systems

Part 1: Ammonia refrigerating systems

Part 2: Refrigerating systems with non-flammable refrigerants (Safety group A1 according to EN 378)

Following the "Meseberger" resolutions of the government of the Federal Republic of Germany in August 2007, a process was initiated that has led to the recent development of new standards for refrigeration systems, and the use of certain components within these systems (for the use of heat exchangers for example)[94]. These will be discussed in more detail within the technical annex on refrigeration systems.

1.3.7.3 US ASHRAE Standard 34-2008

Relevance: Refrigerants

The ASHRAE 34-2007 "*Designation and Safety Classification of Refrigerants"* intends to establish simple ways of referring to commonly used refrigeration to avoid mentioning chemical names, formulas or trade names. The scope of this standard includes a uniform system for assigning reference numbers without being ambiguous and safety classifications to refrigerants. The safety classification is based on the toxicity and flammability data. This standard does not recommend using any particular refrigerant or blend.

1.3.8. SUMMARY OF EXISTING STANDARDS

Considering the products discussed in subtask 1.1 of ENTR Lot 1 study, there are no EN or international use-phase testing standards covering the whole range of products (Table 1-29). Therefore, a need is identified for providing harmonised test standards. More detailed conclusions by product group are discussed in the following sections.

[94] VDMA (German Engineering Federation) *24020 Einheitsblatt: Betriebliche Anforderungen an Kälteanlagen* (Functional requirements for refrigeration systems) (2008).

Table 1-29: Summary of identified performance testing standards

Product category	EU or MS standards	Third country standards
Service cabinets	EN 441:1995 EN ISO 23953:2005 (CECED Italy adaptation to be completed)	ANSI/AHRI 1200:2008 ASHRAE 72:2005 CSA C827-98 (plug-in only)
Blast cabinets	DIN 8953/8954 and EN 328	NSF/ANSI 7:2009
Walk-in cold rooms	ETAG 021 and 016 (design of insulated enclosure) EN14509 (insulation panels)	AHRI 1251 (SI) – 2009 US DOE discussing adapting the ANSI/AHRI 1250:2008 or the ASHRAE 72:2005 standard
Chillers - packaged	EN 14511 (packaged chillers) prEN 14825:2009 (under development)	AHRI 550/590:2003 (packaged compression chillers) ANSI/AHRI 560:2000 (packaged absorption chillers) AS/NZS 4776: 2008 CAN/CSA-C743-09 ASHRAE 90.1-2007
Remote condensing units	EN 13771:2003 / EN 13771:2007 EN 13215	ASHRAE 23-2005 (packaged)

n/a: No testing standards

1.3.8.1 Service cabinets

Regarding testing methodologies, there are plenty of EU and international standards covering the performance of these appliances. EN 441 is also currently in use in certain MS, and is the basis of the UK ECA and DK ETL. Service cabinet performance data quoted in ENTR Lot 1 refer to this test standard.

EN ISO 23953:2005 is currently being analysed to be evaluated by CECED Italia to establish its adaptability to service cabinets, beyond display cabinets. This mainly requires adaptation of the door/lid openings pattern and M-package loading. EFCEM has taken responsibility for the development of a harmonised standard in the EU.

AHRI 1200 (in the US) is not commonly used in EU. Most of the identified third-country standards deal with household equipment. Broadly speaking, an analysis of applicability of household standards (such as EN 153:2006 or EN ISO 15502:2005) and display equipment standards (EN ISO 23953) to solid-door professional equipments is needed in consultation with industry, to identify the most suitable approach for ENTR Lot 1. This variety of options provides a good basis from which to develop a harmonised standard within the EU.

Although uncommon, remote service cabinets pose a greater challenge when measuring electricity consumption. Indeed, remote service cabinets need to receive a certain amount of refrigerating energy from a remote condensing unit in order to operate and are therefore not considered as standalone products. In the EN ISO 23953 standard on refrigerated display cabinets (§1.3.1.1) the energy consumption is given by the total energy consumption in kWh per 24h period (TEC). This approach is similar to what is proposed in the ANSI/AHRI 1200:2008 standard (§ 1.3.1.4).

1.3.8.2 Blast cabinets

For blast cabinets there are no specific standards regarding energy efficiency or performance in the EU (nor in third countries). This may be due to the current focus on cooling performance (to meet food hygiene requirements) rather than energy efficiency.

It was mentioned by stakeholders that EN ISO 23953 is considered as the best alternative to be used for testing blast cabinets. However, due to the particular cycle of activity (discrete peaks of consumption in order to cool down food temperature) of this type of equipment, the instrument used in representation of the foodstuff during testing should be modified to evaluate correctly the equipment. Also, the functioning conditions of the equipment are well specified in the NF AC D 40-003, and can be considered during the energy testing methodology application. However, it was mentioned by stakeholders that the feasible upper limit for testing is equipment of 60kg due to material cost limits. There is some prior development of performance testing standards on which to develop a harmonised approach in the EU. The German standard DIN 8953/8954 and the EN 328 used to determine the capacity of refrigerating equipments are options for these products.

1.3.8.3 Walk-in cold rooms

AHRI 1251 (SI)[95] can be used currently to evaluate the energy performance of walk-in cold rooms as a whole produce. Computerised modelling may be an alternate route to assessing performance, but this approach is currently thought to be impractical by the US DOE.

In terms of individual components, ETAG 021 specifies standards to be taken into account when designing the insulating enclosure of walk-in cold rooms, including thermal performance, thermal resistance, air permeability, water vapour permeability and thermal inertia. For the insulating panels, EN 14509:2006 (itself referencing EN 13165) is the reference standard for calculating the aged thermal performance of insulation material.

For the evaluation refrigeration systems (to be connected to insulated enclosures), standards described within other product sections are also relevant. These include EN 327 for packaged systems (§1.3.2.2), and EN 13771 (§1.3.5.1) and EN 13215 (§1.3.5.2) for remote condensing systems. Another example of refrigeration system testing (for cellar coolers) is provided by PAS 57.

The ATP agreement provides an example of methods to test an insulated enclosure and refrigeration system as a whole product, and also testing and matching of these two elements of a refrigerated cold storage space as separate components.

[95] International System units

1.3.8.4 Process chillers

Classification by temperature range (-25°C/-8°C; -12°C/3°C; 2°C/15°C) seems to be suitable for discriminating final use of chillers. Some stakeholders stated that the power capacity and size are common classifications because they provide the necessary information about energy and working capacity (even if they reach the same temperatures). Other temperature ranges are used by Eurovent to define standard brine conditions: 0°C/-5°C (medium brine) and -10°C/-15°C (low brine).

Existing test standards apply only to packaged chiller energy performances when it comes to measuring their efficiency (e.g. EN 14511 part 1 to 4 and CEN TS 14825, AHRI 550/590:2003, CAN/CSA-C743-02).

The existing EU standards for testing of chillers seem to cover the same information as their US equivalents; there is currently no identified need to modify the existing EU standards (EN 14511:2007) in light of US standards.

1.3.8.5 Remote condensing units

The use of the methods stated in EN 13771-2:2007 for testing remote condensing units in the EU has been identified.

The use of the testing conditions stated in EN 13215:2000 to present manufacturer's performance data is also a common practice in the EU. This standard provides rating conditions that can be used for comparison of different appliances, even though manufacturers claim that the conditions might not be accurate.

1.4. EXISTING LEGISLATION AND VOLUNTARY AGREEMENTS

The aim of this section is to give an overview of existing legislation and agreements (such as voluntary programmes) covered by ENTR Lot 1, at the EU level, in EU MS and in third countries for all products and components (such as motors and refrigerants) and also at a global level for refrigerants.

Appliances covered by ENTR Lot 1 are electrical products containing a refrigerant fluid (and potentially ozone-depleting substances) and many European Directives apply to these products. These Directives can be classified into environmental, energy and safety legislation. EU legislation therefore covers ecodesign, WEEE, refrigerants, construction, and health and safety. Box 1-5 lists the relevant European legislation in the scope of ENTR Lot 1.

Box 1-5: European legislation in the scope of ENTR Lot 1

SCOPE	LEGISLATION
Environmental Legislation	
Entire product	Waste Electrical and Electronic Equipment Directive 2002/96/EC (vending machine)
	Restriction of the use of certain Hazardous Substances in electric and electronic equipment Directive 2002/95/EC (vending machine)
Refrigerating Fluids	Ozone Depleting Substances Regulation 2037/2000
	Fluorinated Greenhouse Gases Regulation 842/2006
Energy Legislations	Energy efficiency requirements for ballasts for fluorescent lighting - Directive 2000/55/EC and Regulation 245/2009 of the European Parliament and of the Council
Safety Legislations	
Entire product	Machinery Directive 95/16/EC
	General Product Safety Directive 2001/95/EC
	Low Voltage Equipment Directive 73/23/EEC
	Pressure equipment Directive (PED) 97/23/EC

Most of the third country legislation identified is mandatory MEPS. The aim of MEPS is to remove the least efficient appliances from sale. A specific test standard for energy consumption measurement is often imposed in the MEPS.

1.4.1. SERVICE CABINETS

1.4.1.1 UK ECA incentive scheme for plug-in commercial service cabinets

Eligibility criteria for the scheme are discussed in §1.2.1.2.

Performance criteria: Products must have an Energy Efficiency Index (EEI) that is less than, or equal to, the thresholds set out in Table 1-30 below, which depend on the type of cabinet.

Table 1-30: EEI performance thresholds for commercial service cabinets[96]

Type	Gross internal volume (litres)	Energy efficiency index performance threshold (kWh/48hrs/m^3) Chilled (M1)	Energy efficiency index performance threshold (kWh/48hrs/m^3) Frozen (L1)
Single door	400 and 600 (+/-15%)	EEI <= 16.0	EEI <= 38.0
Double door	1,300 (+/-15%)	EEI <= 12.0	EEI <= 34.0
Under counter and counter cabinets with solid doors or drawers	150 to 800 (+/-15%)	EEI <= 21.6	EEI <= 40.0

Where:

- EEI is defined as the TEC of the product over a 48 hour test period divided by the product's net volume (in m^3)
- Net volume equals: shelf (or drawer base) area x loading height
- TEC is as defined in BS EN 441-9:1995

Required test procedures: All cabinets must conform to the following temperature classifications (as defined in BS EN 441-6:1995) when tested to BS EN 441:1995/1996 in climate class IV (+30°C, 55% RH):

- For chilled cabinets: M1 (all measurement packs must be between –1 and +5°C).
- For frozen cabinets: L1 (the highest temperature of the warmest measurement pack must be less than or equal to –15°C and the lowest temperature of the warmest measurement pack must be less than or equal to –18°C).

All cabinets must be tested according to the requirements for closed refrigerated cabinets contained in BS EN 441:1995/1996 with the following test conditions:

- Loading: as described in BS EN 441-5:1996. Cabinets with shelves, to be fitted with a minimum of one shelf per 300 mm of open height at equal distances apart. For upright units this equates to a minimum of 4 shelves and for under counter units to a minimum of two shelves. The lowest height shelf should be located at the lowest available height fitting.
- Temperature test: as described in BS EN 441-5:1996, specifically § 3.6.

Below is presented a figure showing the UK ECA VEPS and the performance of the vertical refrigerators and freezers that have been certified under the scheme. This shows a relatively wide spread of performance, indicating that there may be potential for even certified products to improve further.

[96] ECA website, commercial service cabinets criteria: www.eca.gov.uk

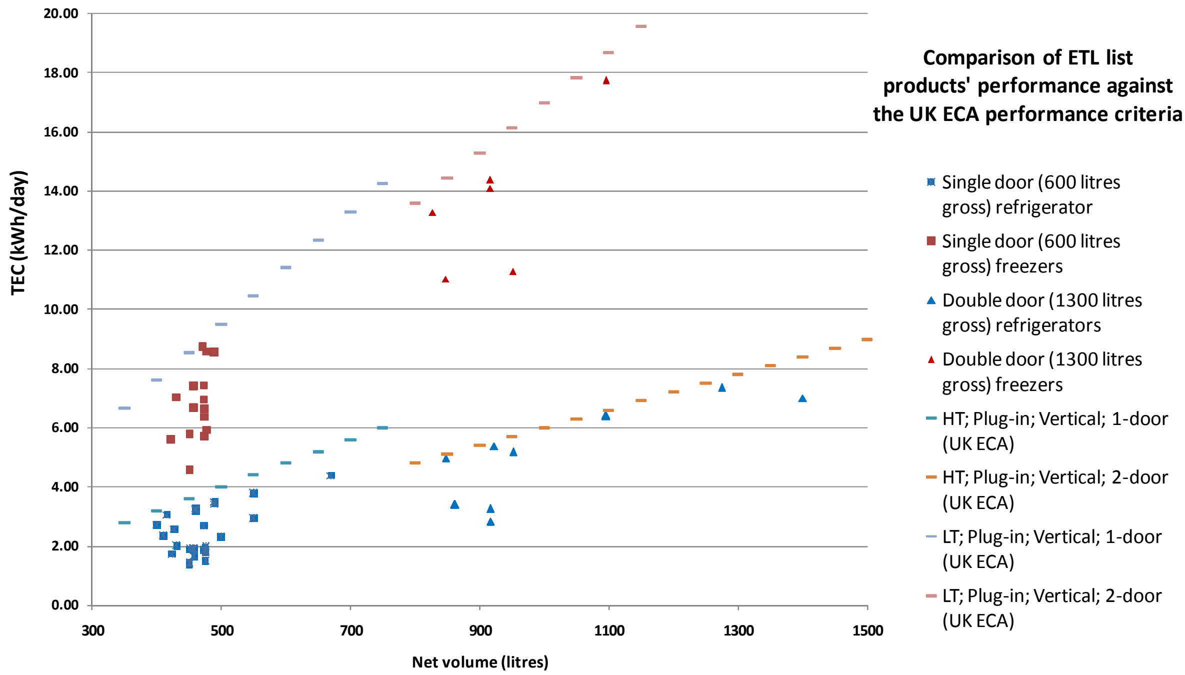


Figure 1-25 : UK ECA performance standards and ETL products

1.4.1.2 US DOE MEPS

The Energy Conservation Program for Commercial and Industrial Equipment final rule was published on January 9, 2009 by the US DOE. The energy conservation standards developed will apply to commercial refrigeration equipment manufactured on or after January 1st, 2012. This rulemaking defines test procedures for measuring energy efficiency and related definitions for commercial refrigeration equipment including:

- Commercial ice-cream freezers
- Self-contained (i.e. plug-in) commercial refrigerators, freezers, and refrigerator-freezers without doors
- Remote condensing commercial refrigerators, freezers, and refrigerator-freezers

Scope: The scope of this rulemaking (*Energy Conservation Standard Rulemaking*) is defined by the three categories of products listed above. However, for remote cabinets, secondary coolant applications are not covered. This is consistent with the ANSI/AHRI 1200 standard which explicitly excludes secondary coolant applications.

Requirements: The test procedure under consideration is the Air-Conditioning, Heating and Refrigeration Institute (AHRI) Standard 1200:2008, "Performance Rating of Commercial Refrigerated Display Merchandisers and Storage cabinets" (see §1.3.1.4). ANSI/ARI Standard 1200 contains rating temperature specifications of 38 °F (±2 °F) for commercial refrigerators and refrigerator compartments, and 0 °F (±2 °F) for commercial freezers and freezer compartments. In the test procedure final rule, DOE also adopted a -15 °F (±2 °F) rating temperature for commercial ice-cream freezers.

Table 1-31 presents MEPS for closed solid door remote condensing commercial refrigerators and commercial freezers and plug-in and remote Ice-cream freezers.

Table 1-31: Maximum daily energy consumption

Equipment category	Equipment family	Rating temperature (°F)	Operating temperature (°F)	Maximum daily energy consumption (kWh/day)
Remote Condensing Commercial Refrigerators and Commercial Freezers.	Vertical Closed Solid (service cabinet)	38	≥32	0.11 × V + 0.26
		0	<32	0.23 × V + 0.54
	Horizontal Closed Solid (service cabinet)	38	≥32	0.11 × V + 0.26
		0	<32	0.23 × V + 0.54
Remote Commercial Ice-cream Freezers	Vertical Closed Solid	-	-	0.27 × V + 0.63
	Horizontal Closed Solid	-	-	0.27 × V + 0.63
Plug-in Commercial Ice-cream Freezers	Vertical Closed Solid	-	-	0.38 × V + 0.88
	Horizontal Closed Solid	-	-	0.38 × V + 0.88

It is interesting to note that although these MEPS cover plug-in (self-contained) solid-door ice-cream temperature products, they do not include refrigerators and freezers (HT and LT), while most stakeholders stated that the proportion of remote service cabinets is very low. This gap may be due to the original scope defined for the MEPS, perhaps focused on display cabinets which frequently rely on remote condensing.

1.4.1.3 US CEC MEPS

The US CEC adopted the California Appliance Efficiency Regulation, which became effective December 29, 2007. It was reviewed on 2009 and the document CEC-400-2009-013 was produced.

Scope: The California Appliance Efficiency Regulation[97] includes energy efficiency levels for the following types of new appliances (within the scope of ENTR Lot 1): automatic commercial ice-makers, refrigerators and freezers with doors (i.e. service cabinets), walk-in refrigerators and freezers, and water dispensers. The Regulation excludes certain refrigeration appliances with a volume exceeding 85 ft^3 (2.4 m^3) and automatic commercial ice-makers with a harvest rate lower than 50 lbs/24 hours or greater than 2500 lbs/24 hours.

Requirements: Volume shall be measured using ANSI/AHAM HRF-1-2004. Energy consumption shall be measured using 10 CFR Section 431.64 (2008).

In the case of service cabinets this regulation establishes maximum energy consumption in kWh, as a function of the volume in ft^3.

The minimum standards described below apply to reach-in, pass-through, roll-in and roll-through product types.

[97] California Energy Commission: www.energy.ca.gov/appliances/2009regulations

Table 1-32: Maximum daily energy consumption for solid-door service cabinets

Appliance according to function	Maximum daily energy consumption (kWh/day)
Refrigeration	0.10 × V + 2.04
Freezer	0.40 x V + 1.38
Refrigerator-freezer	The greater of 0.27 x AV – 0.71 or 0.70
Refrigerator-freezers that have an adjusted volume (AV) of less than 5.19 ft^3	0.70

V: Volume (ft^3)

AV: adjusted total volume, ft^3, as determined in 10 CFR, part 430, appendices A1 and B1 of subpart B (2008), which is: [1.63 x freezer volume (ft^3)] + refrigerator volume (ft^3) for refrigerator-freezer

1.4.1.4 Canada CAN/CSA-C827-98 Energy performance standard for food service refrigerators and freezers

This standard applies to self-contained (i.e. plug-in) commercial refrigerators, refrigerator-freezers, and freezer cabinets that are intended for storage or holding food products and other perishable merchandise, except for cold rooms (walk-in coolers). The compliance date of this regulation started on April 1, 2007, with updated levels in January 2008 and the addition of remote products to the standard in January 2010 (adopting the US DOE standards).

The test procedure under consideration is the Air-Conditioning, Heating and Refrigeration Institute (AHRI) Standard 1200:2008 in order to harmonise with the US DOE methodology. This regulation sets maximum daily electricity consumption figures (see Table 1-33).

Table 1-33: Canadian energy efficiency regulation on commercial refrigerated cabinets[98]

Type			Maximum E daily (kWh/day)		
Commercial refrigerator type	**Type**		**April 1, 2007 - December 31, 2007**	**on or after January 1, 2008**	**on or after January 1, 2010**
Self-contained commercial refrigerators	opaque doors or drawers		0.00441 V + 4.22	0.00441 V + 2.76	N/A
	transparent doors		0.00607 V + 5.78	0.00607 V + 4.77	N/A
	other*		N/A	N/A	N/A
Self-contained commercial freezers	opaque doors	V < 340	7.62	7.07	N/A
		V ≥ 340	0.0141 V + 2.83	0.0141 V + 2.28	N/A
	transparent doors		0.0332 V + 5.10	0.0332 V + 5.10	N/A
	other*		N/A	N/A	N/A
Self-contained commercial refrigerator-freezers	opaque doors		0.00964 AV + 2.63	0.00964 AV + 1.65	N/A
	other*		N/A	N/A	N/A
Remote commercial refrigerators	Any		N/A	N/A	0.003885 V + 0.26
Remote commercial freezers	Vertical		N/A	N/A	0.008122 V + 0.54
	Horizontal		N/A	N/A	0.008125 V + 0.54

* Product has no energy efficiency performance requirements but must meet all other regulatory requirements.

1.4.1.5 Australia/New Zealand refrigerated display cabinets MEPS

Since October 1, 2004, refrigerated display cabinets (both remote and plug-in) manufactured in or imported into Australia must comply with MEPS requirements. These are set out in AS 1731.14-2003 *Refrigerated display cabinets - Minimum energy performance standard (MEPS) requirements*.

Scope: The scope of commercial refrigeration MEPS includes both remote and plug-in refrigerated display cabinets primarily used in commercial applications for the storage of frozen and unfrozen food.

It does not cover commercial refrigeration technologies or applications such as walk-in storage and freezer rooms, ice making and ice storage equipment, refrigerated vending machines, cold water dispensers and processing industries, such as abattoirs and dairies.

Requirements: The MEPS for commercial refrigeration are set out in AS 1731.14-2003 as TEC per Total Display Area (TEC/TDA) in kWh/day/m² for various unit

[98] AV means the adjusted volume of the product in litres calculated as follows:
AV = the refrigerator volume in litres + 1.63 H the freezer volume in litres. Products projected to be covered under ENTR Lot 1 are highlighted in grey
Edaily means the daily energy consumption of the product expressed in kWh per day. V means the volume in litres of the refrigerated compartment. Use AHAM standard ANSI/AHAM HRF-1-2004 entitled Energy Performance and Capacity of Household Refrigerators, Refrigerator-Freezers and Freezers to calculate refrigerator or freezer compartment volumes.

types. Although service cabinets are not explicitly excluded from the scope of AS 1731.14, the MEPS can not apply as no TDA can be defined for service cabinets.

1.4.1.6 US Energy Star voluntary programme for commercial solid door refrigerators and freezers

This programme refers to the ASHRAE Standard 72-2005, *Method of Testing Commercial Refrigerators and Freezers*, and defines energy efficiency requirements for service cabinets. It covers only the plug-in refrigerated cabinets with solid doors (chilled and frozen).

Box 1-6 presents Energy Star program qualifying products, specifications and test requirements for commercial solid door refrigerators and freezers:

Box 1-6: Energy Star Program for commercial solid door refrigerators and freezers[99]

Qualifying Products: For the purposes of ENERGY STAR, the following types of commercial solid door refrigerators, freezers, and refrigerator-freezers may qualify:

A. Reach-in Cabinet: An upright commercial, self-contained refrigeration cabinet with hinged, solid doors but excluding undercounter, roll-in, roll-through, or pass-through cabinets.

B. Undercounter Cabinet: An upright commercial, self-contained refrigeration cabinet with or without a worktop surface (see definition in Section 1) which has hinged, solid doors. In the case where the unit does not have a worktop surface, the unit is intended for installation under a counter. In the case where the unit has a worktop surface, this surface may not add to the total energy consumption of the unit. Preparation tables are not eligible for ENERGY STAR qualification under this specification.

C. Roll-in or Roll-through Cabinet: An upright, self-contained commercial refrigeration cabinet with hinged, solid doors that allows wheeled racks of product to be rolled into or through the refrigerator or freezer.

D. Pass-through Cabinet: An upright commercial, self-contained refrigeration cabinet with hinged, solid doors on both the front and rear of the refrigerator or freezer.

Energy-Efficiency Specifications for Qualifying Products: Only those products listed in Section 2 that also meet the specifications listed in Table 1 below, may qualify as ENERGY STAR.

Table 1: Maximum Daily Energy Consumption (MDEC) Requirements (kWh/day) for ENERGY STAR Qualified Commercial Food-grade Refrigerators and Freezers

Product Volume (in cubic feet)	Refrigerator	Freezer
Vertical Configuration		
Solid Door Cabinets		
$0 < V < 15$	$\leq 0.089V + 1.411$	$\leq 0.250V + 1.250$
$15 \leq V < 30$	$\leq 0.037V + 2.200$	$\leq 0.400V - 1.000$
$30 \leq V < 50$	$\leq 0.056V + 1.635$	$\leq 0.163V + 6.125$
$50 \leq V$	$\leq 0.060V + 1.416$	$\leq 0.158V + 6.333$
Chest Configuration		
Solid or Glass Door Cabinets	$\leq 0.125V + 0.475$	$\leq 0.270V + 0.130$

Note: V = AHAM volume, as defined in Section 1, in cubic feet (ft^3).

This programme states that labelled products are more energy efficient because they are designed with components such as ECM evaporator and condenser fan motors, hot gas anti-sweat heaters, or high-efficiency compressors to reduce energy consumption and utility bills. Compared to standard US models, Energy

[99] Energy Star, see: www.energystar.gov/ia/partners/product_specs/eligibility/commer_refrig_elig.pdf

Star labelled commercial refrigerators and freezers can lead to energy savings of as much as 35% (with a 1.3 year payback in the US)[100].

The US experience also shows that companies offering Energy Star refrigerated display cabinets make up over 90% of the market and about 1 330 products qualify in this range of products.

1.4.1.7 US CEE Commercial Kitchens Initiative

This CEE initiative specifies voluntary minimum performance standards that take the previous US Energy Star standards further for the categories shown in the table below.

Table 1-34: US CEE Commercial Kitchens Initiative VEPS

Door Type	Equipment Type	Specification	Corresponding Base Specification	Maximum Daily Energy Use (kWh/day)
Solid Door	Refrigerator	CEE Tier 1	ENERGY STAR®	.10V + 2.04
		CEE Tier 2	ENERGY STAR® + 40%	.06V + 1.22
	Freezer	CEE Tier 1	ENERGY STAR®	.40V + 1.38
		CEE Tier 2	ENERGY STAR® + 30%	.28V + .97
Glass Door	Refrigerator	CEE Tier 1	25% of top-performing products	.12V + 3.34
		CEE Tier 2	28% more efficient than Tier 1	.086V + 2.39

*V = Volume of unit in cubic feet

1.4.1.8 US AHRI certification programme for commercial refrigerated display merchandisers and storage cabinets

Scope: Commercial Refrigerated Display Merchandisers and Storage Cabinets. Covered products described in the Scope of Program (plug-in and remote) document and that are offered for sale in the US, Canada and Mexico. Remote models are not included in the scope of this certification programme at this time.

Reference standard: ANSI/AHRI Standard 1200:2008

Certified Ratings: The following certification programme ratings are verified by test:

- TDEC (kWh per day)
- Refrigerated Volume (ft^3[m^3])
- TDA (ft^2 [m^2])

For plug-in cabinets, ARI evaluates the performance of the cabinet by calculating the daily energy consumption as a function of the refrigerated volume for products with doors and as a function of the TDA for open cabinets because these respective parameters (i.e. volume and TDA) appear to be the most representative of the energy consumption of these products. Minimum performance criteria to attain certification are not published.

[100] Source: www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=CRF

1.4.2. Blast cabinets

No MEPS, voluntary standards or incentive schemes specific to blast cabinets were identified. There are however relevant health and safety regulations, as discussed in § 1.3.6.2.

1.4.2.1 FR commercial food preparation hygiene requirements law of 29/09/1997

Relevance: blast cabinets, service cabinets

The French law of 29/09/1997 established that all foodstuff elaborated in restaurants should reach temperatures from +63°C to below +10°C within a maximum of 3 hours after preparation. This law does not expressly recommend blast cabinets, but in practice it encourages their use.

1.4.2.2 UK Department of Health Guidelines

Relevance: blast cabinets

In the Guidelines for Cook–Chill and Cook–Freeze Catering Systems (1989), it is expressed that blast chillers should cool down the temperature of foodstuffs from +70°C to +3°C in 90 minutes in order to be considered as safe for storage.

1.4.2.3 Austrian Hygiene Certificate Guideline

Relevance: blast cabinets

According to this hygiene guideline for large-scale catering establishments, such as those within the health service, and comparable equipment for foodstuff *(Gutachten des Ständigen Hygiene-Ausschusses Hygiene-leitlinie für Grossküchen, Küchen des Gesundheitswesens, und vergleichbare Einrichtungen der Gemeinschaftsverpflegung)*, foodstuff prepared in commercial and health establishment kitchens that is not meant to be consumed immediately after cooking should be cooled from +75°C to +10°C within an hour. Afterwards, the foodstuff must be kept in service cabinets.

1.4.3. Walk-in cold rooms

1.4.3.1 US minimum requirements for walk-in cold rooms and walk-in freezers[101]

The US CEC proposed the introduction of energy-related design standards for walk-in cold rooms manufactured before January 1st 2009, as described below.

[101] www1.eere.energy.gov/buildings/appliance_standards/commercial/wicf_faqs.html#doors4

Table 1-35: US CEC design standards for walk-in cold rooms

Motor Type	*Effective Date*	*Required Components*
All	January 1, 2006	Automatic door closers that firmly close all reach-in doors
All	January 1, 2006	Automatic door closers on all doors no wider than four foot or higher than seven foot, that firmly close walk-in doors that have been closed to within one inch of full closure
All	January 1, 2006	Envelope insulation > R-28 for Refrigerators
All	January 1, 2006	Envelope insulation > R-36 for Freezers
Condenser Fan Motors < 1 HP	January 1, 2006	(i) Electronically commutated motors, (ii) permanent split capacitor-type motors, (iii) polyphase motors > ½ HP, or (iv) motors of equivalent efficiency as determined by the Executive Director
Single-phase Evaporator Fan Motors < 1 HP and < 460 volts	January 1, 2006	(i) Electronically commutated motors or (ii) permanent split capacitor-type motors
Single-phase Evaporator Fan Motors < 1 HP and < 460 volts	January 1, 2008	Electronically commutated motors

Walk-in coolers and walk-in freezers manufactured in the US on or after January 1, 2009 should:

- have automatic door closers that firmly close all appliances that have been closed within 2.54cm of full closure, except for doors wider than 1.14m and taller than 2.14m;
- have strip doors, spring hinged doors, or another method of minimising infiltration when doors are open;
- contain wall, ceiling, and door insulation of at least R-25[102] (U value of 0.23) for coolers and R-32 (U value of 0.18) for freezers, except that this subparagraph shall not apply to glazed portions of doors nor to structural members;
- contain floor insulation of at least R-28 (U value 0.20) for freezers;
- for evaporator fan motors of under one horsepower and less than 460 volts, use:
    - electronically commutated motors (brushless direct current motors); or
    - 3-phase motors;
- for condenser fan motors of under one horsepower, use:
    - electronically commutated motors;
    - permanent split capacitor-type motors; or
    - 3-phase motors; and
- for all interior lights, use light sources with an efficacy of 40 lumens per watt (LPW) or more, including ballast losses (if any), except that light sources with an efficacy of 40 LPW or less, including ballast losses (if any), may be used in conjunction with a timer or device that turns off

[102] R value described in §1.1.3.8; 1 h.ft².°F/Btu = 0.176110 K.m²/W

the lights within 15 minutes of when the walk-in cooler or walk-in freezer is not occupied by people.

Walk-in coolers equipped with transparent reach-in doors and walk-in freezers equipped with transparent reach-in doors and manufactured on or after January 1, 2009 shall also meet the following design standards:

- transparent reach-in doors for walk-in freezers and windows in walk-in freezer doors shall be of triple-pane glass with either heat-reflective treated glass or gas fill;
- transparent reach-in doors for walk-in coolers and windows in walk-in cooler doors shall be either:
  1. double-pane glass with heat-reflective treated glass and gas fill; or
  2. triple-pane glass with either heat-reflective treated glass or gas fill;
  3. if the appliance has an antisweat heater;
- without antisweat heat controls, the appliance shall have a total door rail, glass and frame heater power draw of not more than 7.1 watts per square foot (W/ft^2) ($0.66\ W/m^2$) [103] of door opening (for freezers) and $3.0\ W/ft^2$ ($0.28\ W/m^2$) of door opening (for coolers);
- with antisweat heat controls, and where the total door rail, glass and frame heater power draw is more than $7.1\ W/ft^2$ ($0.66\ W/m^2$) of door opening (for freezers) and $3.0\ W/ft^2$ ($0.28\ W/m^2$) of door opening (for coolers), the antisweat heat controls shall reduce the energy use of the antisweat heater in a quantity corresponding to the relative humidity in the air outside the door or to the condensation on the inner glass pane.

Testing requirements: Please see §1.3.3.13.

➢ **US DOE proposed testing procedure for walk-in coolers and freezers[104]**

The US DOE has been developing a proposal for evaluation methods for walk-in cold rooms. Please see § 1.3.3.14.

1.4.3.2 UK ECA incentive scheme for cellar cooling equipment[105]

Cellar cooling equipment covers products that are specifically designed to maintain, by means of a refrigeration system, an indoor environment at a condition suitable for the storage of chilled beverages below +12°C.

The scheme covers three categories of cellar cooling equipment:

- Packaged units where all components mounted on one base for "through the wall” installation.
- Split systems with the equipment supplied in two parts (evaporator and condensing unit) to be connected on installation.
- Remote systems with equipment supplied in three parts (evaporator, compressor/receiver, and condenser) to be connected on installation.

---

[103] $1\ ft^2 = 0.093\ m^2$

[104] www1.eere.energy.gov/buildings/appliance_standards/commercial/wicf.html

[105] www.eca.gov.uk/etl/find/_P_Refrigeration/3.htm?tab=CriteriaPanel

To be eligible, products must:

- Have a cooling capacity of between 2 kW and 12 kW at the standard rating conditions for ambient air temperature of 32°C and a cellar air temperature of +10°C.
- Either be a single packaged unit, or consist of two or three factory-built sub-assemblies that are designed to be connected together during installation.
- Conform with the requirements of EU Pressure Equipment Directive PED 97/23/EC.

Products must have a coefficient of performance (COP) equal to or greater than the figures shown below.

Table 1-36: Performance requirements for ECA approval of cellar cooling equipment

Cooling capacity	COP
Less than 8 kW	>= 2.90
8 kW and over	>= 3.20

Testing is carried out in accordance with PAS 57:2003 with some amendments designed to reduce variability of results of the test methodology[106]. These include:

- Setting one storage temperature for the equipment (+12°C) rather than the PAS 57:2003 approach of having a temperature range (+10 to +12°C);
- measuring the temperature of the thermal mass to ensure that is maintained below the rated storage temperature during and at the end of the cooling capacity and energy consumption tests;
- setting the maximum permissible calorimeter room temperature, and air on to the evaporator, at the equipment's rated storage temperature (+12°C), rather than the PAS 57:2003 approach of having a permissible calorimeter room temperature range above a potential rated storage temperature (+10 ±0.5°C), during the energy consumption test;
- ensuring that the temperature control cycle for the calorimeter room during the energy consumption test ends at the same point as it started at; and
- requiring the test results to be specified to two decimal places.

Specifically, the new requirements are:

Section 6.2 "Cooling capacity measurement"

The test period shall be at least 1 hour and at the end of the test period, the temperature of the thermal mass must be at or below the temperature that it was at when the test period started.

Section 6.3 "System energy consumption measurement":

[106] Source: ECA Scheme

System energy measurement conditions - room B temperature at 10 °C ± 2 °C.

Steady state conditions:

b) air on to the evaporator is maintained within the band 8 °C to 12 °C.

d) the thermal mass is maintained at a temperature of 10 °C ± 0.5 °C.

The temperature in test room B for the system efficiency test shall be 10 °C ± 2 °C, with the average temperature during the test period being 10 °C ± 0.5 °C.

The test period shall be at least 2 hours and must end at the same point in the temperature control cycle for room B that the test started at.

At the end of the test period, the temperature of the thermal mass must be at or below the temperature that it was at when the test period started.

Section 6.4 “Conditions to be recorded”:

Section 6.4.2 “Temperature (°C), accuracy ± 0.5 °C of the:

Add “m) thermal mass at two locations (the closest location to, and furthest location from, the air off the evaporator).”

Test reports must be submitted and contain a statement of achieved performance at the required rating points and the information specified in section 8 of PAS 57:2003.

The following additional information shall be included in the test report:

- A copy of data (specified to two decimal places) recorded for both the capacity and energy consumption tests.
- Thermal mass - type, temperature and quantity. Number and type of containers used.
- Photograph(s) of the interior of Room B clearly showing the position of the evaporator(s) and the thermal mass.
- Room A & B dimensions, insulation type and U value.

If the test report has not been prepared by an independent body, then evidence must be provided that a representative sample of product test data has been independently verified or crosschecked.

1.4.3.3 PQS Quality Assurance protocol E01/CR/FR-VP2

The document, published as guidance from the World Health Organisation, sets out a Quality Assurance (QA) protocol for the installation of cold rooms and freezer rooms. Combination cold and/or freezer rooms are required to comply with all specifications for both cold room and freezer rooms. It is stated that the assessment should be conducted by the customer, or their designated QA assessor.

The interesting aspect of this for walk-in cold rooms is the “Holdover test”, a simple test procedure for the insulated enclosure whereby the electricity supply is cut off and the period required for the internal temperature to rise to +10°C (for cold rooms, or -10°C for freezer rooms) from normal operating temperature is recorded (BS EN 4376-1:1991 is referenced within the documentation – see §1.3.3.7).

The door must remain closed throughout the test. External ambient air temperature is also recorded throughout the test period. Compliance is proven if the time period is equal to, or greater than, 8 hours.

Follow-up documentation and questionnaires are proposed to ensure evidence of conformity, and provide the customer with explanatory details of the design and questions to provoke good user practice.

The cost of the Holdover test is approximately €600[107].

1.4.3.4 ATP agreement on the international carriage

The agreement details the following aspects of interest:

- Minimum requirements K coefficient values for the insulated enclosure: The K coefficient of equipment of classes B, C, E and F shall in every case be equal to or less than 0.40 $W/m^2.K$ (classes that are required to go down to (or below) -10°C), and the other classes equal or lower to 0.70 $W/m^2.K$.
- In the case of separate testing of insulated enclosure and refrigeration system) a minimum required cooling capacity factor for the refrigeration system: if the refrigerating system with all its accessories has undergone separate test to determine its effective refrigerating capacity at the prescribed reference temperatures, it will be acceptable if the effective refrigerating capacity of the system in continuous operation exceeds the heat loss through the walls for enclosure tested under the class considered, multiplied by the factor 1.75.
- System of certification that incorporates "type approval" for similar equipment (differentiating parameters that would not be permitted within this approval are defined).
- Requirements for product marking.
- Requirements for product test reports.

The agreement states that checks for conformity with the standards prescribed shall be made:

(a) before equipment enters into service;

(b) periodically, at least once every six years;

(c) whenever required by the competent authority.

Except in the cases provided for in appendix 2, sections 5 and 6 of the agreement, the checks shall be made at a testing station designated or approved by the competent authority of the country in which the equipment is registered or recorded, unless, in the case of the check referred to in (a) above, a check has already been made on the equipment itself or on its prototype in a testing station designated or approved by the competent authority of the country in which the equipment was manufactured.

A certificate of compliance with the standards shall be issued by the competent authority of the country in which the equipment is to be registered. This

[107] Source : GR Scott

documentation, or the required manufacturer's plate, can be used by competent authorities for identification during inspection.

Product ranges can be "Type Approved" to the required standards, after testing of one unit, after which Type Approval certification lasts for 6 years. The competent authority shall take steps to verify that production of other units is in conformity with the approved type. For this purpose it may check by testing sample units drawn at random from the production series. After 6 years, it is possible to renew the certification for 3 year periods by having an in-service "K coefficient" test at an approved ATP 'Designated Station' authorised by any country that is a signatory to the agreement. If, in the course of the six-year period, the production series exceeds 100 units, the competent authority shall determine the percentage of units to be tested.

If a vehicle fitted with equipment does not have an ATP certificate, and no Type Approvals have been issued, then the only option is to obtain a certificate by having a 'one off' test at an approved test centre or at the owner's site.

A unit shall not be regarded as being of the same type as the unit tested unless it satisfies the following minimum conditions:

(i) If it is insulated equipment, the construction shall be comparable and, in particular, the insulating material and the method of insulation shall be identical:

- the thickness of the insulating material shall be not less than that of the reference equipment;
- the interior fittings shall be identical or simplified;
- the number of doors and the number of hatches or other openings shall be the same or less; and
- the inside surface area of the body shall not be as much as 20% greater or smaller.

(ii) ...

(iii) If it is mechanically refrigerated equipment, in which case the reference equipment shall be either:...

(a) mechanically refrigerated equipment;

- the conditions set out in (i) above shall be satisfied; and
- the effective refrigerating capacity of the mechanical refrigeration appliance per unit of inside surface area, under the same temperature conditions, shall be greater or equal;

or (b) insulated equipment to which it is intended to have fitted, at a later date, a mechanical refrigeration unit and which is complete in every detail but with the refrigeration unit removed and the aperture filled, during the measurement of the K coefficient, with close fitting panels of the same overall thickness and type of insulation as is fitted to the front wall. In which case:

- the conditions set out in (i) above shall be satisfied; and

the effective refrigerating capacity of the mechanical refrigeration unit fitted to insulated reference equipment shall be as defined.

For further explanations of the agreement, including definitions and test procedures, please see Annex 1-1, §1.14.

1.4.4. PROCESS CHILLERS

1.4.4.1 EU EUROVENT certification programme for liquid chilling packages

A EUROVENT certification scheme for liquid chilling packages exists.

Scope: this certification scheme applies to standard chillers used for air conditioning (high temperature) and for refrigeration and covers three applications:

- air conditioning, with leaving chilled water temperature between +2°C and +15°C
- medium brine, with leaving brine temperature between +3°C and -12°C
- low brine, with leaving brine temperature between -8°C and -25°CA special application for heating and cooling floors is also included.

They may operate with any type of compressor, but only electrically driven chillers are included. All refrigerants are considered. Chillers may be air-cooled, water cooled or evaporative cooled and with remote condensers. Reverse cycle chillers shall be certified in cooling and in heating mode.

The following units are excluded from the programme: chillers powered by other than electric motor drives, free cooling ratings, heat recovery and no reverse cycle heat pumps and 60 Hz units.

The load rate and the performance criteria are only established for the cooling capacity mode and for air conditioning chillers (packaged chillers working at high temperature).

Requirements: Cooling capacity standard ratings are established at the Standard Rating Conditions and verified by tests conducted in accordance with EN 14511.

Table 1-37 presents the capacity test Standard Rating Conditions that apply for each application.

Table 1-37: Capacity test Standard Rating Conditions[108]

		Temperatures			
		Cooling		Heating	
Application	Code	Evaporator	Condenser	Evaporator	Condenser
Air conditioning	LCP/A../AC Air / Water	+12 to +7	35a	40/45	7(6)
	LCP/W../AC Water / Water	+12 to +7	30/35	40/45	10/b
	LCP/W../AC-MB Water / Brine	+12 to +7	30/35	40/45	0/-3
	LCP/T../AC without flasheconomiser	+12 to +7	45-40c	-	-
	LCP/T../AC with flasheconomiser	+12 to +7	45d	-	-
Medium Brine	LCP/A../MB Air / Water	-5 to 0	35a	40/45	7(6)
	LCP/W../MB Brine / Brine	-5 to 0	30/35	40/45	10/b

[108] EUROVENT website: www.eurovent-certification.com

		Temperatures			
		Cooling		Heating	
	or Brine / Water				
	LCP / T../MB without flasheconomiser	-5 to 0	45-40b	-	-
	LCP/T../MB with flasheconomiser	-5 to 0	45d	-	-
Low Brine	LCP/A../LB Air / Water	-15 to -10	35a	40/45	7(6)
Low Brine	LCP/W../LB Brine / Brine or Brine / Water	-15 to -10	30/35	40/45	10/b
Low Brine	LCP/T../LB without flasheconomiser	-15 to -10	45-40b	-	-
Low Brine	LCP/T../LB with flasheconomiser	-15 to -10	45d	-	-
Cool-heating Floor	LCP/A../CHF Air / Water	+18 to +23	35a	30/35	7(6)
Cool-heating Floor	LCP/W../CHF Water / Water	+18 to +23	30/35	30/35	10/b
Cool-heating Floor	LCP/W../CHF-MB Brine / Brine or Water / Brine	+18 to +23	30/35	30/35	0/-3

a = Measurement with the same water flow as in cooling mode, b = Dry bulb; c = The temperature corresponds to compressor discharge pressure (bubble point) – liquid at expansion valve; d = The temperature corresponds to compressor discharge pressure

The following characteristics of Liquid Chilling Packages are verified by tests at Standard Rating Conditions and at one of the Application Rating Conditions selected by Eurovent:

- cooling capacity
- energy efficiency ratio (EER)
- European Seasonal Energy Efficiency Ratio (ESEER[109])
- water pressure drop at evaporator in cooling mode (units without pump)
- available pressure at evaporator in cooling mode (units with pump)
- water pressure drop at condenser in cooling mode
- A-weighted sound power level for air cooled chillers
- heating capacity for reverse cycle units
- coefficient of performance
- water pressure drop at evaporator in heating mode (units without pump)
- available pressure at evaporator in heating mode (units with pump)
- water pressure drop at condenser in heating mode

[109] The European Seasonal Energy Efficiency Ratio is a weighed formula taking into account the variation of EER with the load rate and the variation of air or water inlet condenser temperature. ESEER is calculated as follows: ESEER = 0.03.EER100% + 0.33.EER75% + 0.41.EER50% + 0.23.EER25%

Energy Efficiency Classification of equipment: The purpose of Eurovent Energy Efficiency Classes is to simplify the selection of the best units for each type of chillers.

The classification (see Table 1-38) is entirely voluntary and is based on existing chillers presented to certification. It is not related to any European Directive. The energy efficiency of chillers is designated by "Eurovent Class A" or "Eurovent Class B" in catalogues.

Table 1-38: Energy efficiency classification in cooling mode[110]

Cooling Mode						
EER Class	Air Cooled	Air cooled ducted	Air Cooled, Floor	Water Cooled	Water Cooled, Floor	Remote Condenser
A	>=3,1	>=2,7	>=3,8	>=5,05	>=5,1	>=3,55
B	2,9->3,1	2,5->2,7	3,65->3,8	4,65->5,05	4,9->5,1	3,4->3,55
C	2,7->2,9	2,3->2,5	3,5->3,65	4,25->4,65	4,7->4,9	3,25->3,4
D	2,5->2,7	2,1->2,3	3,35->3,5	3,85?4,25	4,5->4,7	3,1->3,25
E	2,3->2,5	1,9->2,1	3,2->3,35	3,45->3,85	4,3->4,5	2,95->3,1
F	2,1->2,3	1,7->1,9	3,05->3,2	3,05->3,45	4,1->4,3	2,8->2,95
G	<2,1	<1,7	<3,05	<3,05	<4,1	<2,8

Part load certification: Chillers usually operate at full load only during a limited period of time during a year. Therefore, the part load performance is closer to reality and Eurovent decided to certify, together with full load efficiency, an average annual part load efficiency of chillers.

A study[111] partly funded by the European Commission through the SAVE Programme was performed and an index called ESEER – Seasonal energy efficiency ratio – has been defined. This index is similar to the IPLV (Integrated Part Load Value) used by ARI in the US and takes into account several parameters in order to establish an average use of chillers throughout Europe: weather data, building load characteristics, operational hours etc. Therefore, the ESEER is a realistic tool, much better than full load EER, to be used to compare average efficiency of two chillers. However, it must be kept in mind that ESEER cannot be used to calculate exact energy consumption for a particular use in a particular geographic position. Neither ESEER nor IPLV give an indication of energy use in an industrial application, but are instead relevant to air conditioning applications.

In order to compute ESEER the three part load EER for 25%, 50% and 75% load are combined with full load EER. This global single figure is published in the Eurovent Directory of certified products together with cooling capacity and power input for standard conditions at full load. The operating temperatures and average weighting coefficients for Europe are given in Table 1-39.

[110] EUROVENT website: www.eurovent-certification.com

[111] Energy Efficiency and Certification of Central Air Conditioners (EECCAC), *Save Programme: Project 4.1031/P/00-009-2000*, co-ordinator: ARMINES, April 2003

Table 1-39: Operative ESEER temperatures and coefficients for air cooled and water cooled chillers in Europe[112]

	ESEER parameters		
Part load ratio	Air temperature (°C)	Water Temperatures (°C)	Weighting coefficients
100	35	30	3%
75	30	26	33%
50	25	22	41%
25	20	18	23%

Stakeholders mentioned that the ESEER is soon to be replaced by SEER (as defined in prEN 14825:2009).

1.4.4.2 UK ECA incentive scheme for packaged chillers (only for High temperature-Air conditioning)

Eligibility Criteria: To be eligible, products must:

- Incorporate an electrically powered compressor (or compressors).
- Be one of the 16 specific categories of packaged chillers covered by the ECA Scheme as detailed in table below, which are classified according to:
    - Refrigeration capacity (in kW).
    - Whether the product is air-cooled or water-cooled.
    - Whether the product uses an integral or remote condenser.
    - The heat transfer medium used (water or brine).
- Be subject to quality assurance procedures that ensure consistency of performance between one production item and any other.
- Be CE Marked.

[112] EUROVENT Website: www.eurovent-certification.com

Table 1-40: Performance thresholds for packaged chillers[113]

Product Category			Cooling Capacity (kW)	Performance thresholds	
				Cooling EER	Heating COP
1.	Air-cooled packaged chillers that provide cooling only.	<u>without</u> integral free cooling mechanism.	Up to 100kW	>= 2.60	
			Over 100 to 500 kW	>=2.60	
			Over 500 to 750 kW	>= 2.70	
			Over 750 to 1,500 kW	>= 2.80	
		<u>with</u> integral free cooling mechanism.	Up to 100kW	>= 2.50	
			Over 100 to 500 kW	>= 2.50	
			Over 500 to 750 kW	>= 2.60	
			Over 750 to 1,500 kW	>= 2.70	
2.	Air-cooled, reverse cycle, packaged chillers that provide heating and cooling.		Up to 100kW	>= 2.70	>= 2.70
			Over 100 to 500 kW	>= 2.70	>= 2.70
			Over 500 to 750 kW	>= 2.80	>= 2.80
3.	Water-cooled packaged chillers that provide cooling only.		Up to 100kW	>= 4.10	
			Over 100 to 500 kW	>= 4.10	
			Over 500 to 750 kW	>= 4.50	
			Over 750 to 2,000 kW	>= 5.00	
4.	Water-cooled, reverse cycle, packaged chillers that provide heating and cooling.		Up to 100kW	>= 4.10	>= 3.70
			Over 100 to 500 kW	>= 4.10	>= 3.70
			Over 500 to 750 kW	>= 4.50	>= 4.10
			Over 750 to 2,000 kW	>= 4.60	>= 4.20

Where:

- EER = net cooling capacity (kW) / effective power input (kW) in cooling mode.
- COP = net heating capacity (kW) / effective power input (kW) in heating mode.
- The refrigeration capacity (kW) is determined in accordance with the procedures and rating conditions in BS EN 14511:2004 or 2007 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling*.

Required test procedures: All products must be tested in accordance with the procedures and standard rating conditions laid down in BS EN 14511:2004 or 2007. A detailed test report must be prepared for each individual product.

113 ECA Website, packaged chillers criteria: www.eca.gov.uk

1.4.4.3 US ASHRAE 90.1-2007

Relevance: Industrial process chillers working at high temperature

The **ASHRAE Standard 90.1.2007** *Energy standards for buildings except low-rise residential buildings* provides minimum energy-efficiency requirements for the design and construction of new buildings and their systems, new portions of buildings and new systems in existing buildings. It includes Minimum Efficiency Requirements for water chilling packages with reference to AHRI 550/590 test method for electrically operated water chilling packages, and ANSI/AHRI 560 test method for absorption water chilling packages. The recommended energy performance levels from this standard are as follows:

Table 1-41: Performance levels for chillers according to ASHRAE 90.1-2007 table 6.8.1.C

Chiller	Capacity (RT – refrigeration tonne)	COP*	IPLV*
Air cooled electrical	All	2.80	3.05
Air cooled w/o condenser	All	3.10	3.45
Water cooled Reciprocating	All	4.20	5.05
Water cool screw rotary and scroll	< 150 RT (530 kW)	4.45	5.20
	≥ 150 RT and < 300 RT (530kW – 1,060kW)	4.90	5.60
	≥ 300 RT (1,060kW)	5.50	6.15
Water cool Centrifugal	< 150 RT (530 kW)	5.00	5.25
	≥ 150 RT and < 300 RT (530kW – 1,060kW)	5.55	5.90
	≥ 300 RT (1,060kW)	6.10	6.40
Air cooled absorption single effect	All	0.60	
Water cooled absorption	All	0.7	
Absorption double effect indirect fired	All	1.00	1.05
Absorption double effect direct fired	All	1.00	1.00

*COP – Coefficient of Performance

*IPLV – Integrated Part Load Value

1.4.4.4 CAN CSA-C743-09 performance standard for packaged water chillers

The **CAN/CSA-C743-09** “Performance Standard for Rating Packaged Water Chillers” applies to factory-designed and prefabricated water-cooled absorption chiller/heater units, single-effect indirect-fired by steam or hot water, and double-effect, both indirect-fired by steam or hot water and direct-fired by oil, natural gas, or LP gas; water is the refrigerant and lithium bromide is the absorbent. This standard does not apply to absorption chiller/heater units with air-cooled condensers, nor does it apply to applications employing heat pumping or exhaust gas firing.

This standard applies to chillers with exiting brine temperatures greater than 0 °C (32°F).

Table 1-42: Minimum Energy Efficiency Requirements for Packaged water chillers[114]

Type	Capacity range, kW (tons)	COP[115]	IPLV[116]
Vapour compression			
air-cooled with condenser	< 528 (150)	2.80	3.05
	≥ 528 (150)	2.80	3.05
air-cooled without condenser	all	3.10	5.45
water-cooled, reciprocating	all	4.20	5.05
water-cooled, rotary screw, scroll	< 528 (150)	4.45	5.20
	≥ 528 (150) and ≤ 1,055 (300)	4.9	5.60
	>1,055 (300)	5.5	6.15
water-cooled, centrifugal	< 528 (150)	5.00	5.25
	≥ 528 (150) and ≤ 1,055 (300)	5.55	5.90
	> 1,055 (300)	6.10	6.40
Absorption			
single-effect absorption, air-cooled	all	0.60	N/A
single-effect absorption, water-cooled	all	0.70	N/A
double-effect absorption, indirect-fired	all	1.00	1.05
double-effect absorption, direct-fired	all	1.00	1.00

1.4.4.5 Australia/New Zealand water chillers MEPS

The MEPS covered by AS/NZS 4776.1:2008 concerns water chillers with a capacity higher than 350kW. These MEPS are based on the EUROVENT certification scheme, and apply to high temperature packaged water chillers.

Table 1-43: Minimum Energy Efficiency Requirements for Packaged water chillers[117]

Capacity range, kWh	Minimum COP		Minimum IPLV	
	Air cooled	Water cooled	Air cooled	Water cooled
<350	N/A	N/A	N/A	N/A
350-499	2.70	5.00	3.70	5.50
500-699	2.70	5.10	3.70	6.00
700-999	2.70	5.50	4.10	6.20
1 000-1 499	2.70	5.80	4.10	6.50
>1 500	2.70	6.00	4.10	6.50

[114] Canadian Office of Energy Efficiency: oee.nrcan-rncan.gc.ca/regulations/packaged_water_chillers.cfm?attr=8
[115] COP: Coefficient Of Performance is the ratio of the cooling capacity in watts [W] to the power input value in watts [W] at any given set of Rating Conditions expressed in watts/watt [W/W]
[116] IPLV: Integrated Part Load Value is a single number part-load efficiency figure of merit calculated per the methods described in 5.3 of ARI 560 relative to Absorption Water Chilling And Water Heating Packages
[117] www.energyrating.gov.au/pubs/factsheet-chiller-meps.pdf. 2010

1.4.5. REMOTE CONDENSING UNITS

1.4.5.1 UK ECA incentive scheme for air-cooled condensing units

Eligibility Criteria: To be eligible, products must:

- Operate with one or more identified standard refrigerants,
- Be a factory assembled unit that incorporates the following components (at least):
  - air-cooled refrigerant condenser,
  - one or more electrical compressors
  - a control systems for the compressor(s) and cooling fan(s)
- Conform to requirements to respect design, manufacture and testing procedures.
- Have a COP greater than the values shown in Table 1-44.

Table 1-44: Performance thresholds for air-condensing units[118]

Temperature category	Evaporating temperature (Dew point) (°C)	Ambient (condenser air-on) temperature (°C)	Compressor suction gas temperature (°C)	COP threshold
HT units	+5	+20	+20	≥3.9
MT units	-10	+20	+20	≥2.8
LT units	-35	+20	+20	≥1.6

Where:

- COP = net heating capacity (kW) / effective power input (kW) in heating mode.
- The refrigeration capacity (kW) is determined in accordance with the procedures and rating conditions in BS EN 14511:2004 or 2007 *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling*.

Required test procedures: the performance can be tested by either of the two following methods:

- Method A:

  COP at relevant UK rating point (see Table 1-44) must be calculated with the method used to generate its published performance over the standard range of air temperature and evaporating temperature conditions.

  The accuracy must be confirmed in the following way:

  - performance should be determined at three test conditions within +/-+1°C of the temperatures in Table 1-44;
  - the level of uncertainty (at 95% confidence) in the calculated values of COP must be determined using statistical methods.

[118] ECA website, packaged chillers criteria: www.eca.gov.uk

The COP must exceed the threshold proposed in Table 1-44 by at least the level of uncertainty in the calculations.

The test report must include:

- details of calculations method used to determine COP,
- a copy of the published performance data for the product,
- manufacturer's design data for the product and key components (including refrigerant, condenser fan motor type, and condenser),
- refrigerating capacity and COP of the compressor,
- where applicable, evidence of independent verification of the compressor,
- copy of the compressor's performance data by the manufacturer,
- test data from the product operating at full load:
    - compressor's inlet and outlet condensing and evaporating pressures and dew temperatures,
    - superheat and sub-cooling at the compressor's inlet and the unit's outlet;
    - condenser air inlet temperature,
    - compressor input power in kW (where compressors are not listed on the Energy Technology Product list, or their performance independently verified)

- Method B:

  When using this method, the performance of the product must be demonstrated following the procedure from BS EN 13771-2:2007 (see §1.3.5.1).

  To obtain the refrigerant properties, one of the following standards must be used:

    - The US National Institute of Standards and Technology (NIST) Standard reference database 23 thermodynamics and transport properties of refrigerants and refrigerant mixtures database : 6.0 or later.
    - The ASERCOM properties database as defined in the ASERCOM Compressor certification scheme, which is based closely on the NIST database.

  Data for a suction gas temperature of +20°C may be obtained by the thermodynamic translation of data physically tested at 10K superheat[119]. This is only applicable for high temperature only.

[119] Superheating refers to the process of heating a substance over its boiling point. This is reached under specific pressure conditions.

The report shall include a statement of achieve performance according to Table 1-44, and data on refrigerating capacity and COP at +32°C as specified in EN 13215:2000.

1.4.6. EU ENVIRONMENTAL LEGISLATIONS

The following European environmental legislation applies at the product level.

1.4.6.1 European Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE)

The **WEEE Directive**, effective 13 August 2005, requires separate collection, treatment and recovery of electrical and electronic waste.

The purpose of the Directive is "as a first priority, the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste".

Scope: The Directive applies to electrical and electronic equipment[120] falling under the categories set out in Annex IA of the Directive.

According to the list of products provided in Annex IB, large cooling appliances, refrigerators, freezers and other large appliances used for refrigeration, conservation and storage of food fall under the category 1 "Large household appliances" of Annex IA.

Targets for category 1 are set to:

- 75% of reuse and recycling of component, material and substance by an average weight per appliance
- 80% of recovery (reuse and recycling + energy recovery) by an average weight per appliance

Environmental aspects of the products that can be impacted by the standard: End of life, material content.

In December 2008, the EU Commission published a proposal for revision of the WEEE Directive. The main objectives of this revision are to set new collection and treatment targets and to clarify the scope and definitions of current legislation.

1.4.6.2 European Directive 2002/95/EC on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS)

This **RoHS Directive** requires the substitution of various heavy metals (lead, mercury, cadmium, and hexavalent chromium) and brominated flame retardants (polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE)) in new electrical and electronic equipment put on the market from 1 July 2006.

Scope: The Directive applies to the categories of electrical and electronic equipment that are covered by the WEEE directive except medical devices and

[120] EEE: equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields designed for use with a voltage rating not exceeding 1 000 Volt for alternating current and 1 500 Volt for direct current

monitoring and control instruments. This Directive covers assemblies or subassemblies of products.

According to the list of products provided in Annex IB, large cooling appliances, refrigerators, freezers and other large appliances used for refrigeration, conservation and storage of food fall under the category 1 “Large household appliances” of Annex IA.

Environmental aspects of the products that can be impacted by the standard: Material content.

The RoHS revision published in December 2008, foresees incorporation of categories 8 and 9 of Annex IA (Medical products and monitoring and control instruments) into RoHS. The proposal calls for most medical products to be compliant by January 1, 2014, in vitro medical devices to be compliant by January 1, 2016, and industrial monitoring and control instruments by January 1, 2017.

1.4.7. LEGISLATION RELATED TO REFRIGERANT FLUIDS

1.4.7.1 European Regulation N°2037/2000 on Ozone Depleting Substances (ODS)

Following the Montreal Protocol, the EU implemented Regulation EC No. 2037/2000 on substances that deplete the ozone layer. It specifies an accelerated HCFC (hydrochlorofluorocarbon) phase out schedule, compulsory recovery of CFCs (chlorofluorocarbons) and HCFCs or ban of their use, and leak control. The European schedule for the phase out of ozone depleting refrigerants is stricter than the one established by the Montreal Protocol (and chosen by the US). This triggered a transition in the choice of refrigerants used in the commercial refrigeration industry.

From 2000 to 2002, the use of CFCs, the production of CFCs and the production of equipment using such refrigerant were banned.

Since January 2001, the use of HCFCs in new systems in Europe for all types of refrigeration equipment has been forbidden. Concerning HCFC production, the regulation adopted the following provisions for actors selling these refrigerants, and for their use:

- 01/01/2008: Reduction of sales by 85% with respect to 2001, lowering of production by 65% with respect to 1997;
- 01/01/2010: Prohibiting of sales of virgin HCFCs;
- 01/01/2010: Prohibiting of the use of virgin HCFCs in the maintenance and servicing of all equipment;
- 01/01/2014: Lowering of production by 80% with respect to 1997;
- 01/01/2015: Prohibiting of the use of recycled HCFCs in the maintenance and servicing of all equipment;
- 01/01/2020: Lowering of production by 85% with respect to 1997;
- 01/01/2025: Prohibiting of production.

Recycled or reclaimed HCFCs may only be used for the servicing and maintenance of refrigeration equipment until 2015 (as already foreseen in Regulation EC N°2037/2000), only if they are recycled by the company operating the equipment or carrying out the servicing or maintenance. Furthermore, the revision introduces amendments to the current legislation to facilitate the task of enforcing and preventing the illegal trade or use of ODS in the EU. It also tightens current provisions on the recovery and destruction of ODS contained in products and equipment – the so-called ODS banks. The new provisions include a list of new substances in the regulation for the first time and for which the reporting of volumes produced and imported is required. The revision also bans the use of methyl bromide for quarantine and pre-shipment as of March 2010.

1.4.7.2 European Regulation N° 842/2006 on certain fluorinated greenhouse gases

The **European Regulation N° 842/2006** regulation entered into force on 4 July 2006 and applies from 4 July 2007.

The objective of this Regulation is to "contain, prevent and thereby reduce emissions of the fluorinated greenhouse gases covered by the Kyoto Protocol".

Scope: It applies to the fluorinated greenhouse gases listed in Annex I of the regulation.

This Regulation addresses:

- the containment, the use, the recovery and the destruction of the fluorinated greenhouse gases listed in Annex I of the regulation
- the labelling and disposal of certain products and equipment containing those gases;
- the reporting of information on those gases
- the control of uses referred to in Article 8 of the regulation
- the prohibitions with respect to placing on the market of the products and equipment referred to in Article 9 and Annex II of the regulation
- the training and certification of personnel and companies involved in certain activities provided for by this regulation

According to Article 3, the following test intervals are given.

Table 1-45: Test intervals for refrigeration systems with varying refrigerant charges

Test interval	Quantity of fluorinated greenhouse gases
Every 12 months	≥ 3 kg ≥ 6 kg for labelled, hermetically sealed systems ≥ 30 kg for systems with automatic leakage detection system
Every 6 months	≥ 30 kg ≥ 300 kg for systems with leakage detection system
Every 3 months	≥ 300 kg and an obligation to install a leakage detection system

After repair of a leak, the refrigerating systems shall be checked for leak tightness within one month to ensure that the repair was effective.

Users, whose refrigerating systems have a refrigerant charge of more than 300 kg are required to install leakage detection systems. These leakage detection systems are checked at least once per year to ensure proper functioning. If a correctly functioning and suitable leakage detection system is available, the frequency of the above required control measures is halved.

The following table presents the schedule of prohibition of placing on the market of products and equipments containing fluorinated greenhouse gases listed in the Annex I of the regulation:

Table 1-46: Schedule of prohibition of placing on the market of fluorinated greenhouse gases containing equipment

Fluorinated greenhouse gases	Products and equipment	Date of prohibition
fluorinated greenhouse gases	non-refillable containers	4 July 2007
hydrofluorocarbons and perfluorocarbons	non-confined direct-evaporation systems containing refrigerants	4 July 2007
perfluorocarbons	fire protection systems and fire extinguishers	4 July 2007
fluorinated greenhouse gases	windows for domestic use	4 July 2007
fluorinated greenhouse gases	other windows	4 July 2008
fluorinated greenhouse gases	Footwear	4 July 2006
fluorinated greenhouse gases	Tires	4 July 2007
fluorinated greenhouse gases	one component foams except when required to meet national safety standards	4 July 2008
Hydrofluorocarbons	Novelty aerosols	4 July 2009

1.4.7.3 DK statutory order 552[121]

This Danish legislation bans the use of HFC in foams and refrigeration systems except with charges between 10 kg and 250 kg. This Order applies to HFCs, perfluorocarbons (PFC) and sulphurhexafluoride (SF_6) and sets a general ban on new products containing these substances from June 1 2006. There are some exemptions from this general ban. For instance, the ban on HFCs will come into force for cooling equipment with HFC charges > 10 kg from 01.01.07 and the use of HFC for service purposes is exempted from the Order.

1.4.7.4 Austria Ordinance No 447/2002

Amended by Ordinance No 139/2007: The Ordinance bans the placing on the market and use of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6) greenhouse gases in certain equipment, units and products, unless they are used for research, development and analytical purposes. Concerning stationary applications, the bans apply only to small plug-in units with a refrigerant charge of 150g or less and to stand alone equipment with a refrigerant charge of 20 kg or more.

1.4.7.5 Norway - Tax and refund scheme for imported HFCs

This policy measure is a tax on imported HFCs and PFCs, which was introduced explicitly as a greenhouse gas reduction measure. The special tax (Regulations no. 1451 of 11 December 2001) is set at 190.50 Norwegian Kroner (approximately 24 €) per tonne of CO_2- equivalents and applies to both imports as well as national production (although there is currently none) of HFC gases, whether in bulk or in products. The tax, which is collected by the Norwegian Ministry of Finance, makes

[121] Danish Ministry of the Environment website: www.mst.dk/English/Chemicals/Legislation/Fact_sheets/Fachtsheet_no_46.htm

the import price of the refrigerant higher, leading to a more restricted use of the gas, and bringing alternatives within reach. The tax is coupled to a refund scheme. As a result the tax for R404a is currently at approximately 82 €/kg and for R134a at 32€/kg.

A refund of taxes on HFCs and PFCs (Regulations no. 1060 of 30 June 2004) is paid to stimulate the safe removal and disposal of refuse gas. The refund is disbursed for the quantity of HFCs and PFCs that is delivered to an approved destruction facility for destruction. The refund rates equal the differentiated tax rates for the tax on HFCs and PFCs applicable at the time of delivery. The refund is administered by the Ministry of Environment's Pollution Control Authority (SFT).

1.4.8. ENERGY-EFFICIENCY AND USE LEGISLATION

This section presents the extent to which the components used in refrigerating equipment are covered by existing legislation, and in particular Ecodesign implementing measures.

As a general guideline, energy efficiency related components of the products covered in the ENTR lot 1 study will be covered by the study as follows:

- If the component is placed separately on the market and then integrated in refrigerating equipment (e.g. a pump bought for a remote unit):
    - If Ecodesign measures covering the component are in place it is then covered by the relevant Ecodesign measure
    - If no specific Ecodesign measure is in place improvement solutions for this component will be investigated in the study
- If the component is bought on the OEM (Original Equipment Manufacturer) market and then integrated in a refrigerating equipment which is CE-marked:
    - If relevant Ecodesign measures are in place, the Ecodesign measure on refrigerating equipment may require that components comply with them
    - If no specific Ecodesign measure is in force or covers the given component (e.g. some motors used in refrigerating equipment do not fall into the scope of the dedicated Ecodesign measure), improvement solutions for this component will be investigated in the study

1.4.8.1 EuP TREN Lot 13 – Legislation related to household refrigerating appliances

Ecodesign requirements for household refrigerating appliances have been developed in the framework of the Ecodesign Directive 2009/125/EC based on a preparatory study on domestic refrigerators and freezers (TREN Lot 13)[122].

This Regulation establishes ecodesign requirements for the placing on the market of electric mains-operated household refrigerating appliances with a storage volume up to 1 500 litres.

[122] TREN Lot 13 Website: www.ecocold-domestic.org/

* Generic ecodesign requirements (see Annex II.1 of the Regulation) apply to wine storage appliances and household refrigerating appliances.
* Specific ecodesign requirement (see Annex II.2 of the Regulation) apply to household refrigerating appliances with a storage volume equal to or higher than 10 litres, and neither to wine storage appliances and nor to absorption-type refrigerating appliances and other-type refrigerating appliances belonging to Categories 4 to 9. The requirements are presented in the table below.

Table 1-47: Specific ecodesign requirements for household refrigerating appliances

Appliance type	Application date	Energy Efficiency Index (EEI)
Compression-type refrigerating appliances	1 July 2010	EEI < 55
	1 July 2012	EEI < 44
	1 July 2014	EEI < 42
Absorption-type and other-type refrigerating appliances	1 July 2010	EEI < 150
	1 July 2012	EEI < 125
	1 July 2015	EEI < 110

The Energy Efficiency Index of household refrigerating appliances is calculated in accordance with the procedure described in Annex IV of the Regulation.

1.4.8.2 EuP TREN Lot 11 – Electric motors

Ecodesign requirements for electric motors have been developed in the framework of the Ecodesign Directive 2009/125/EC based on the TREN Lot 11 preparatory study[123], covering:

* Electric motors 1-150kW
* Water pumps (in commercial buildings, drinking water pumping, food industry, agriculture)
* Circulators in buildings
* Ventilation fans (non-residential buildings)

So far, ecodesign requirements have only been put in place for electric motors and circulators. Requirements for fans and water pumps are under development.

Motors

Minimum efficiency requirements have been established for electric motors in Commission Regulation (EC) No 640/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors, including electric motors equipped with variable speed drives, and motors integrated into other products – apart from motors completely integrated into a product (for example gear, pump, fan or compressor) of which the energy performance cannot be tested independently from the product.

The motors falling under the scope of the Ecodesign requirements are electric single-speed, three-phase 50 Hz or 50/60 Hz, squirrel cage induction motor, from 0.75 to 175 kW that:

* have 2-6 poles;

[123] TREN Lot 11 Website: www.ecomotors.org/

- have a rated voltage of UN up to 1000 V;
- have a rated output PN between 0.75 kW and 375 kW; and
- is rated on the basis of continuous duty operation.

The EC ecodesign requirements for motors (nominal minimum efficiencies) are set out in Annex I of the draft commission regulation.

The regulation is therefore not applicable to products or components covered in ENTR Lot 1, as motors are either small and single-phase (for use as fans) or integrated into hermetic compressors.

Fans

The possible ecodesign requirements for fans (minimum energy performance requirements) are set out in Annex I of the working document on “possible ecodesign requirements for ventilation fans”, and are proposed to cover fans from 125W to 500kW across the following types:

- Axial fan
- Centrifugal forward curved fan and centrifugal radial bladed fan
- Centrifugal backward curved fan without housing
- Centrifugal backward curved fan with housing
- Mixed flow fan
- Cross flow fan

Although minimum efficiency requirements have been established for electric motors, including those that are part of a motor-fan system, most fans covered by the fans Regulation are used in combination with motors not covered by Regulation (EC) No 640/2009.

Regarding coverage of fans integrated into other products, the working document on proposed regulation of these products under Directive 2009/125/EC states:

“Many fans are integrated in other products without being separately placed on the market or put into service within the meaning of Article 5 of Directive 2009/125/EC and of Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC. To achieve the full cost-efficient energy-saving potential, fans within a 125 W – 500 kW power range integrated in other products should also be subject to the provisions of this Regulation.”

This potential regulation therefore has relevance to products covered in ENTR Lot 1.

Pumps

The pumps falling under the scope of the possible Ecodesign requirements are:

- Single stage end suction water pumps with characteristics as follows:
    - operating temperature between -10 and +120°C
    - single suction, single impeller
    - all efficiencies based on full (untrimmed) impeller

- Vertical multistage (MS) water pumps with characteristics as follows:
  - operating temperature between -10 and +120°C
  - vertical multistage pumps in in-line and ring section design
  - 2900 rpm pumps only
  - efficiency is measured and judged on the basis of a 3 stage pump
- Submersible multistage (MSS) pumps with nominal size 4” and 6”

1.4.8.3 Legislation related to the lighting system

The European Parliament and the Council of the European Union has issued a Directive 2000/55/EC of the European Parliament and of the Council on energy efficiency requirements for ballasts for fluorescent lighting put on the EU market, implemented via Regulation 245/2009, applying to electric mains-operated ballasts for fluorescent lighting sources as defined in European Standard EN 50294:1998.

Mandatory ecodesign requirements apply to products placed on the market wherever they are installed, therefore such requirements cannot be made dependent on the application in which the product is used (such as office lighting or public street lighting).

1.4.8.4 Legislations related to tertiary and domestic lighting

Requirements for street lighting and office lighting are under development in the framework of the Ecodesign Directive 2009/125/EC.

The draft legislation which was agreed by the Regulatory Committee in September 2008 sets requirements for linear and compact fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaries able to operate such lamps. However, there are several limitations, for instance very small HID lamps now increasingly popular in the retail sector are not covered. Reflector lamps were covered under a separate piece of legislation on directional light sources (TREN Lot 19: Part 2). The products foreseen to be covered are used in streets and offices, but also in other applications (e.g. industrial plants, shops, public buildings).

Depending on their specifications, the Ecodesign measure on commercial refrigeration could require that lights placed separately on the market and then integrated in refrigerating equipment comply with possible ecodesign requirements of tertiary and domestic lighting.

1.4.8.5 European Directive on Electromagnetic Compatibility (ECM) 2004/108/EC

This Directive ensures that radio-communications operate in accordance with International Telecommunication Union (ITU) radio regulations, and that electrical supply networks and telecommunications networks, as well as equipment connected to them, are protected against electromagnetic disturbance.

1.4.8.6 European Directive on construction products 89/106/EEC

Many manufacturers of insulating enclosures and panels used for walk-in cold rooms provide these components without any refrigeration appliance (condensing unit and/or evaporator). For these manufacturers, the CE mark and product certification is based on Directive EC 89/106. The Directive covers the approximation of laws, regulations and administrative provisions of the Member States relating to construction products. Within *Annex I: Essential requirements*, it states:

The construction works and its heating, cooling and ventilation installations must be designed and built in such a way that the amount of energy required in use shall be low, having regard to the climatic conditions of the location and the occupants.

Essential requirements cover mechanical strength and stability, safety in the event of fire, hygiene, health and the environment, safety in use, protection against noise and energy economy and heat retention, as set out in Annex 1 to the Directive. ETAG 021 (§1.3.3.2) has been developed for cold storage room and cold storage building enclosure kits, and sets out methods for verification, assessment and attestation of the products.

Only construction products that comply with the national standards transposing the harmonised standards into a European technical approval or, in the absence of such approvals, into national technical specifications complying with the essential standards are eligible to bear the "CE" marking to ensure that all construction works bearing the "CE" marking satisfy the essential requirements. It is up to the manufacturers or their representatives established in the Community to attest, either on the basis of their own resources or through an approved certification body, that their products conform to the requirements. Products which have been declared to conform with the Directive but which do not satisfy the essential requirements and therefore pose a health and safety threat may be temporarily withdrawn from the market by the Member States. Where non-conformity is attributable to the technical specifications, to their application or to omissions inherent therein, the Commission will decide, after consulting the Standing Committee on Construction, whether the European or national technical specification should or should not continue to enjoy presumption of conformity[124].

1.4.9. Health and safety legislation

The following pieces of legislation applies either to the product as an entity or to different stages of the manufacture process.

1.4.9.1 European Directive 95/16/EC on Machinery, amended by 2006/42/EC

The Directive applies to machinery, defined as “an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application”.

This Directive addresses essential health and safety requirements relating to the design and construction of machinery. These requirements are provided in the Annex IA of the Directive.

Effective 29 June 2006, this Directive had to be transposed at the member state level before 29 June 2008. Before 29 December 2009, professional refrigeration products were covered only by the Low Voltage Directive (including service cabinets, horizontal refrigeration products and blast chillers).

[124] ec.europa.eu/enterprise/sectors/construction/documents/legislation/cpd/index_en.htm

1.4.9.2 European Directive 2001/95/EC on General Product Safety

This Directive covers all the products "which are intended for consumers or likely, under reasonably foreseeable conditions, to be used by consumers even if not intended for them, and are supplied or made available in the course of a commercial activity, and whether new, used or reconditioned".

The Directive requires producers to place only safe products on the market, and to provide information about risks. A safe product is defined as one which, "under normal or reasonably foreseeable conditions of use including duration […] does not present any risk or only the minimum risks compatible with the product's use, considered to be acceptable and consistent with a high level of protection for the safety and health of persons […]". It obliges Member States to survey products on the market.

This Directive is effective since 15/01/2004.

1.4.9.3 European Directive 73/23/EEC on Low Voltage Equipments (LVD)

According to the Directive, electrical equipment are defined as "any equipment designed for use with a voltage rating of between 50 and 1 000 V for alternating current and between 75 and 1 500 V for direct current, other than the equipment and phenomena listed in Annex II" of the Directive.

This Directive covers all risks arising from the use of electrical equipment, including not just electrical ones but also mechanical, chemical (such as, in particular, emission of aggressive substances), health aspects of noise and vibrations, and ergonomic aspects as far as ergonomic requirements are necessary to protect against hazards in the sense of the Directive. The LVD lays down eleven "safety objectives", which represent the essential requirements of this Directive.

This Directive was amended by the Directive 93/68/EEC which adds that before being placed on the market, the electrical equipment referred to in Article 1 must have affixed to it the CE marking provided for in Article 10 attesting to its conformity to the provisions of this Directive, including the conformity assessment procedure described in Annex IV of the Directive.

1.4.9.4 Pressure Equipment Directive (PED) 1997/23/EC

This Directive, effective since 29/11/1999, applies to the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum allowable pressure PS greater than 0.5 bars. This Directive establishes that the pressure equipment and the assemblies under the scope may be placed on the market and put into serve only if, when properly installed and maintained and used for their intended purpose, they do not endanger the health and safety of persons. The Directive also establishes technical requirements for equipment, listed in Annex I of the Directive. The compliment of the Directive is certified by the CE Marking.

1.4.9.5 European Directive 98/83/EC on quality of water

The **Directive 98/83/EC** on quality of water intended for human consumption as for objective to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean. Directive requirements will need to be taken into consideration for product categories using water for human consumption (i.e. beverage machines, water dispensers and ice-makers).

1.4.9.6 Hazard Analysis Critical Control Point (HACCP)

HACCP is an internationally recognised and recommended system for food safety management. It focuses on identifying the 'critical points' in a process where food safety problems (or 'hazards') could arise and puts in place preventative measures. This is sometimes referred to as 'controlling hazards'. Keeping records is also an important part of HACCP systems[125].

1.4.9.7 Summary of temperature and time constraints for cooked foodstuff

The parameters of the post-cooking process in different countries within the EU are shown in the table below.

Table 1-48: Summary of chilling temperature and time constraints within the EU

Country	Initial temperature (°C)	Final temperature (°C)	Time to reach final temperature (min)
UK	+70	+3	90
France	+63	+10	180
Austria	+75	+10	60

1.4.10. Other voluntary agreements

1.4.10.1 EUROVENT certification programmes for refrigeration components

Eurovent also manages voluntary certification schemes for several refrigeration components, such as fan coil units, ducted fan coil units, air coolers for refrigeration, air cooled condensers, dry coolers, air handling units, and cooling and heating coils.

1.4.10.2 ASERCOM certification of refrigerant compressors

The Association of European Refrigeration Compressor and Controls Manufacturers (ASERCOM) also provides a performance certification programme for refrigeration compressors. Its objective is to provide comparable and reliable data using common test methods, thus providing common reference points for all manufacturers.

1.4.10.3 DK demanufacture of refrigeration equipment[126]

Since January 2006, a standard for the “Demanufacture of Refrigeration Equipment” was implemented in Danish law. The RAL quality mark GZ-728 is the European standard for the demanufacturing of refrigeration devices. These quality assurance and test specifications apply to the demanufacturing of waste refrigeration equipment containing CFCs. The specifications cover the collection, storage and processing of such equipment and the handling of the materials recovered prior to re-use or disposal.

[125] www.food.gov.uk/foodindustry/regulation/hygleg/hygleginfo/foodhygknow/
[126] RAL website: www.ral-online.org

1.4.11. SUMMARY OF EXISTING LEGISLATION AND VOLUNTARY MEASURES

Table 1-49 summarises all existing mandatory and voluntary initiatives covering the product groups. Detailed conclusions by product group are discussed in the following sections. Some of these mandatory and voluntary standards, or elements of them, may be applicable to the EU context, and this will be discussed in further detail in Task 7 after technical, environmental and economic analysis of the Base Cases, Best Available Technology and improvement options.

One important general consideration at this stage is the need for harmonised testing standards, through which appropriate and consistent evaluation of product performance can be made.

Table 1-49: Summary of existing mandatory and voluntary standards

Equipment	EU	US	Canada	Australia / New Zealand
Service Cabinets	VEPS: UK ECA[127]	MEPS: DOE, CEC[128] VEPS: Energy Star, AHRI[131]	MEPS[129]	(MEPS[130] for refrigerated display cabinets only)
Blast cabinets	FR AC D 40-003 (Food safety)	N/A	N/A	N/A
Walk-in cold rooms	-	MEPS: US minimum component requirements	N/A	N/A
Process chillers	VEPS: UK ECA[127] EU EUROVENT (A/C only)	N/A	MEPS[129]	MEPS[132]
Remote condensing units	VEPS: UK ECA (air cooled only)	N/A	N/A	N/A

N/A: No standards found

1.4.11.1 Service cabinets

The terminology "professional" is better harmonised with current safety regulation definitions, such as the machinery and low voltage directives (§1.4.9.), which require a declaration of intended use, distinguishing between household and professional use. This issue is potentially confused by the use of EN 60335-2-24:2010 (§1.3.6.4) of some manufacturers for safety, which covers both domestic and similar equipment, for professional service cabinets. For food safety purposes, HACCP regulation effects the open display of food, while only the limits on M-package temperature described in EN ISO 23953 regulate food that is contained within equipment.

The service cabinet product group has the greatest number of mandatory and voluntary standards of all the products covered in ENTR Lot 1. In the EU, service cabinets' minimum energy performance requirements are only covered within the scope of the UK ECA. In third countries, regulations from Canada, Australia and the US could be taken into account to establish minimum energy performance

[127] UK Enhanced Capital Allowance Scheme
[128] California Appliance Efficiency Regulation
[129] Canadian Energy Efficiency Regulation
[130] AU/NZ Minimum Energy Performance Standards
[131] Air Conditioning and Refrigeration Institute Certification Program
[132] AU/NZ Minimum Energy Performance Standards

standards in EU[133].These are compared below to provide an idea of the ranges and variability of these standards, and some of the technical variations that might need to be taken into account should EU mandatory measures be considered. **However, it must be noted that the limits set by different MEPS and VEPS are based on different measurement methodologies[134].** These methodologies can lead to variation in resulting energy consumption figures of 5 to 10% for an identical product. The graphs below, Figure 1-26 to Figure 1-29, are provided to demonstrate different approaches, and should not be used for direct comparison of the MEPS levels (where different test methodologies are used).

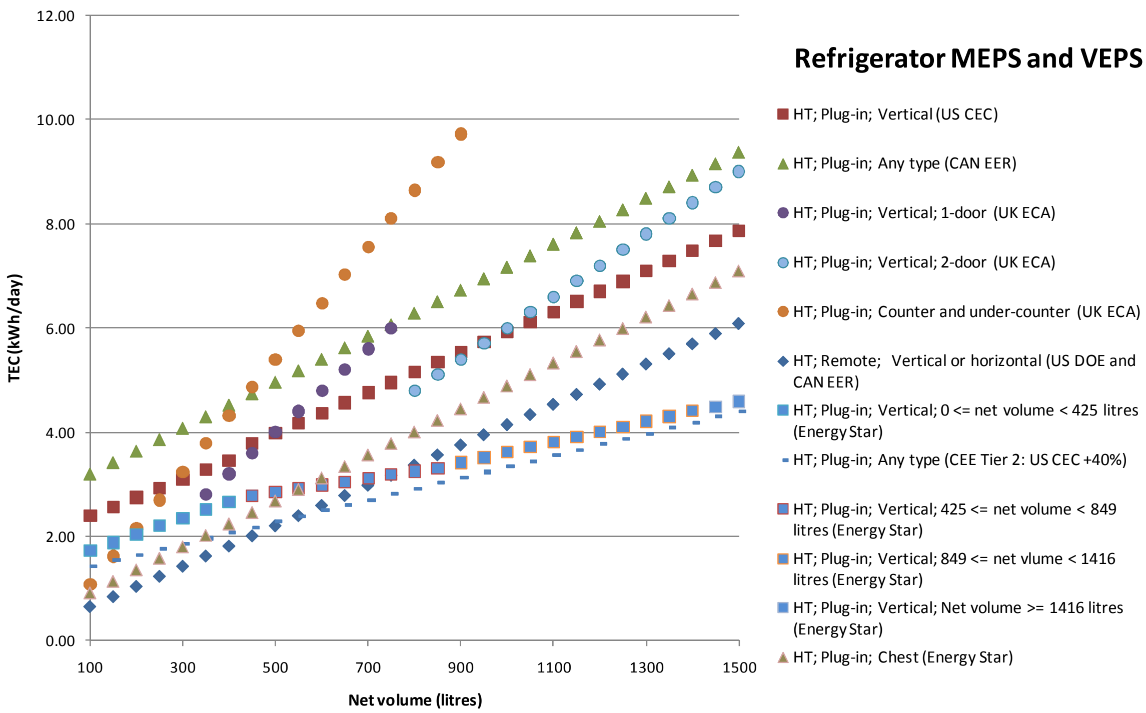


Figure 1-26: Comparison of MEPS and VEPS for refrigerator (HT) service cabinets

[133] The North-American approach to MEPS for refrigerated cabinets is a formula X*V + Y where volume is defined in ft³. For detailed information on the US and Canadian MEPS for storage cabinets, please refer to section 1.4.2.1

[134] Hence, if one considers an appliance of 500l internal net volume, the limit of Energy Star might be 2,3 kWh/day while the limit of the UK ECA is 4 kWh/day, but an identical appliance may satisfy both limits due to the different test methodologies used to assess the energy consumption. Source: Electrolux.

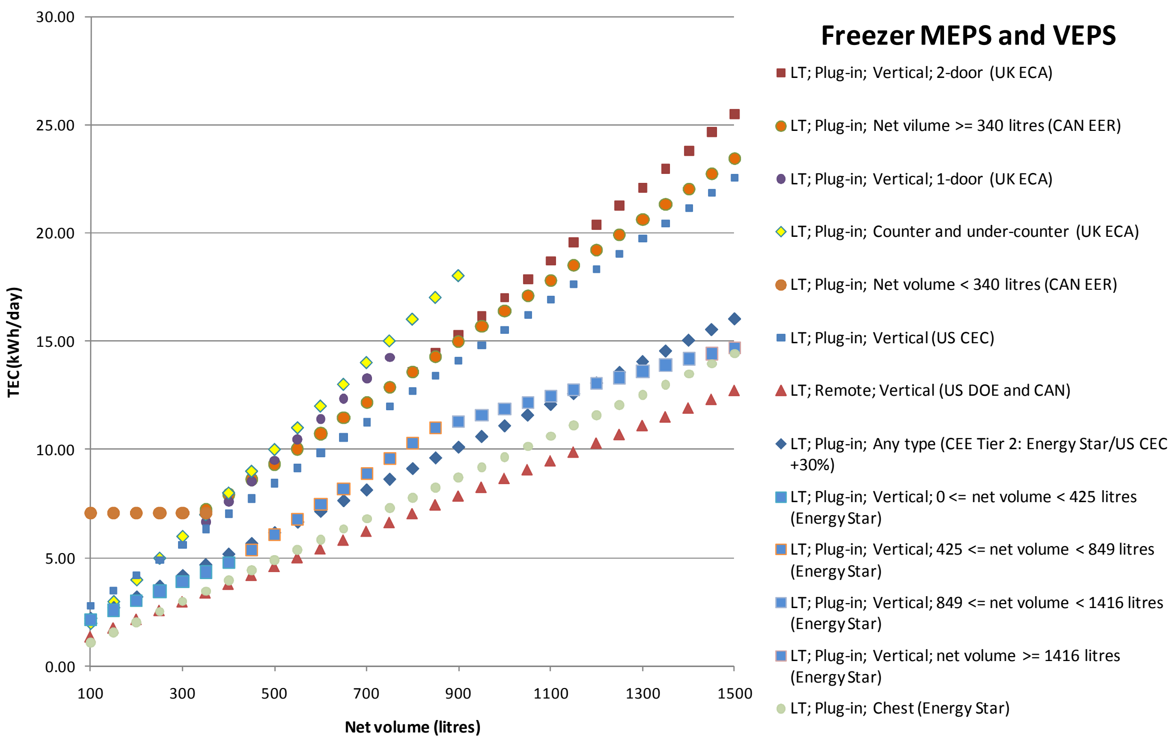


Figure 1-27: Comparison of MEPS and VEPS freezer (LT) service cabinets

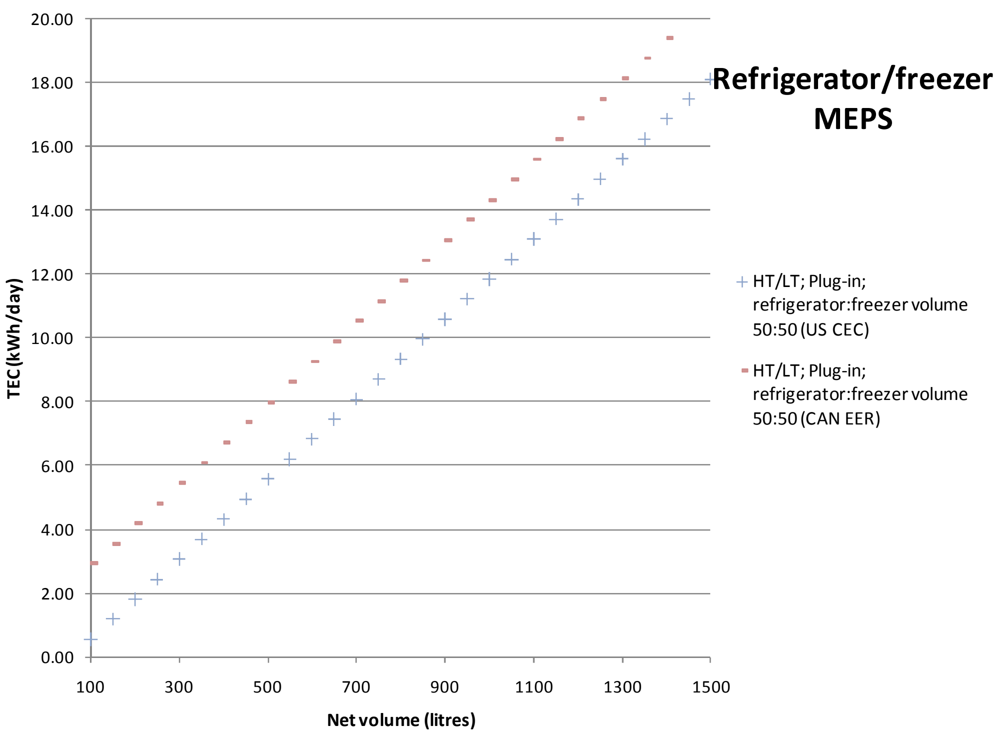


Figure 1-28: Comparison of MEPS for refrigerator-freezer (HT/LT) service cabinets

In general, apart from the US CEC MEPS at low net volume, remote product standards are more stringent than those for plug-in products. In addition, it is interesting to note that different ranges of standards have been set for distinct ranges of product net volumes in the UK ECA and CAN EER schemes. Finally, through examination of the US DOE and CEC MEPS, and the UK ECA VEPS, it appears that there is significant variation in the differentiation of similar products across operation temperatures by mandatory and voluntary schemes, as shown below.

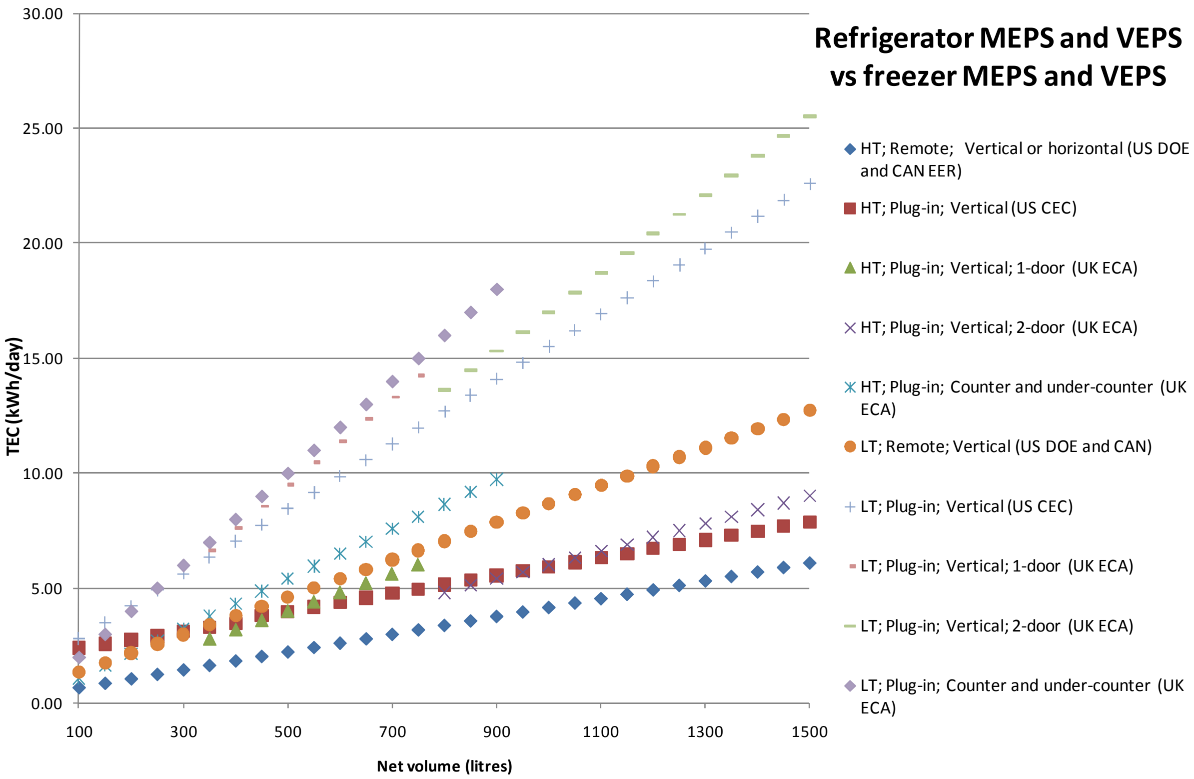


Figure 1-29: Comparison of MEPS and VEPS for refrigerator and freezer service cabinets

1.4.11.2 Blast cabinets

No legislation, minimal energy performance standards or agreements concerning blast equipment have been identified.

1.4.11.3 Walk-in cold rooms

Currently there are no mandatory or voluntary minimum performance standards for walk-in cold rooms, only minimum component requirements set by the US. A testing standard is under development by the US DOE, and MEPS are due to be defined in around 2013 (three years after final rule on testing standards is made).

1.4.11.4 Process chillers

MEPS from UK, USA, Canada, and Australia are summarised in Figure 1-30. In the graph is shown how Canada and USA share the same level of strictness for chillers. These standards are related only to packaged units. All of the values are reported with respect to COP. The least demanding scheme is the UK ECA, which requires half of the efficiency for equipment then its American equivalent.

The UK ECA scheme and standard AS/NZS 4776:2008 could be used as a model to develop energy performance requirements for Packaged Chillers in the EU. Nevertheless, their ranges of classification are different and any approach developed would need to be homogenised. As for all other products within the scope, it is very important to take into account the type of refrigerant for environmental reasons. However, the energy performance of the equipment is more related to the configuration than the employed refrigerant[135].

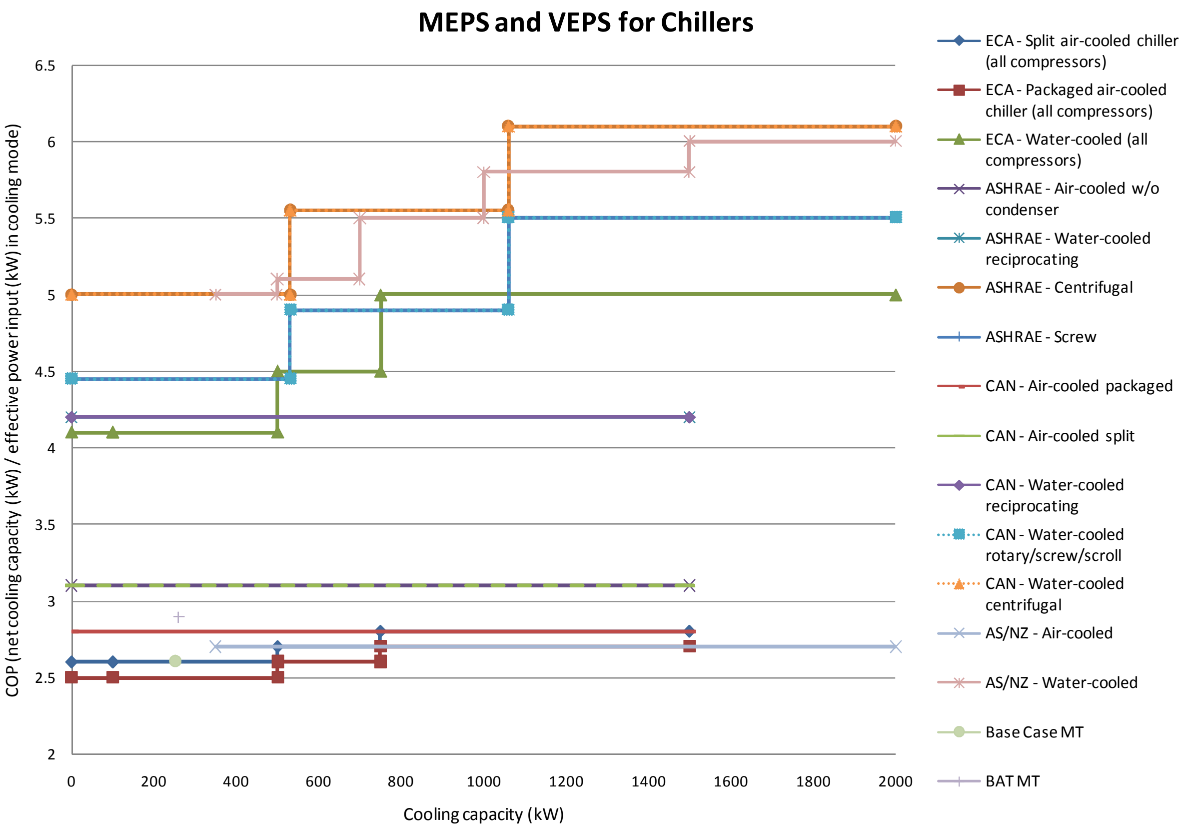


Figure 1-30 MEPS and VEPS for Chillers from third countries and the UK

1.4.11.5 Remote condensing units

Only the UK ECA scheme establishes voluntary minimum standards, for air-cooled remote condensing units. They are summarised in the figure and table below. There is no minimum energy performance standard for remote condensing units.

[135] Mark Ellis, consultation 2010.

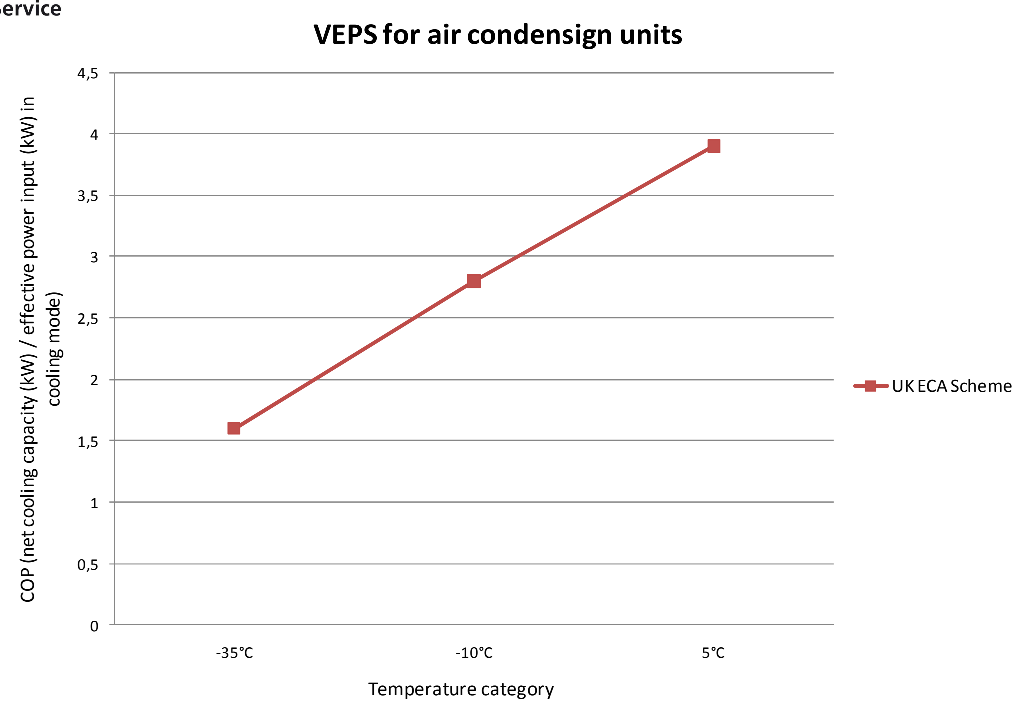


Figure 1-31: VEPS for remote condensing units

Presented below are the UK ECA performance levels, with respective operating conditions.

Table 1-50: VEPS for remote condensing units

Temperature	Evaporating temperature	Ambient temperature	Compressor suction gas temperature	COP threshold
High temperature units	+5°C	20°C	20°C	>=3.9
Medium temperature units	-10°C	20°C	20°C	>=2.8
Low temperature units	-35°C	20°C	20°C	>=1.6

1.5. CONCLUSIONS FOR TASK 1

The preliminary discussions and scope presented in Task 1 outlined the key issues and parameters related to the products relevant to the ENTR Lot 1.

Initial classifications for the product groups have been defined by category. Accurate classifications are crucial to allow effective market data collection, which in turn will ensure that the Base Cases (the current "average" products) to be analysed in Task 4 are accurately reflecting the market.

Testing standards have been adapted for use with service cabinets, and others are available for chillers and remote condensing units. Walk-in cold rooms and blast cabinets are however lacking energy consumption testing standards in the EU, although there is scope for development of these, based on the FR NF AC D40-003 for blast cabinets and the AHRI 1200/DOE approach for walk-in cold rooms.

The identification of the relevant legislation worldwide reveals that many third countries have already developed obligatory minimum standards for some product categories but that harmonised international or EU standards are relatively lacking.

For some product categories, voluntary programmes exist in the EU whose purpose is to provide a tool for comparison of competing products and also to set any energy efficiency requirements (e.g. UK ECA). The US Energy Star experience shows that companies offering Energy Star refrigerated display cabinets make up over 90% of the market and about 1 330 products qualify in this range of products.

There are therefore clear avenues for development of both testing and performance standards, which could be based upon existing initiatives. Existing mandatory and voluntary minimum standards may provide a basis for EU MEPS and will be further analysed in Task 7.

ANNEXES

This page is left intentionally blank

Annex 1-1: Additional standards related to refrigeration and freezing equipment

This annex provides a source of additional information, listing standards related to products covered in ENTR Lot 1 that are not directly relevant to the study. System-related standards will de described in the technical annex.

1.6. EN 153:2006

Relevance: Service cabinets

The **EN 153:2006** (superseding EN 153:1995) "*Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage cabinets, food freezers and their combinations, together with associated characteristics"* is the main EU harmonised standard used for the measurement of the energy consumption of refrigerators and freezers. This standard was prepared by European Committee for Standardisation/Technical Committee CEN/TC 44.

Scope: Household refrigerators, frozen food storage cabinets, food freezers and similar equipments

This standard is used for household refrigeration appliances but can be used by the industry to test commercial refrigeration appliances which are similar to household refrigerators and freezers such as plug-in service cabinets (industry common practice). Though, further specifications may be necessary for the testing requirements of such products as they do not operate in a "home" (e.g. the frequency of door opening might be an important parameter for service cabinets as they are more intensively used than household appliances). The use of EN 153 has been superseded by EN ISO 23953, according to stakeholders.

Requirements: EN 153 proposes a test method to be applied and defines control procedures for checking values declared by the manufacturers.

Regarding testing methods EN 153 references to the **EN ISO 15502:2005** (see next standard), but includes some modifications to conform its requirements to the EU legislation on rational use of energy i.e. Directive 2003/66/EC, and in particular:

- in Clause 5 – Design, only clause 5.1 and 5.6 of EN ISO 15502 apply. In order to enable direct comparison between all climate class appliances for the checking of energy consumption, the test temperature is always set at +25°C for all class (SN, N, ST, and T (see Table 1-51 for class description)
- the refrigerating appliance with a rated voltage within the range between 220V and 240V shall be tested at 230V ± 1% with a frequency of 50 Hz ± 1%
- a specific normative Annex C – "Rated characteristics and control procedure", was set, which has an informative nature in EN/ISO 15502, and deals with the control procedure of the declared values, which is fundamental for the verification of the compliance to any legislation on cold appliances.

The main changes in EN 153:2006 compared to the previous 1995 edition are:

- the rated voltage to test the refrigerating appliances, changed from 220V to 230V
- inclusion of a correction formula for the energy consumption measured value, to be normalised at ambient temperature = +25°C; when possible ambient temperature range is from +24.5°C to +25.5°C
- addition of a normative annex on built-in refrigerating appliances
- addition of reference to Directives 94/2/EC and 92/75/EEC
- editorial modifications to be consistent with EN ISO 15502

1.7. EN ISO 15502:2005 (CORRIGENDUM 1:2007)

Relevance: Service cabinets

The **EN ISO 15502:2005 (corrigendum 1:2007)** test method related to "*Household refrigerating appliances - Characteristics and test methods"*, prepared by Technical Committee ISO/TC 86, Refrigeration and air-conditioning, Subcommittee SC 5, Testing and rating of household refrigeration appliances is the internationally recognised standard which specifies the essential characteristics of household refrigerating appliances, factory assembled and cooled by internal natural convection or forced air circulation.

Scope: Household refrigerating appliances and similar appliances (e.g. plug-in service cabinets)

This test method is applicable to plug-in service cabinets as these appliances are very similar to household appliances (common practice in the industry). As mentioned for EN ISO 153:2006, further specifications could be set for the testing requirements for these products.

Requirements: The EN ISO 15502:2005 standard describes the following specifications:

- essential characteristics of household refrigerating appliances, factory assembled, and cooled by internal natural convection or forced air circulation:
    - refrigerating appliances types
    - compartments and sections
        - fresh food compartment
        - cellar compartment
        - chill compartment
        - ice-making compartment
        - frozen food compartment
            - one, two, or three star compartment
            - food freezer compartment/four star compartment
        - two star section (part of a food freezer compartment or cabinet, or three-star compartment or cabinet)
    - physical aspects and dimensions
    - definitions relating to performance characteristics, including:
        - freezing capacity
        - ice-making capacity
        - defrost types
    - definitions relating to refrigerating system
    - symbols
    - classification
        - in climatic classes: SN, N, ST, T

Table 1-51: Climatic classes of Household refrigerating appliances (EN ISO 15502)

Class	Symbol	Ambient temperature range (°C)
Extended temperate	SN	+10 to +32
Temperate	N	+16 to +32
Subtropical	ST	+16 to +38
Tropical	T	+16 to +43

        - in refrigerator-freezer types: “type I” and “type II” (depending in the number of user-adjustable temperature control devices)
    - materials, design and manufacture characteristics
    - storage temperatures:

Table 1-52: Refrigerating appliances storage temperatures in °C (EN ISO 15502)

Storage temperature in °C						
Fresh food storage compartment		Food freezer and three-star compartment/cabinet	Two-star compartment / section	One-star compartment	Cellar compartment	Chill compartment
t_{1m}, t_{2m}, t_{3m}	T_{ma}	t***	t**	t*	t_{cc}	t_{cc}
0 ≤t1m, t2m, t3m ≤ 8	≤ +4	≤-18[a]	≤-12[a]	≤-6	$+8 \le t_{cm} \le +14$	$-2 \le t_{cc} \le +3$

[a] as a result of a defrost cycle, the storage temperatures of frost free and/or adaptive defrost refrigeration appliances are permitted to rise by no more than 3K during a period not greater than 4 hours or 20% of the duration of the operating cycle, whichever is the shorter.
t_{cc} instantaneous temperature value (cellar or chill compartment); t_{ma} arithmetic average of t_{1m}, t_{2m}, t_{3m}

- test methods for the determination of
  - linear dimensions, volumes and areas:
    - linear dimensions (shall be measured to the nearest millimetre
    - volumes of compartments and sections (shall be expressed to the nearest whole number of cubic decimetres or of litres): gross volume, total storage volume, storage volume of fresh-food storage, chill, cellar, ice-making compartments; food freezer compartments/cabinets and frozen-food storage compartments/cabinets; two-star sections
    - volumes of shelves and partitions
    - storage shelf area
  - air tightness of seals of doors, lids, and drawers
  - mechanical strength of shelves and similar components
  - storage temperatures
  - water vapour condensation: to determine the extent of condensation of water on the external surface of the cabinet under specified ambient conditions (temperature and relative humidity)
  - energy consumption: to measure the energy consumption of refrigerating appliances under specified test conditions, calculated for a period of exactly 24h from the measured value, and expressed in kilowatt-hours per 24h (kWh/24h), to two decimal places.
  - Temperature rise time: to check the time for the temperature rise of test packages from -8°C to -9°C
  - Freezing capacity of food freezers and food freezer compartments, loaded with test packages
  - Ice making capacity of appliance in the ice tray or in the automatic ice-maker, in kilograms of produced in 24h (kg of ice/24h)

- test conditions:
  - ambient temperature and humidity

- for checking the storage temperatures, the ambient temperature shall be:
  - +10°C and +32°C for appliances in class SN
  - +10°C and +32°C for appliances in class N
  - +10°C and +32°C for appliances in class ST
  - +10°C and +32°C for appliances in class T
- For checking the energy consumption, temperature rise time, freezing capacity and ice-making capacity of all cold appliances the ambient temperature shall be +25°C for class SN, N, ST and +32°C for class T
- for other tests: at temperature stated in the test specifications

- installation of the test appliances
- test packages
- operating requirements of the test appliances
- measuring instruments
- final test report requirements

- type of marking and information to be included in the rating plate
- technical and commercial product information
- instructions for users

Following a formal request started in 2003 by some Member States, the ISO technical management board agreed to transfer the responsibility for standards on the performance and rating of household refrigerators and freezers from ISO to IEC which was confirmed by IEC with AC/28/2006 in September 2006. A new Sub-Committee SC 59M (*Performance of electrical household and similar cooling and freezing appliances*) has been created within IEC TC59 (*Performance of household and similar electrical appliances*), the Technical Committee already addressing other home appliances.

1.8. EN 28960:1993 (ISO 8960:1991)

Relevance: Service cabinet

The **EN 28960:1993 (ISO 8960:1991)** standard related to "*Refrigerators, frozen food storage cabinets and food freezers for household and similar use – Measurement of emission of airborne acoustical noise"* is linked to the international standard on noise measurement **IEC 60704-1** with replacement or additions to conform to the specificities of refrigerating and freezing appliances. This standard is currently under revision.

1.9. ANSI/ARI 420-2008

The **ANSI/ARI 420-2008** standard "*Performance rating of forced-circulation free-delivery unit coolers for refrigeration"* establishes for forced-circulation free-delivery unit coolers for refrigeration: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; marking and nameplate data; and conformance conditions.

Scope: This standard applies to factory-made, Forced-Circulation, Free-Delivery Unit Coolers, operating with a Volatile Refrigerant fed by either direct expansion or liquid overfeed at wet and/or dry conditions.

Exclusion: This standard does not apply to air-conditioning units used primarily for comfort cooling for which testing methods are given in other standards, unit coolers operating at latent load conditions with refrigerant saturation temperature < 32 ºF (0.0 ºC) to prevent frost, unit coolers installed in or connected to ductwork, unit coolers using zeotropic refrigerants with glides greater than 2.0 ºF (1.1 ºC), field testing of unit coolers.

1.10. ANSI/ARI 530-2005

The **ANSI/ARI 530-2005** standard *"Rating of Sound and Vibration for Refrigerant Compressors"* establishes the rating of sound and vibration for refrigerant applies to External-drive, Hermetic and Semi-Hermetic Refrigerant Compressors. In the case of External-drive Refrigerant Compressors, the driving mechanism shall be excluded from the sound and vibration measurements. However, for Semi-Hermetic Refrigerant Compressors where compressors. It the driving mechanism is an integral part of the compressor assembly, it shall be included in the measurements.

1.11. ANSI/ARI 520-2004

The **ANSI/ARI 520-2004** standard "*Performance rating of positive displacement condensing units"* establishes, for positive displacement condensing units**:** definitions; test requirements; rating requirements; minimum data requirements for published ratings; operating requirements; marking and nameplate data and conformance conditions.

Scope: This standard applies to electric motor driven, single and variable capacity positive displacement condensing units for air-cooled, evaporatively-cooled, and water-cooled refrigeration applications.

Exclusions: This standard does not apply to condensing units intended for use in household refrigerators and freezers, automotive air-conditioners, dehumidifiers.

Test Requirements: The tests required for this standard shall be conducted in accordance with ASHRAE Standard 23 (see ASHRAE standards).

1.12. ANSI/ARI 540-2004

The **ANSI/ARI 540-2004** standard "*Performance rating of positive displacement refrigerant compressors and compressor units*" establishes, for single and variable capacity positive displacement refrigerant compressors and compressor units: definitions; test requirements; rating requirements; minimum data requirements for published ratings; operating requirements; marking and nameplate data and conformance conditions.

Scope: This standard applies to electric motor driven, single and variable capacity positive displacement refrigerant compressors and compressor units. This standard also applies to the presentation of performance data for positive displacement refrigerant compressors and compressor units for air-cooled, evaporatively-cooled or water-cooled air-conditioning, heat pump and refrigeration applications.

Exclusions: This standard does not apply to compressors and compressor units employing ammonia (covered in ARI Standard 510) and compressors and compressor units intended for use in household refrigerators and freezers, automotive air-conditioners and dehumidifiers

Test Requirements: The tests required for this standard shall be conducted in accordance with ASHRAE Standard 23 (see ASHRAE standards).

Rating conditions: Table 1-53 and Table 1-54 present standard rating conditions for compressors and compressor units respectively for commercial refrigeration and air conditioners and heat pumps applications.

Table 1-53: Standard rating conditions for compressors and compressor units for commercial refrigeration applications

Standard Rating Conditions for Compressors and Compressor Units for Commercial Refrigeration Applications (Based on 95°F [35°C] Ambient Temperature)								
Suction Dew Point Temperature		Compressor Type	Discharge Dew Point Temperature		Return Gas Temperature		Subcooling	
°F	°C		°F	°C	°F	°C	°F	°C
45	7.2	All	130	54.4	65	18	15	8.3
20	-6.7	All*	120	48.9	40/65*	4.4/18*	0	0
-10	-23	Hermetic	120	48.9	40	4.4	0	0
-25	-32	All*	105	40.6	40/65*	4.4/18*	0	0
-40	-40	All*	105	40.6	40/65*	4.4/18*	0	0

Note: If airflow across the compressor is used to determine ratings, it shall be specified by the compressor manufacturer.
* 1) For hermetic type compressors, 40°F [4.4°C] return gas temperature shall be used.
2) For external drive and accessible hermetic type compressors, 65°F [18°C] return gas temperature shall be used.

Table 1-54: Standard rating conditions for compressors and compressor units used in air conditioners and heat pumps

Standard Rating Conditions for Compressors and Compressor Units Used In Air Conditioners and Heat Pumps (Based on 95°F [35°C] Temperature Surrounding Compressor-- See Notes 1 and 3)								
Rating Test Point	Intended Use	Suction Dew Point Temperature		Discharge Dew Point Temperature		Return Gas Temperature		Capacity Setting (Note 2)
		°F	°C	°F	°C	°F	°C	
A	Air Source (Cooling)	45	7.2	130	54.4	65	18	MAX.
B	Air Source (Cooling)	45	7.2	115	46.1	65	18	MAX.
C	Air Source (Cooling & Heating)	45	7.2	100	37.8	65	18	MIN.
D	Air Source (Heating)	30	-1.1	110	43.3	50	10.0	MAX.
E	Air Source (Heating)	5.0	-15	95	35	25	-3.9	MAX.
F	Air Source (Cooling)	45	7.2	80	27	65	18	MIN.
G	Air Source (Heating)	35	1.7	90	32	55	13	MIN.
H	Water Source (Cooling & Heating)	45	7.2	120	48.9	65	18	MAX. & MIN.

NOTE:
1) If airflow across the compressor is used to determine ratings, it shall be specified by the compressor manufacturer.
2) The maximum and minimum capacity setting is the highest and lowest displacement capacity obtainable by the compressor or compressor unit.
3)15°F [8.3°C] degrees of subcooling

Rating requirements: General performance data, covering the operational spectrum of the equipment, must be presented in tabular form and include:

- Suction dew point temperature range, °F [°C]
- Discharge dew point temperature range, °F [°C]
- Applicable superheat, °F [°C]
- Power Input, W [W]
- Compressor or Compressor Unit Efficiency, percent
- Refrigerant mass flow rate, lb/h [kg/s]
- Current, A [A]
- Refrigerant designation per ASHRAE Standard 34

Performance Data must be reported for the following conditions for the compressor or compressor unit application depending on the usage intended (extreme ends of the data may be omitted and not reported due to limits of acceptable operation of the compressor or compressor unit as determined by the manufacturer):

- Air-Conditioning (including heat pumps):
    - -10°F to 55°F [-23°C to +13°C] suction dew point temperature in +5°F [+3°C] increments
    - +80°F to +140°F [+27°C to +60°C] discharge dew point temperature in +10°F [+5.6°C] increments
    - Return gas temperature per Table 1-54
- High Temperature (water coolers and walk-in coolers, for example):
    - +20°F to +50°F [-7°C to +10°C] suction dew point temperature in +5°F [+3°C] increments
    - +80°F to +140°F [+27°C to +60°C] discharge dew point temperature in +10°F [+5.6°C] increments
    - Return gas temperature per Table 1-53
- Medium Temperature (service cabinets, for example):
    - -10°F to +32°F [-23°C to 0°C] suction dew point temperature in +5°F [+3°C] increments
    - +80°F to +140°F [+27°C to +60°C] discharge dew point temperature in +10°F [+5.6°C] increments
    - Return gas temperature per Table 1-53
- Low Temperature (freezer cases, for example):
    - -40°F to +10°F [-40°C to -12°C] suction dew point temperature in +5°F [+3°C] increments
    - +80°F to +140°F [+27°C to +60°C] discharge dew point temperature in +10°F [+5.6°C] increments
    - Return gas temperature per Table 1-53

1.13. ISO 5149:1993

International standard ISO 5149:1993 (not a standard endorsed by any of the European Standards Bodies) “Mechanical refrigerating systems used for cooling and heating – safety requirements”.

Scope: All types of refrigerating systems in which the refrigerant is evaporated and condensed in a closed circuit, including heat pumps and absorption systems, except for systems using water or air as the refrigerant. It is applicable to new refrigerating systems, extensions and modifications of already existing systems, and for used systems.

Requirements: This standard specifies the requirements relating to the safety of persons and property for the design, construction, installation and operation of refrigerating systems. It gives a classification of the refrigerating systems.

1.14. ATP AGREEMENT

1.14.1. INTRODUCTION

As described in §1.3.3.10 and §1.4.3.4, ATP is a multi-lateral agreement for overland cross-border carriage of perishable foodstuffs. It ensures that vehicles used for this carriage meet agreed international standards, which apply to the bodywork (insulating box) and refrigeration systems.

Published by the United Nations, includes: the terms of the agreement and a list of signatories; definitions and classifications of equipment; provisions relating to the checking for compliance; methods and procedures for measuring the insulating capacity and the efficiency of the refrigeration system; requirements for the monitoring of air temperature during use; requirements for food sampling during use; and temperature requirements for various chilled foodstuff.

1.14.2. DEFINITIONS

Insulated equipment. Equipment of which the body is built with insulating walls, doors, floor and roof.

K coefficient. The overall heat transfer coefficient (K coefficient) of the insulated equipment.

I_N = Normally insulated equipment

I_R = Heavily insulated equipment

Mechanically refrigerated equipment. Insulated equipment either fitted with its own refrigerating appliance, or served jointly with other units of transport equipment by such an appliance (fitted with either a mechanical compressor, or an "absorption" device, etc.). 6 classes of refrigerating equipment (A to F) aredescribed, able to maintain temperature below a certain maximum (or within a specific range), with a mean external ambient temperature of +30°C.

Refrigeration unit. Packaged refrigeration system.

W_O = Refrigerating capacity of a refrigeration unit when the evaporator is free from frost

T_i = inside temperature

1.14.3. REQUIREMENTS

The mechanically refrigerated equipment shall be capable, with a mean outside temperature of + 30 °C, of lowering the temperature T_i inside the empty body to, and thereafter maintaining it continuously in the following manner at:

- Class A: T_i may be chosen between + 12 °C and 0 °C inclusive;

- Class B: T_i may be chosen between + 12 °C and - 10 °C inclusive;
- Class C: T_i may be chosen between + 12 °C and - 20 °C inclusive.
- Class D: T_i is equal to or less than 0 °C;
- Class E: T_i is equal to or less than - 10 °C;
- Class F: T_i is equal to or less than - 20 °C.

In the case of classes A, B and C, any desired practically constant T_i (in conformity with the standards defined above), while in the case of classes D, E and F a fixed practically constant T_i (in conformity with the standards defined above).

The K coefficient of equipment of classes B, C, E and F shall in every case be equal to or less than 0.40 $W/m^2.K$ (classes that are required to go down to (or below) -10°C).

Testing stations shall be provided with the equipment and instruments necessary to ensure that the K coefficient is determined with a maximum margin of error of ±10% when using the method of internal cooling and ±5% when using the method of internal heating.

The overall coefficient of heat transfer (K coefficient), is such that the equipment is assignable to one or other of the following two categories:

- I_N specified by a K coefficient equal to or less than 0.70 $W/m^2.K$;
- I_R specified by a K coefficient equal to or less than 0.40 $W/m^2.K$ and by sidewalls with a thickness of at least 45mm for transport equipment of a width greater than 2.50m.

If the refrigerating appliance with all its accessories has undergone separately, to the satisfaction of the competent authority, a test to determine its effective refrigerating capacity at the prescribed reference temperatures, the transport equipment may be accepted as mechanically refrigerated equipment without undergoing an efficiency test if the effective refrigerating capacity of the appliance in continuous operation exceeds the heat loss through the walls for the class under consideration, multiplied by the factor 1.75.

For insulated bodies, the manufacturer's plate shall be on the outside of the body. The manufacturer's plate shall show clearly and indelibly at least the following particulars:

- Country of manufacture or letters used in international road traffic;
- Name of manufacturer or company;
- Model (figures and/or letters);
- Serial number;
- Month and year of manufacture.

Industry estimates that insulation will deteriorate at about 5% per annum, therefore fuel costs will increase proportionally. In order to ensure the best performance of the refrigeration equipment, maintenance should be carried out at regular intervals, comprising of:

- Refrigerated unit servicing
- Temperature control thermostat calibration check
- Thermostat and temperature recorder calibration check

- Inspection of the bodywork for holes/damage. This should be promptly repaired with the correct materials to ensure that insulation deterioration due to moisture ingress is kept to a minimum.
- Inspection of door operation and seal condition to prevent the ingress of dust, moisture and undesirable odours, as well as air leakage/temperature loss.

1.14.4. Test methods and procedures (Annex 1, Appendix 2 of the Agreement)

The following extracts and summaries of the requirements of the testing procedures and methods are described (including relevant section numbers).

1.14.4.1 Definitions and general principles (Section 1)

The overall heat transfer coefficient (K coefficient) of the special equipment is defined by the following formula:

$K = W / S. \Delta T$

where W is either the heating power or the cooling capacity, as the case may be, required to maintain a constant absolute temperature difference ΔT between the mean inside temperature T_i and the mean outside temperature T_e, during continuous operation, when the mean outside temperature T_e is constant for a body of mean surface area S.

The mean surface area S of the body is the geometric mean of the inside surface area Si and the outside surface area S_e of the body:

$S = \sqrt{(S_i . S_e)}$

In determining the two surface areas S_i and S_e, structural peculiarities and surface irregularities of the body, such as chamfers, wheel-arches and similar features, shall be taken into account and shall be noted under the appropriate heading in test reports; however, if the body is covered with corrugated sheet metal the area considered shall be that of the plane surface occupied, not that of the developed corrugated surface.

Temperature measuring points (1.3)

Describes the positions of 12 measuring points inside, and 12 measuring points outside, of the insulated equipment are specified. The mean temperature of the walls is the arithmetic mean of the mean of the outside temperatures and the mean of the inside temperatures.

Steady state period and duration of test (1.7)

Describes the permitted variance of the mean outside and inside temperatures, and the heating power (or cooling capacity) during the steady state period.

1.14.4.2 Insulating capacity of equipment (Section 2)

Section 2 sets out procedures for measuring the K coefficient of the insulated box.

Test method (2.1.2)

The K coefficient shall be measured in continuous operation either by the internal cooling method or by the internal heating method.

Describes the specifications for these two test options.

Test procedure (2.1.4)

In either case, the empty body shall be placed in an insulated chamber whose mean temperature shall be kept uniform to within ±0.5K, to a level where the temperature difference between the inside of the body and the insulated chamber is 25°C ±2K, the average temperature of the walls of the body being maintained at +20°C ±0.5K.

Also describes the air flow and other requirements.

Verification of the K coefficient (2.3.1)

If the test is solely to test the K coefficient, the tests can be stopped one the steps as described above have been met.

Accuracy of the K coefficient (2.3.2)

Minimum margin of error is ±10% for internal cooling method and ±5% for internal heating method.

1.14.4.3 Effectiveness of thermal appliances [*applications*] of the equipment (Section 3)

Section 3 sets out procedures for testing that the whole product (insulated box plus refrigeration system) meets the performance requirements in terms of achieving the given temperature classification.

Test method (3.2.1)

The empty body shall be placed in an insulated chamber whose mean temperature shall be kept uniform, and constant to within ± 0.5K, at + 30°C. The mass of air in the chamber shall be made to circulate as specified in section 2, and the temperature measuring instruments protected against radiation shall be placed inside and outside the body at the points specified in section 1.

Test procedure (3.2.2)

When the mean inside temperature of the body reaches the outside temperature (+30°C), the doors, hatches and other openings shall be closed and the refrigerating appliance and the inside ventilating appliances (if any) shall be started up at maximum capacity. In addition, in the case of new equipment, a heating appliance with a heating capacity equal to 35% of the heat exchanged through the walls in continuous operation shall be started up inside the body when the temperature prescribed for the class to which the equipment is presumed to belong has been reached.

Criterion of satisfaction (3.2.5)

The test shall be deemed satisfactory if the refrigerating appliance is able to maintain the prescribed temperature conditions during the said 12-hour periods, with any automatic defrosting of the refrigerating unit not being taken into account.

1.14.4.4 Procedure for measuring the effective refrigerating capacity of unit when evaporator is free from frost (Section 4)

Section 4 sets out procedures for measuring refrigeration system cooling capacity.

General principles (4.1)

Refrigerating capacity, W_O, of a unit when the evaporator is free from frost can be calculated by attachment to either a calorimeter box or the insulated body of a unit of transport equipment, operating continuously, and this can be described as:

$W_o = W_j + U.\ \Delta T$

where: U is the heat leakage of the calorimeter box or insulated body, Watts/°C; ΔT is the difference between the mean inside temperature T_i and the mean outside temperature T_e of the calorimeter or insulated body (K); W_j is the heat dissipated by the fan heater unit to maintain each temperature difference in equilibrium.

Test method (4.2)

Describes in detail the calculation methods, instrumentation (4.2.2), conditions (4.2.3), and procedure (4.3) for calculation of the refrigeration unit capacity, both for tests using the methodology described in section 2, or the calorimeter box method (it is preferable to use a calibrated calorimeter box to obtain maximum accuracy). However, it is sufficient to measure U directly, the value of this coefficient being defined by the following relationship where:

$U = W / \Delta T_m$

where:

W is the heating power (in watts) dissipated by the internal heater and fans; ΔT_m is the difference between the mean internal temperature T_i and the mean external temperature T_e; U is the heat flow per degree of difference between the air temperature inside and outside the calorimeter box or unit of transport equipment measured with the refrigeration unit fitted.

The calorimeter box or unit of transport equipment (insulated box) is placed in a test chamber, and both should be heavily insulated. If a calorimeter box is used, U. Δ T should be not more than 35% of the total heat flow W_o.

Test result (4.4)

The refrigeration capacity for ATP purposes is that relating to the mean temperature at the inlet(s) of the evaporator (temperature measuring instruments protected against radiation).

1.14.4.5 Checking the insulating capacity of equipment in service (Section 5)

General examination of the equipment (5.1)

Checking the insulating capacity of equipment in service can be carried out through the methods described in section 2, or a general examination which investigates aspects such as the condition of the walls and insulation. An examination of air-tightness (5.2) should also be carried out, with an observer stationed inside the equipment, which has been placed in a brightly-illuminated area (or other improved method).

Decisions (5.3)

If the condition of the equipment is judged as acceptable, it can be kept in service in its class for no more than 3 years. If not, tests as described in section 2 should be undertaken. Heavily insulated equipment, if not accapted as suitable for its class, may be used as normally insulated for a further 3 years.

If the inspection applies to a "type approved" series, each unit should be inspected and 1% should be tested under conditions specified in section 2. If acceptable, the units can be kept in service for a further 6 years.

1.14.4.6 Verifying the effectiveness of thermal appliances of equipment in service (Section 6)

Mechanically refrigerated equipment (6.2)

Checking of the thermal performance of mechanically refrigerated equipment in service can be carried out through the methods described in section 3, or alternatively through the examination as described in section 5, and in addition it shall be verified that, when the outside temperature is not lower than + 15°C, the inside temperature of the empty equipment can be brought to the class temperature within a maximum period (in minutes), as prescribed in table X.

Table 1-55: ATP refrigeration equipment in-service test requirements

Outside temperature	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	°C
Class C, F	360	350	340	330	320	310	300	290	280	270	260	250	240	230	220	210	min
Class B, E	270	262	253	245	236	228	219	211	202	194	185	177	168	160	151	143	min
Class A, D	180	173	166	159	152	145	138	131	124	117	110	103	96	89	82	75	min

If the equipment was brought into service before the signing of the agreement, it shall be verified that, when the outside temperature is not lower than + 15°C, the inside temperature of the empty equipment, which has been previously brought to the outside temperature, can be brought within a maximum period of 6 hours:

- In the case of equipment in classes A, B or C, to the minimum temperature, as prescribed;
- In the case of equipment in classes D, E or F, to the limit temperature, as prescribed.

Temperature measuring points are described for this test procedure (6.4).

Provisions (6.5)

If accepted, the equipment can be kept in service for a further 3 years. In not accepted, the tests decribed in section 3 must be carried out, and if then accepted the equipment may be kept in service for a further period of six years.

If the test applies to a "type approved" series, each thermal appliance should be inspected for general condition and the effectiveness of 1% of the refrigeration uinits should be tested under conditions specified in section 3. If acceptable, the units can be kept in service for a further 6 years.

1.14.5. COMPLIANCE AND ENFORCEMENT

Checks for conformity with the standards shall be made:

(a) before equipment enters into service;

(b) periodically, at least once every six years;

(c) whenever required by the competent authority.

Except in the cases provided for in appendix 2, sections 5 and 6 of the agreement, the checks shall be made at a testing station designated or approved by the competent authority of the country in which the equipment is registered or recorded, unless, in the case of the check referred to in (a) above, a check has already been made on the equipment itself or on its prototype in a testing station designated or approved by the competent authority of the country in which the equipment was manufactured.

A certificate of compliance with the standards shall be issued by the competent authority of the country in which the equipment is to be registered. This documentation, or the required manufacturer's plate, can be used by competent authorities for identification during inspection.

Product ranges can be "Type Approved" to the required standards, after testing of one unit, after which Type Approval certification lasts for 6 years. The competent authority shall take steps to verify that production of other units is in conformity with the approved type. For this purpose it may check by testing sample units drawn at random from the production series. After 6 years, it is possible to renew the certification for 3 year periods by having an in-service "K coefficient" test at an approved ATP 'Designated Station' authorised by any country that is a signatory to the agreement. If, in the course of the six-year period, the production series exceeds 100 units, the competent authority shall determine the percentage of units to be tested.

If a vehicle fitted with equipment does not have an ATP certificate, and no Type Approvals have been issued, then the only option is to obtain a certificate by having a 'one off' test at an approved test centre or at the owner's site.

A unit shall not be regarded as being of the same type as the unit tested unless it satisfies the following minimum conditions:

(i) If it is insulated equipment, the construction shall be comparable and, in particular, the insulating material and the method of insulation shall be identical:

- the thickness of the insulating material shall be not less than that of the reference equipment;
- the interior fittings shall be identical or simplified;

- the number of doors and the number of hatches or other openings shall be the same or less; and
- the inside surface area of the body shall not be as much as 20% greater or smaller.

(ii) ...

(iii) If it is mechanically refrigerated equipment, in which case the reference equipment shall be either:...

(a) mechanically refrigerated equipment;

- the conditions set out in (i) above shall be satisfied; and
- the effective refrigerating capacity of the mechanical refrigeration appliance per unit of inside surface area, under the same temperature conditions, shall be greater or equal;

or (b) insulated equipment to which it is intended to have fitted, at a later date, a mechanical refrigeration unit and which is complete in every detail but with the refrigeration unit removed and the aperture filled, during the measurement of the K coefficient, with close fitting panels of the same overall thickness and type of insulation as is fitted to the front wall. In which case:

- the conditions set out in (i) above shall be satisfied; and
- the effective refrigerating capacity of the mechanical refrigeration unit fitted to insulated reference equipment shall be as defined.

1.15. OTHER RELATED STANDARDS

- **EN 13215:2000**: *Condensing units for refrigeration rating conditions, tolerances and presentation of manufacturer's performance data*
- **EN 12900:2005:** *Refrigerant compressors - Rating conditions, tolerances and presentation of manufacturer's performance data*

  The purpose of this norm is to specify the rating conditions, tolerance and method of presenting data for positive displacement refrigerant compressors. Single stage and single and two stage compressors using liquid for sub-cooling are included. The results obtained can be used as comparative parameters between equipments.

- **EN 14276-1:2006**: *Pressure equipment for refrigerating systems and heat pumps - Part 1: Vessels - General requirements*
- **EN 13313:2001**: *Refrigerating systems and heat pumps - Competence of personnel*
- **EN 12178:2003**: *Refrigerating systems and heat pumps - Liquid level indicating devices - Requirements, testing and marking*
- **EN 13136:2001**: *Refrigerating systems and heat pumps - Pressure relief devices and their associated piping - Methods for calculation*
- **EN 1861:1998**: *Refrigerating systems and heat pumps - System flow diagrams and piping and instrument diagrams - Layout and symbols*
- **EN 12284:2003**: *Refrigerating systems and heat pumps - Valves - Requirements, testing and marking*
- **EN 12900:2005**: *Refrigerant compressors - Rating conditions, tolerances and presentation of manufacturer's performance data*
- **EN 12524:2000**. *Building materials and products. Hygrothermal properties. Tabulated design values*.
- **ISO 6946:2007**: *Building components and building elements – Thermal resistance and thermal transmittance – Calculation method*

  This document provides the calculation method for thermal properties od building components and elements (walk-in cold rooms included). It also states approximate method to be used in inhomogeneous layers.

- **BS EN 14509:2006:** *Self-supporting double skin metal faced insulating panels. Factory made products. Specifications*
- **CWA 15596:2006:** The CEN Work Agreement **CWA 15596:2006** defines the "*Code of practice on cleanability of commercial food equipment used in the retail and catering sectors*". It is linked to the main standard on safety requirements **IEC 60335**. CWA is not a standard in a formal document and deals with cleanability, construction, not food safety standard.

This page is left intentionally blank

Annex 1-2: Summary of data for selection of the Base Cases

The matrix below summarises previous data, **no longer valid**, used to prioritise the refrigeration products for further analysis in Task 4 of ENTR Lot 1. Table 1-57 shows the updated data as per the results of this study. These figures indicated that the products for further analysis as Base Cases, due to their significant energy saving potentials, should be:

- Service cabinets.
- Blast cabinets.
- Walk-in cold rooms.
- Remote condensing units.
- Industrial process chillers.

Table 1-56: Market and energy consumption figures for products in the scope of ENTR Lot 1

ENTR Lot 1	Product type	EU-27 sales [units in 2008]	EU-27 stock [units in 2008]	EU-27 sales [units in 2020]	EU-27 stock [units in 2020]	Estimated average total energy consump. per product [kWh/year]	Approximate lifetime (years of sales to replace stock) [years]	Total stock energy consump. TWh/year (2008)	Total stock energy consump. TWh/year freeze scenario (2020)	Estimated average energy saving potential per product [% in 2020]	Total stock energy consump. TWh/year with energy savings scenario (2020)	Estimated EU-27 savings in TWh/year in 2020
Product												
Service Cabinets	*Remote*	39 744	326 016	44 023	362 162	4 500	8	1,47	1,63	25%	1,35	0,28
	Plug-in	357 700	2 934 147	396 207	3 259 454	4 500	8	13,20	14,67	33%	11,37	3,29
	Total	397 444	3 260 163	440 230	3 621 615	-		-	-	-	-	-
Blast Cabinets	*Remote*	250 000	1 550 000	276 913	1 722 050	6 750	6	10,46	11,62	21%	9,73	1,90
	Plug-in	250 000	1 550 000	276 913	1 722 050	6 750	6	10,46	11,62	33%	8,69	2,94
	Total	500 000	3 100 000	553 826	3 444 100	-		-	-	-	-	-
Walk-in cold rooms	*Remote*	22 072	380 415	24 808	422 593	15 100	16	5,74	6,38	31%	5,99	0,40
	*Remote + PCU**	22 072	380 415	24 808	422 593	15 100	16	5,74	6,38	39%	5,80	0,58
	Plug-in	44 145	760 830	49 615	845 185	15 100	16	11,49	12,76	39%	11,62	1,15
	Total	88 289	1 521 659	99 230	1 690 370	-		-	-	-	-	-
Dessert and beverage machines	-	150 000	1 500 000	166 630	1 666 304	650	9	0,98	1,08	17%	0,97	0,11
Industrial process chillers	*Packaged*	3 911	79 296	4 185	70 941	399 105	17	31,65	28,31	30%	26,68	1,63
	Plant	391	7 930	419	7 094	399 105	17	3,16	2,83	30%	2,67	0,16
	Total	4 302	87 226	4 604	78 035	-		-	-	-	-	-
Water dispensers	*Bottled water*	222 222	2 000 000	250 000	2 222 200	950	8	1,90	2,11	23%	1,79	0,32
	Mains water	55 556	500 000	62 500	555 550	950	8	0,48	0,53	23%	0,45	0,08
	Total	277 778	2 500 000	312 500	2 777 750	-		-	-	-	-	-
Ice-makers	-	120 148	985 756	133 081	1 095 052	5 000	8	4,93	5,48	10%	5,10	0,38
TOTAL	-	1 797 220	15 917 767	2 038 990	17 662 115	-		102	105	-	92	13
**Packaged condensing units (PCU)*	-	259 259	2 962 963	328 889	3 288 889	22 359	10	66,25	73,54	23%	63,38	10,16

Table 1-57: Updated market and energy consumption figures for products in the scope of ENTR Lot 1

Product	EU-27 sales [units in 2008]	EU-27 sales* [units in 2008]	EU-27 stock [units in 2008]	EU-27 stock* [units in 2008]	EU-27 sales [units in 2020]	EU-27 sales* [units in 2020]
ENTR Lot 1	*2009*	*11/2010*	*2009*	*11/2010*	*2009*	*11/2010*
Service Cabinets	397,444	397,444	3,260,163	3,260,163	440,230	440,230
Variation		0%		0%		0%
Blast Cabinets	500,000	173,655	3,100,000	1,331,197	553,826	224,155
Variation		-65%		-57%		-60%
Walk-in cold rooms	88,289	88,289	1,521,659	1,521,659	99,230	99,230
Variation		0%		0%		0%
Industrial process chillers	4,302	6,441	87,226	80,929	4,604	8,105
Variation		50%		-7%		76%
*Packaged condensing units (PCU)	631,101	599,759	5,260,581	5,243,301	644,986	502,614
Variation		-5%		0%		-22%
Dessert and beverage machines	150,000		1,500,000		166,630	
Water dispensers	277,778		2,500,000		312,500	
Ice-makers	120,148		985,756		133,081	
Refrigeration compressors	253,000		1,771,000		253,076	
Refrigeration condensors	50,600		354,200		39,316	

* Weighted Base Case used. Weighted average considering market shares for products working at several temperature ranges

Table 1-57: Updated market and energy consumption figures for products in the scope of ENTR Lot 1 (continuation)

Product	EU-27 stock [units in 2020]	EU-27 stock [units in 2020]*	Stock Increase Factor 2008-2020	Stock Increase Factor 2008-2020*	Estimated average total energy consump. per product [kWh/year]	Estimated average total energy consump. Per weighted product [kWh/year]*
ENTR Lot 1	*2009*	*11/2010*	*2009*	*11/2010*	*2009*	*02/2011*
Service Cabinets	3,621,615	3,621,615	8	8	4,500	2,900
Variation		0%		0%		-36%
Blast Cabinets	3,444,100	1,761,092	6	8	6,750	3,031
Variation		-49%		26%		-55%
Walk-in cold rooms	1,690,370	1,690,370	17	17	15,100	12,155
Variation		0%		0%		-20%
Industrial process chillers	78,035	106,442	17	13	399,105	494,300
Variation		36%		-23%		24%
*Packaged condensing units (PCU)	5,839,245	6,301,534	9	13	22,359	35,207
Variation		8%		38%		57%
Dessert and beverage machines	1,666,304		1.11		650	
Water dispensers	2,777,750		1.11		-	
Ice-makers	1,095,052		1.11		5,000	
Refrigeration compressors	1,771,533		1.00		22,920	
Refrigeration condensors	393,162		1.11		19,102	

* Weighted Base Case used. Weighted average considering market shares for products working at several temperature ranges

Table 1-57: Updated market and energy consumption figures for products in the scope of ENTR Lot 1 (continuation)

Product	Estimated average energy saving potential per product [% in 2020]	Task 7 LLCC saving potential	Total stock energy consump. [TWh/year in 2008]	Total stock energy consump. [TWh/year in 2008]*	Total stock energy consump. (freeze scenario) [TWh/year in 2020]	Estimated EU-27 saving with annual BAU 1% annual improvment [TWh/year in 2020]	Estimated EU-27 savings with complete LLCC efficiency [TWh/year in 2020]
ENTR Lot 1	*2009*	*02/2011*	*2009*	*02/2011*	*02/2011*	*02/2011*	*02/2011*
Service Cabinets	32%	46%	14.67	9.45	10.50	1.20	4.86
Variation				-36%**			
Blast Cabinets	27%	37%	20.93	4.03	5.34	0.51	1.98
Variation				-81%**			
Walk-in cold rooms	37%	37%***	22.98	18.50	20.55	2.35	7.60
Variation				-20%**			
Industrial process chillers	30%	27%	34.81	40.00	52.61	5.07	14.21
Variation				15%**			
*Packaged condensing units (PCU)	23%	23%	117.62	184.60	221.85	23.41	51.03
Variation				57%**			
Dessert and beverage machines	17%						
Water dispensers	0%						
Ice-makers	10%						
Refrigeration compressors	5%						
Refrigeration condensors	3%						
		TOTAL	211.01	255.38	310.86	32.54	79.67
		Variation		21%		10%	26%

* Weighted Base Case used. Weighted average considering market shares for products working at several temperature ranges
** Difference in the total stock energy consumption differences are due to the change in stock and new estimates of the energy consumption per unit (related to the weighting methodology)
***Walk-in cold room value corresponds to stage 1 as defined in Task 7

Annex 1-3: Summary of data for minibars

Minibars are small refrigerated cabinets (average volume 30 litres), typically used to store drinks and snacks, and which are used in applications where low noise levels are necessary for comfort reasons (e.g. hotels rooms). Noiseless but more energy consuming technologies such as absorption (and in a smaller proportion thermoelectric) refrigeration are typically used in these products in order to fit the noise restriction needs of these applications.

Minibars were initially foreseen as a product to be included in the scope of this present study. However, this product's environmental performance is already being discussed in the framework of the Ecodesign Directive, in the context of the development of ecodesign requirements for domestic refrigerators and freezers. The draft regulation on possible implementing measures for household refrigerating appliances[136] presents requirements covering *"electric mains operated household refrigerating appliances including those sold for non-household use or for the refrigeration of items other than foodstuffs."*

In terms of specific ecodesign requirements, this draft regulation set the maximum annual energy consumptions in terms of Energy Efficiency Index (EEI)[137] value that refrigeration appliances shall fulfil. Proposed minimum EEI values depending on the time after the implementing measure has come into force are shown in Table 1-58.

Table 1-58 Minimum Energy Efficiency Index[137]

Refrigeration technology	EEI[137] after the implementing measure has come into force		
	1 July 2010	1 July 2012	1 July 2015
Compression-type	<55	<44	<42
Absorption-type and other-type	<150	<125	<110

The previous explanatory note of the working document[138] also stated that the differentiation of the requirements for the compression and the absorption is considered necessary because the compressor-type appliances are inherently more energy efficient; however, the absorption-type and the thermoelectric-type appliances are significantly less energy efficient, but are noiseless.

Generic ecodesign requirements are also included in the draft regulation:

[136] Source: EC, Draft Commission Regulation Implementing Directive 2005/32/EC with regard to Household Refrigerating Appliances, 2009

[137] Energy Efficiency Index EEI is equal to the energy consumption of an equipment over a 48 hours period subject to specified ambient conditions and prescribed number of doors. .

[138] Source: EC, Meeting of the tenth Consultation Forum, Working Document on a Possible Commission Regulation Implementing Directive 2005/32/EC with regard to Household Refrigerating Appliances, 2008

"From 1 July 2010: For household refrigerating appliances, information shall be provided in the instruction booklet provided by manufacturers concerning:

- *the combination of drawers, baskets and shelves that result in the most efficient use of energy for the appliance; and*
- *how to minimize the energy consumption of the household refrigerating appliance in the use-phase.*

From 1 July 2013:

- *(a) The fast freezing facility, or any similar function achieved through modification of the thermostat settings, in freezers and freezer compartments, shall, once activated by the end-user according to the manufacturer's instructions, automatically revert to the previous normal storage temperature conditions after no more than 72 hours. This requirement does not apply to refrigerator-freezers with one thermostat and one compressor which are equipped with an electromechanical control board.*
- *(b) Refrigerator-freezers with one thermostat and one compressor which are equipped with an electronic control board and can be used in ambient temperatures below +16 °C according to the manufacturer's instructions shall be such that any winter setting switch or similar function guaranteeing the correct frozen-food storage temperature is automatically operated according to the ambient temperature where the appliance is installed.*
- *(c) Household refrigerating appliances with a storage volume below 10 litres shall automatically enter in an operating condition with a power consumption of 0.00 Watt after no more than 1 hour when empty. The mere presence of a hard off switch shall not be considered sufficient to fulfil this requirement."*

The annual market of the electric absorption refrigeration appliances is about 250,000 to 300,000 units, and the market for thermoelectric appliances is smaller. As a comparison, there are about 18 million domestic compressor refrigerators.

- **EN 732:1998**

Relevance: Mini-bars

The safety and noise standard **EN 732:1998** "*Specifications for dedicated liquefied petroleum gas appliances – Absorption refrigerators*" applies to absorption refrigerators for the technical characteristics, safety requirements, test methods and marking of absorption refrigerating appliances using commercial butane and propane (liquefied petroleum gases).

As mentioned, minibars have been included in the scope of the development of implementing measures for household refrigerating appliances. Therefore, minibars will not be discussed further in this study.

Annex 1-4: Summary of data for wine storage appliances

Wine storage appliances can be used both in the residential and in the commercial sectors. However, as for minibars, this product's environmental performance is already being discussed in the framework of the Ecodesign Directive, in the context of the development of ecodesign requirements for domestic refrigerators and freezers. For this category of appliances, generic and specific ecodesign requirements have already been adopted:

- generic requirements: *"From 1 July 2010: For wine storage appliances, the following information shall be displayed in the instruction booklet provided by manufacturers: 'This appliance is intended to be used exclusively for the storage of wine'."*
- Specific requirements are described in Table 1-58 above.

Wine storage appliances are therefore excluded from the scope of the present study.

This page is left intentionally blank

Annex 1-5: Summary of data for dessert and beverage machines

1.15.1.1 General product definition

This category refers to a range of products use to refrigerate, store, and dispense beverages or desserts for consumption. Most common applications are ice cream makers, milk-shake or slush machines and cold drink dispensers.

1.15.1.2 Existing product definitions

According to the International Dictionary of Refrigeration[26], an ice-cream cabinet is a refrigerated cabinet for retail storage of ice-cream. The ice-cream freezer is an apparatus for freezing the "cream" mix into ice-cream. There are no other equipment definitions in the category of dessert and beverage machines in the dictionary.

1.15.1.3 Product description

In all the applications mentioned above, the temperatures are kept low by a refrigeration process based on vapour-compression technology. Apart from the refrigeration process (already explained in § 1.1.3.2), these products include specific processes for each application:

- Ice cream makers: an ice cream maker has two functions; the mixture has to be cooled, and during this cooling process, the mixture has to be constantly churned to break up ice crystals that form and introduce some air to the mixture so that the resultant ice cream will have a smooth and creamy texture. Ice cream machines typically have an integral condensing unit (plug-in). The condenser can either be water cooled or air cooled.
- Milk-shake or slush machines: the range of units covered therefore have many differences based on e.g. the type of product going into a unit (e.g. milk, fruit based slush, yogurt), the type of product coming out (e.g. milkshake, slushy, frozen yogurt), the amount of product that will be drawn in a specific time period, the unit size, and cooling type.
- Cold drink dispensers (soda fountains): this product keeps cold drinks at low temperatures avoiding freezing and facilitating the serving process of beverages.

According to preliminary analysis from main EU manufacturer's technical data sheets, dessert and beverage machines are mostly plug-in units working with air-cooled condensers, and the electricity consumption of such machines ranges from 300 to 1000 kWh/year.

1.15.1.4 Functional unit and performance parameter

The primary function of dessert and beverage machines is to produce, store and dispense a certain amount of frozen dessert or beverage. The primary performance parameter can therefore be defined as the amount of energy used to produce a certain amount of frozen dessert or beverage in kWh/litre of product.

1.15.1.5 Dessert and beverage machine classification and preliminary scope for the study

The preliminary classification for beverage and dessert machines is illustrated in Figure 1-32. At this stage, no sufficient data is available to decide if a more refine classification based on the type of dessert or the type of beverage is necessary. This will be further assessed in Task 4.

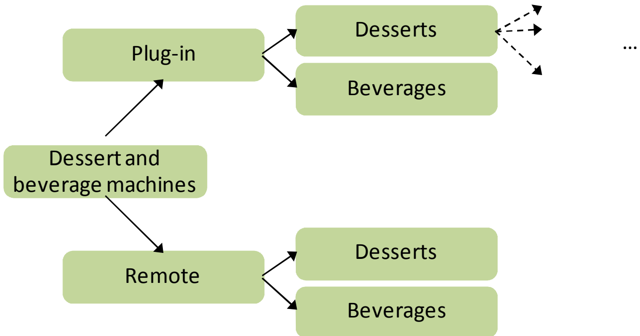


Figure 1-32: classification for dessert and beverage machines

No performance testing standard has been identified for these appliances. Dessert and beverage machines are not within the scope of any particular MEPS or labelling scheme proposed in EU or in third countries.

Dessert and beverage machines are excluded from the scope of the present study.

Annex 1-6: Summary of data for water dispensers

1.15.1.6 General product definition

A water dispenser is a device that cools and dispenses drinking water. According to the International Dictionary of Refrigeration[139] a water dispenser is a factory-made unit in which drinking water is cooled by refrigeration, and can be dispensed by some form of valve control.

1.15.1.7 Existing product definitions

- **USA/California Appliance Efficiency Program**

Under the California 2009 Appliance Efficiency Regulation[140], a water dispenser is defined as *"a factory-made assembly that mechanically cools and heats potable water and that dispenses the cooled or heated water by integral or remote means"*

- **US Energy Star**

The Energy Star certification program covers bottled water dispensers which are defined as a *"freestanding device that consumes energy and dispenses water from removable 4- to 5-gallon plastic bottles commonly positioned on top of the unit."* [141]

1.15.1.8 Product description

Water dispensers exist in several configurations:

- Mains-connected (see Figure 1-33 (a) and (b)). These devices dispense water directly from municipal water supply and are connected to water disposal systems to dispose of unused water.
- Bottled water dispenses (see Figure 1-33 (c)). In this case, water is supplied from bottles of water placed on the top of the unit. Water coolers are not connected to a water disposal system to dump excess water apart from a small basin to catch minor spills. Some water coolers include a second dispenser that delivers hot water. The heating unit is integrated to the water cooler.

Moreover, water dispensers can be, standalone products, wall mounted, or split products where the dispensing mechanism is packaged but in a separate location from the refrigeration unit.

This preliminary product description will be further detailed in Task 4.

[139] International Institute of Refrigeration. *International Dictionary of Refrigeration*. 2007
[140] Source: www.energy.ca.gov/2007publications/CEC-400-2007-016/CEC-400-2007-016-REV1.PDF
[141] Source: US Energy Star program requirements for water coolers www.energystar.gov/ia/partners/product_specs/program_reqs/water.pdf

(a) (b) (c)

Figure 1-33 Typical water dispensers

Preliminary data shows that these products have electricity consumptions ranging from 300kWh/year to 1600kWh/year[142].

1.15.1.9 Functional unit and performance parameter

The primary function of water coolers is to cool down and maintain water at appropriate dispensing temperature.

The performance of water coolers can be measured by amount of energy required to fulfil this function. The primary performance parameter can therefore be defined by the energy consumption required to provide a certain amount of water at the appropriate dispensing temperatures. This refers to what the ENERGY STAR program defines as the "standby energy consumption".

1.15.1.10 Water dispenser classification and water dispensers included in the scope

A preliminary classification of water dispensers in provided in Figure 1-34 .

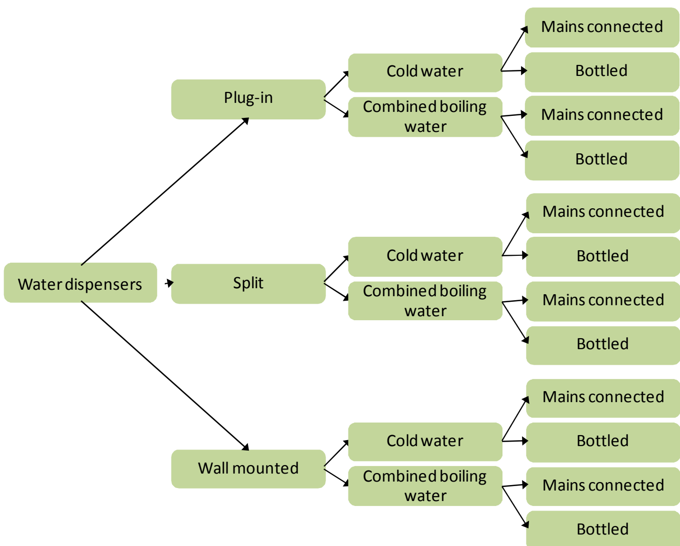


Figure 1-34: Classification for water dispensers

- **ARI 1010-2002 (withdrawn, see ASHRAE 18-2008)**

Relevance: Drinking water dispensers

[142] Source: Mark Ellis, *Minimum Energy Performance Standards for Self-Contained Commercial Refrigeration*, Prepared for the Australian Greenhouse Office, Final Draft Report, 2000

Then **ARI 1010-2002** "*Self Contained, Mechanically Refrigerated Drinking water Coolers*" establishes for Self-Contained, Mechanically-Refrigerated Drinking- Water Coolers: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; operating requirements; marking and nameplate data; and conformance conditions. This standard has been withdrawn and is now replaced by ASHRAE Standard 18-2008.

- **ASHRAE Standard 18-2008**

Relevance: Water dispenser

The **ASHRAE Standard 18-2008** (revised 18-2006) *"Methods of Testing for Rating Drinking-Water Coolers with Self-Contained Mechanical Refrigeration"* (ANSI approved) prescribes a method of testing for the cooling capacity and energy consumption of self-contained mechanically refrigerated drinking-water coolers. This 2008 revision updates the 2006 edition to provide the rating information that was lost when ARI Standard 1010 was withdrawn. The purposes of this standard are to establish the types of equipment to which the provisions of this standard apply, to define terms describing the equipment covered and terms related to testing, to specify types of instrumentation and test apparatus required in testing, to specify methods of procedure to be used when testing for rating, to specify a uniform method for calculation of results, and to specify data and results to be recorded.

- **CAN/CSA-C815-99 (R2008)**

Relevance: Drinking water coolers

The **CAN/CSA-C815-99 (R2008)** "*Energy Performance of Drinking Water Coolers*" deals with self-contained drinking water coolers, giving the energy performance requirements. It is applicable for those equipments whose capacity is up to 20mL/s. The standard provides measuring methods and maximum levels of energy consumption. This document does not apply to equipments intended for use on central circulating-type systems or employing remote type condensing units.

There has not been identified any particular standard, for testing or estimating minimal energy performance for water dispensers in EU.

However, there are several possible models to follow from third countries: Canadian regulation (CAN/CSA-C815-99 (R2008)) establishes the maximum energy use according to the litres dispensed in a period of time, and appears most suitable for the EU context, whilst USA voluntary programme (Energy Star) establishes the same parameter in maximal energy use per day.

A MEPS proposal for chilled (and boiled) water dispensers commissioned by the National Appliance and Equipment Energy Efficiency Committee (NAEEEC) was released on October 26, 2004. In this proposal, associated MEPS levels for chilled and combined boiling and chilled water dispensers were set to be equivalent to the ENERGY STAR criteria.

- **ENERGY STAR Programme for bottled water coolers (Version 1.1 2004)**

This programme provides energy efficiency criteria for bottled water dispensers and refers to the **ARI 1010:2002 Standard** for Self-Contained Mechanically-Refrigerated Drinking-Water Coolers. It is estimated[143] that ENERGY STAR qualified water coolers use about half the energy compared to conventional models.

Box 1-7 presents ENERGY STAR program qualifying products and specifications for bottled water coolers.

Box 1-7: ENERGY STAR Programme for Bottled Water Coolers[144]

Qualifying Products: For the purposes of ENERGY STAR, bottled water coolers include the following:

A. Cold Only Bottled Units: These units dispense either cold water only, or both cold and room-temperature water.

B. Hot and Cold Bottled Units: These units dispense both hot and cold water. Some units may have a third room-temperature tap. Units have an electric resistance heater and a refrigeration cycle.

C. Cook and Cold Bottled Units: These units dispense both cold and room-temperature water.

Energy-Efficiency Specifications for Qualifying Products: Only those products listed in Section 2 that meet the criteria outlined in Table 1 below may qualify as ENERGY STAR.

Table 1: Energy-Efficiency Criteria for ENERGY STAR Qualified Bottled Water Coolers

Product Category	Energy Use Under Test Conditions
cold only and cook and cold bottled units	$\leq$ 0.16 kW-hours/day
hot and cold bottled units	$\leq$ 1.20 kW-hours/day

Water dispensers are excluded from the scope of the present study.

143 ENERGY STAR: www.energystar.gov/ia/partners/product_specs/eligibility/water_elig.pdf
144 ENERGY STAR: www.energystar.gov/ia/partners/product_specs/eligibility/water_elig.pdf

Annex 1-7: Summary of data for ice-makers

1.15.1.11 General product definition

Ice-makers are machines used to produce ice. Some ice-makers also have a storage capacity, while others have a dispensing functionality. Typical applications include e.g. ice production and storage in food preparation and display (hostel, restaurants), for ice sales to customers, and for drinks in food retailing. According to the International Dictionary of Refrigeration[145], an ice-maker is a compact refrigeration unit designed to automatically produce comparatively small quantities of ice.

1.15.1.12 Existing product definitions

- **California Energy Commission (CEC)**

The CEC defined ice makers as following:[146]

"Automatic commercial ice-maker" means a factory-made assembly that is shipped in one or more packages that consists of a condensing unit and ice-making section operating as an integrated unit, that makes and harvests ice, and that may store or dispense ice.""

- **US Energy Star**

Current Energy Star requirements for commercial ice machines define this type of product as a *"factory-made assembly (not necessarily shipped in one package) consisting of a condensing unit and ice-making section operating as an integrated unit, with means for making and harvesting ice."*

The program further categorises ice machines into three sub-types:

- Ice Making Head (IMH): A model with the ice-making mechanism and the condensing unit in a single package, but with a separate ice storage bin.
- Packaged condensing unit (PCU): A model in which the ice-making mechanism and condenser or condensing unit are in separate sections.
- Self-Contained (SCU): A model in which the ice-making mechanism and storage compartment are in an integral cabinet.

1.15.1.13 Product description

An ice-maker consists of two major subsystems: the refrigeration system and water supply/circulation/purge system. Ice-makers typically use vapour compression refrigeration to produce the refrigeration needed for ice production. However at this stage no quantitative data for the EU market is available to assess the share of compression-based appliances.

---

[145] International Institute of Refrigeration. *International Dictionary of Refrigeration*. 2007

[146] Source: California Energy Commission, Appliance Efficiency regulation, 2007 www.energy.ca.gov/2007publications/CEC-400-2007-016/CEC-400-2007-016-REV1.PDF

The ice production process in an ice-maker can be described as following:

- water circulated into a sump which typically contains 10-40 % more water than necessary for the production of a batch of ice.
- the water is then circulated over the evaporator in a freezing chamber, releasing its heat to the refrigerant flowing inside the evaporator and the water cools down and freezes. During the vapour-compression refrigeration cycle, compressor, condenser fan (for air-cooled machines) and the water circulating pump are activated.
- when the proper batch weight has been reached, the ice-maker enters the harvest mode. According to a US study[147], most machines use hot-gas harvest, in which hot refrigerant vapour warms the evaporator and melts the ice, freeing it on the plate, and it can be assumed most EU ice-makers operate typically as such. Once free, the ice falls into the storage bin below.
- during the harvesting process, the water remaining in the sump is purged and fresh water is flushed to remove any impurities.
- water fills the sump and the ice production-cycle repeats.

In some ice-makers, the freezing and harvest process take place simultaneously.

Depending of the location of the condensing unit (i.e. compressor and condenser), and on the location of the storage bin, ice-makers are typically classified in three sub categories[148] which influence the components included in the ice-maker:

- ice-making head units (plug-in ice makers, no storage): standard ice-makers with the ice-making mechanism and the condensing unit in a single package, but with separate ice storage
- self-contained units (plug-in ice makers, with storage): models in which the ice-making mechanism and storage compartment are in an integral cabinet
- packaged condensing units (remote ice makers, without storage): split-system models in which the ice-making mechanism and the condensing unit or the condenser, are in separate sections.

Moreover, each of these sub categories of ice-makers can operate continuously (continuous freeze and harvest of ice at the same time) or alternatively (alternate freezing and harvesting periods, also known as “cube type”, or “batch”).

About 80%[149] of ice-makers are estimated to have integral air-cooled condensers (plug-in). Other condenser configurations include ice-makers with integral water-cooled condensers (i.e. plug-in refrigerating equipment), and remote air-cooled condensing units (i.e. remote refrigerating equipment).

[147] Source: Arthur D. Little Inc, *Energy Savings Potential for Commercial Refrigeration Equipment*, US DOE, 1996 and MARK ELLIS & Associates, *Self-Contained Commercial Refrigeration*, Australian Greenhouse Office, 2000 and MARK ELLIS & Associates, *Remote Commercial Refrigeration*, Australian Greenhouse Office, 2000

[148] Source: Classification used by US DoE Federal energy management program

[149] Source: American Council for an Energy Efficient Economy - As a preliminary basis, similar situation is assumed in Europe as well

Preliminary estimates range the electricity consumption of ice-makers around 5,000kWh/year[150].

1.15.1.14 Functional unit and performance parameter

The main functionality of ice-makers is to produce a certain amount of ice within a certain period of time (e.g. 24 hours). Some types of ice-makers also propose storage and /or dispensing function.

The performance of an ice-maker can therefore be expressed as the amount of energy used to produce a certain amount of ice in kWh/kg of ice (i.e. primary functional parameter). Canadian efficiency standards not only deal with the energy consumption, but with the water use to produce 1kg of ice (including waste water and water used by the condensing unit). This parameter should be further taken into account in possible regulations.

Drinking water requirements and in particular drinking water Directive requirements will also need particular attention for this product. For ice-makers using a remote condensing unit an approach similar to what is done in the ARI 820 standard for ice-makers (USA)[151] could be used. Alternatively, an approach similar to what is done for remote display cabinets (ISO 23953) could be used to include the energy consumption of the packaged condensing unit in the total electricity consumption of the ice maker. This will be further elaborated in Task 4.

1.15.1.15 Ice-maker classification and ice makers in the scope of the study

California regulation on energy efficiency (CEC-400-2009-013) presents a simple classification for these equipments based on the physical configuration of the equipment related to the harvest rate[152].

Table 1-59: US California State ice-makers classification

Equipment type	Type of cooling	Harvest rate (kg/24H)
Ice making head	Water	< 227
		> 227 and < 652
		> 652
	Air	< 204
		> 204
Remote condensing (but not remote compressor)	Air	< 454
		> 454
Remote condensing and compressor	Air	< 934
		> 934
Self-contained	Water	< 91
		> 91
	Air	< 80
		> 80

[150] Source: Mark Ellis & Associates. *Minimum Energy Performance Standards for Commercial Refrigeration Cabinets*. EECA Energy efficiency and Conservation Authority, June 2003

[151] For remote ice makers, the energy consumption is calculated based on a total power input which includes condenser fan power (source: ARI 820 standard)

[152] California energy commission: www.energy.ca.gov/2007publications/CEC-400-2007-016/CEC-400-2007-016-REV1.PDF

Canadian standard (CAN/CSA-C742-08) features a very similar classification to the one presented by the California regulation. Nevertheless, the equipments are first classified into batch or continuous processes.

Table 1-60: Canadian classification for ice-makers

Process	Equipment type	Type of cooling	Harvest rate (kg/24H)
Batch	Ice making head	Water	< 227
			≥ 227 and < 651
			≥ 651
		Air	< 204
			≥ 204
	Self-contained	Water	< 91
			≥ 91
		Air	< 79
			≥ 79
	Remote condensing (but not remote compressor)	Air	< 454
			≥ 454
	Remote condensing and compressor	Air	< 423
			≥ 423
Continuous	All	Air	< 300
			≥ 300
		Water	< 300
			≥ 300

A preliminary classification of ice-makers is proposed as illustrated in Figure 1-35.

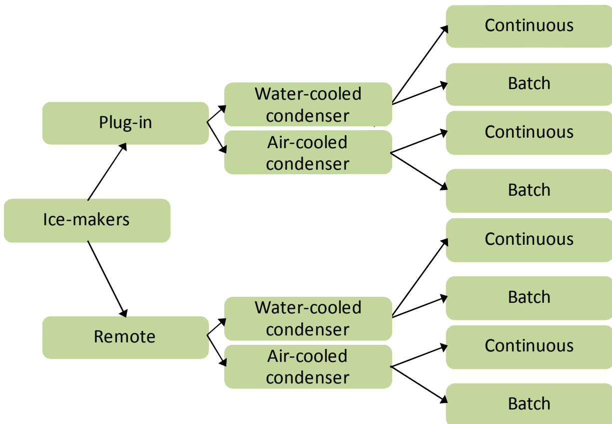


Figure 1-35: Classification of ice-makers

- **AHRI 810-2007**

Relevance: Ice-makers

The **AHRI 810-2007** standard *"Performance Rating of Automatic Commercial Ice-makers"* describes standard test methods for performance rating of Automatic Commercial Ice-Makers

Scope: The scope of this standard covers the following Automatic Ice-Makers:

- Plug-in Model (model in which the ice-making mechanism and storage compartment are in an integral cabinet)

- Split System Ice-Maker (model in which the ice-making mechanism and condenser or condensing unit are in separate sections)
- Cubes Type Ice Maker (The word "cube" is not a reference to a specific shape or size. It is a method of distinguishing equipment that has alternate freezing and harvesting periods)
- Continuous Type Ice Maker

Test Requirements: The tests required for this standard shall be conducted in accordance with ASHRAE Standard 29 (see ASHRAE standards).

Rating Conditions: The conditions of test for Standard Ratings are as follows:

- Ambient temperature: +90.0°F [+32.2°C] (For a Split System Ice-Maker, the condenser air inlet temperature shall be +90.0°F [+32.2°C] with the indoor ambient temperature +90.0°F [+32.2°C]
- Water inlet temperature: +70.0°F [+21.1°C]
- Water inlet pressure: 30.0 ±3.0 psig [207 ±21.0 kPa]

Rating Requirements: The Standard Ratings include:

- Ice Harvest Rate: the gross weight of ice harvested, stated in lb/24 h [kg/24 h], stated in multiples of 1.
- Condenser Water Use Rate: the amount of water used by the condensing unit (if water cooled), stated in gal/100 lb [L/45.0 kg] of ice, stated in multiples of 1.
- Potable Water Use Rate: the amount of potable water used in making ice, including Dump Water, stated in gal/100 lb [L/45.0 kg] of ice, stated in multiples of 0.1.
- Energy Consumption Rate: total energy input rate, stated in kWh/100 lb [kWh/45.0 kg] of ice stated in multiples of 0.1. For split system ice-makers, total power input includes condenser fan power only.
- Bin Theoretical Storage Capacity: for plug-in model ice-makers only, the theoretical storage capacity and the storage effectiveness of the ice storage bin shall be determined in accordance with ARI Standard 820. For these models, the internal volume is the volume calculated up to the intended shut-off level. The intended shut-off level is defined as the height of the thermostat bulb; the bottom of the curtain or the height of the electric eye, depending upon the mechanism used to shut off the ice-maker.
- Ice Hardness Factor: for continuous type ice-makers only, the ice hardness factor is the latent heat capacity of ice harvested, Btu/lb [W/kg], divided by 92.9 W/kg [144 Btu/lb], multiplied by 100, %.
- **ASHRAE Standard 29-2009**

Relevance: Ice-makers

The **ASHRAE Standard 29-2009** (revised in 2005) "*Methods of Testing Automatic Ice makers*" (ANSI Approved) prescribes the methods of testing automatic ice makers. The automatic ice maker may comprise one or more sections for shipping purposes. This standard does not include automatic ice makers installed in household refrigerators, combination refrigerator-freezers, and household freezers.

- **CAN/CSA-C742-08**

Relevance: Ice-makers

The **CAN/CSA-C742-08** standard "*Energy performance of automatic icemakers and ice storage bins*" applies to factory-made automatic icemakers (cube, flake, crushed, or fragmented ice in batches or in a continuous process) with a capacity not exceeding 1814 kg/day, measured at standard rating conditions. It specifies requirements and test procedures for energy and water consumption and storage effectiveness and applies to self-contained icemakers where the ice-making mechanism and storage compartment are integrated in one cabinet; and split-system icemakers that have the ice-making mechanism and condensing unit in separate sections Condensers can be air- or water-cooled (see §1.4.2.1).

- **AS/NZS 4865.1:2008**

Relevance: Ice-makers

The Australian/New Zealand Standard **AS/NZS 4865.1:2008** *"Performance of commercial ice makers and ice storage bins - Part 1: Test methods for ice makers—Environmental performance"* specifies methods of measuring the electrical power consumption of water and air-cooled commercial ice makers connected to a nominal 230 V mains electricity supply. This standard applies to batch-type and continuous ice makers that produce ice in irregular shapes, flakes, ribbons or wafers as well as uniformly shaped ice cubes where the finished product does not exceed approximately 100 g in weight.

This standard is linked to the Minimum energy performance standard (MEPS) requirements AS/NZS 4865.3:2008.

➢ Automatic Ice-Makers (CSA C742-08)[153]

As of January 1, 2008, Canada has amended their Energy Efficiency Regulations to strengthen the minimum energy efficiency requirements for automatic ice-makers. The Canadian Standards Association test method CSA C742 Performance of Automatic Ice-Makers and Ice Storage Bins is used to test equipment and ensure compliance with the requirements of the Regulations. Automatic ice-makers manufactured on or after January 1, 2008 must meet the minimum efficiency levels as specified in the Table 1-61. These values are equivalent to the requirements for the state of California that have been effective since January 1, 2008.

Table 1-61 : Minimum energy efficiency requirements for automatic ice-makers[154]

Equipment Type	Type of Cooling	Production of Ice (kg per 24 hours)	Maximum Energy Use (kJ per kg), (where H is the ice harvest rate in kg per 24 hours)	Maximum Condenser Water Use (litres per kg), (if water-cooled)
Ice-making head	water	< 227 ≥ 227 to < 651 ≥ 651	619.0 - (0.961 x H) 442.8 - (0.192 x H) 317.4	16.67 - (0.0018 x H)
Ice-making head	air	< 204 ≥ 204	814.2 - (1.502 x H) 546.8 - (0.192 x H)	
Remote-condensing (but not remote compressor)	air	< 454 ≥ 454	702.3 - (0.664 x H) 404.7	
Remote-condensing and remote compressor	air	< 423 ≥ 423	702.3 - (0.664 x H) 420.6	
Self-contained	water	< 91 ≥ 91	904.7 - (3.32 x H) 603.1	15.95 - (0.0016 x H)
Self-contained	air	< 79 ≥ 79	1428 - (8.19 x H) 777.7	

➢ Commercial Ice-makers

In Australia, commercial ice-makers fall under the products that are currently proposed for regulation in the future (AS/NZS 4865.3:2008: Environmental performance of ice-makers), these MEPS and associated test methods (AS/NZS 4865.1:2008) are currently waiting for RIS approval[155] by the Australian Government.

➢ ENERGY STAR Programme for commercial ice machines

[153] Canadian Office of Energy Efficiency: www.oee.nrcan.gc.ca/regulations/product/commercialrefrigerators.cfm?text=N&printview=N

[154] Canadian Office of Energy Efficiency: www.oee.nrcan.gc.ca/regulations/bulletin/ice-makers-mar-2007.cfm?text=N&printview=N

[155] Regulation Impact Statement (RIS) is required, under the Australian Government's requirements, when a regulatory proposal is likely to have significant impacts on business and individuals or the economy.

This programme provides energy efficiency criteria for commercial ice machines in reference to the AHRI 810-2006 standard of the *Performance Rating of Automatic Commercial Ice Makers.* Commercial ice machines that have earned the ENERGY STAR are on average 15% more energy-efficient and 10% more water-efficient than standard models. This programme excludes water cooled units and flake and nugget ice machines.

Box 1-8 presents ENERGY STAR programme qualifying products and specifications for commercial ice machines.

Box 1-8: ENERGY STAR Programme for commercial ice machines[156]

Qualifying Products: Commercial ice machines must meet the definitions provided in Section 1, above, to be eligible for ENERGY STAR. **Ice machines that use water-cooled technology as well as flake and nugget ice machines are not eligible for ENERGY STAR under this Version 1.0 specification.** EPA intends to include flake and nugget ice machines once a test standard is made available and a robust database is established that may be used to derive performance requirements.

Efficiency Requirements for Qualifying Products: Commercial ice machines must meet the requirements provided below to qualify as ENERGY STAR.

Table 1: Efficiency Requirements for Commercial Cubed Ice Machines

Equipment Type	Harvest Rate, H (lbs ice/day)	Energy Use Limit (kWh/100 lbs ice)	Potable Water Use Limit (gal/100 lbs ice)
Air-Cooled			
IMH	< 450	9.23 – 0.0077H	≤ 25
	≥ 450	6.20 – 0.0010H	≤ 25
RCU (without remote compressor)	< 1000	8.05 – 0.0035H	≤ 25
	≥ 1000	4.64	≤ 25
RCU (with remote compressor)	< 934	8.05 – 0.0035H	≤ 25
	≥ 934	4.82	≤ 25
SCU	< 175	16.7 – 0.0436H	≤ 35
	≥ 175	9.11	≤ 35

Test Criteria: Partner is required to perform tests and self-certify those product models that meet the ENERGY STAR guidelines. The test results must be reported to EPA using the Commercial Ice Machine Qualifying Product Information (QPI) Form.

In performing these tests, Partner agrees to use the Air-Conditioning and Refrigeration Institute (ARI) Standard 810-2006, *Performance Rating of Automatic Commercial Ice-Makers.*

- **AHRI Certification Program: automatic commercial ice-makers and ice-storage bins**[157]

Scope: Automatic Commercial Ice-Makers consisting of a condensing unit and ice-making section operating as an integrated unit for making and harvesting ice in batches. A self-contained Ice-Maker is a single unit totally integrated in a cabinet. A Split-System Ice-Maker has its ice making mechanism and condenser or condensing unit in separate sections. Also included is the non-refrigerated ice-

[156] ENERGY STAR: www.energystar.gov/ia/products/commercial_food_service/comm_ice_machines/Eligibility_CIM.pdf

[157] AHRI: www.ahrinet.org/Content/AutomaticCommercialIceMakersandIceStorageBins_82.aspx

storage bin (non-refrigerated compartment, factory-made assembly for the storage of ice).

Reference standards: AHRI 810-2007 on the Performance Rating of Automatic Commercial Ice Makers and **AHRI 820-2000** for Ice Storage Bins

Certified Ratings: The following Certification Program ratings are verified by test at the Standard Rating Conditions:

- Ice Harvest Rate, lb/24 h [kg/24 h]
- Potable Water Use Rate, gal/100 lb of ice [L/45.0 kg of ice]
- Condenser Water Use Rate, gal/100 lb of ice [L/45.0 kg of ice]
- Energy Consumption Rate, kWh/100 lb of ice [kWh/45.0 kg of ice]
- Bin Theoretical Storage Capacity, lb [kg] (Self-Contained Models only)
- Theoretical Storage Capacity, lb [kg]

Ice-makers are excluded from the scope of the present study.

This page is left intentionally blank

Annex 1-8: Other information

Market Transformation Programme

The Market Transformation Programme (MTP) was launched following a consultation paper issued by the Environment & Business Division, in October 1997.

The MTP supports the development and implementation of UK Government policy on sustainable products. MTP's aim is to reduce the environmental impact of products across the product life cycle by:

- Collecting information.
- Building evidence of future environmental impacts.
- Working with industry and other stakeholders.

The approach is to communicate and interpret Government policy objectives as a set of specific action plans, or road maps, looking ahead at least ten years, and to get buy-in from policy-makers and industry at UK, EU, and international levels. SPMP also supports policy delivery, in particular, by developing corresponding product ecodesign information (labels) and performance requirements (standards) to encourage innovation and competition.

Scope: Domestic or commercial appliances including commercial refrigeration (liquid chillers, service cabinets, cold rooms, cellar cooling equipment, ice-making machines, refrigerated display cases, and refrigerated vending machines).

Identification of saving potentials for commercial refrigeration

In a 2006 report[158], MTP develops three standard scenarios to illustrate the potential impacts of the associate market transformation strategies:

- Reference scenario: without policy intervention
- Earliest Best Practice scenario: what would happen if everyone started buying the best available products
- Policy scenario: estimate of the likely effects of a program of policy measures

Comparing these scenarios, savings potential for energy use of commercial refrigeration has been identified. The development of minimum energy performance standards covering full and part load could help to access a significant proportion of the identified savings potential.

There is also great potential for savings through better service/maintenance and optimisation of present equipment and systems.

Moreover, refrigerants have an additional impact due to their direct carbon emissions through leakages and disposal. The development of refrigerants with no

[158] Sustainable Products 2006: Policy Analysis and Projections www.mtprog.com/ReferenceLibrary/MTP_SP06_web.pdf

ozone-depleting potential and little, or no, global warming potential offers the possibility of reducing direct carbon emissions. In the case of more efficient refrigerants, it will reduce energy consumption and hence indirect carbon emissions as well.

Proposed actions: The proposed actions for commercial refrigeration are:

- Revise performance criteria and expand the product range for the Enhanced Capital Allowance (ECA) scheme to include display and service cabinets and reverse cycle liquid chillers (>100 kW). (Revision completed in 2008)
- Engage trade groups and key buyers in green procurement initiatives.
- Develop standard and performance benchmarks for part-load operation of liquid chillers. Part-load testing and seasonal efficiency ratings would be more representative of the real-life situation. They need to be considered as a potential criterion for ECA.
- Development of criteria/thresholds and implementation of the Ecodesign Directive for display cabinets, liquid chillers and vending machines.

The figure below shows UK scenarios for service cabinet electricity consumption of new service cabinets sold or to be sold in the UK between 2000 and 2020[159] where:

- The reference projection takes into account underlying trends in markets and technologies and the estimated or implicit impacts of historical and current policy measures. It does not take into account the impact of policies which are still being developed and are not targeted at specific products. The intention is to revise these projections once it becomes clearer how these new policy measures will affect commercial refrigeration products.
- The Earliest Best Practice (EBP) projection shows what would happen if all new UK sales were based on the most resource efficient options, taking into account design and production cycles, but not taking account of price or other market barriers.
- The P1 projection sets a target level of ambition that the Government is proposing could be delivered at a low cost, taking into account such things as current UK and global performance benchmarks, economies of scale and the capacity of the supply chain to take coherent action to deliver more energy efficient products.

[159] DEFRA: Policy Brief: Improving the energy performance of commercial refrigeration products – July 2008

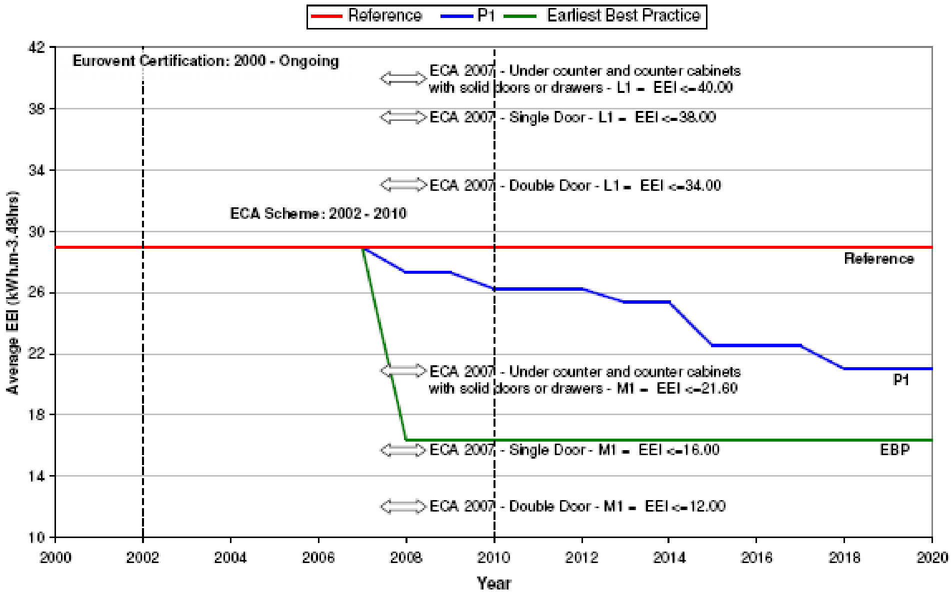


Figure 1-36: Indicative energy efficiency (EEI) for refrigerated service cabinets[160]

[160] DEFRA: Policy Brief: Improving the energy performance of commercial refrigeration products – July 2008

This page is left intentionally blank

Glossary

AEC	Annual energy consumption
Air-off temperature	Temperature of the air blown off the evaporator (evaporating temperature)
Air-on temperature	Temperature of ambient air blown onto the condenser
Base Case	An abstract construct representing the average product on the market
BAT	Best available technology
BAU	Business as usual
BC	Blast cabinet
Binary ice	Binary ice is the mixture of a substance in solid state in micron size and the same substance in liquid state. In some cases, it requires of a depressant to avoid coagulation of the solid part. Normally the employed substance is water
Blowing agent	In foam production, blowing or foaming agents are chemicals that by changing of state during the foam production process, release gases able to change the configuration of resins (foam solid structure)
BNAT	Best not-yet-available technology
CH	Process chiller
Combined model	Refrigeration equipments able to work in chilling and freezing cycles.
Commercial chilling service cabinets	Refrigerated enclosure designed for the storage, but not the display, of chilled foodstuff, accessible via one or more doors and/or drawers, and which is able to store the foodstuff at a temperature down to a minimum of 0°C.
Commercial freezing service cabinets	Refrigerated enclosure designed for the storage, but not the display, of frozen foodstuff, accessible via one or more doors and/or drawers, that includes a compressor, condenser and evaporator, and which is able to store the foodstuff at a temperature below 0°C.
Commercial or industrial air-, water-cooled refrigeration process chillers – low temperature	Systems including at least compressor, condenser, expansion valve and evaporator, among other parts, designed to provide cooling capacity for a process or chambers. They are designed to provide outlet evaporator temperatures from -25°C to -8°C.

Commercial or industrial air-, water-cooled refrigeration process chillers – medium temperature	Systems including at least compressor, condenser, expansion valve and evaporator, among other parts, designed to provide cooling capacity for a process or chambers. They are designed to provide outlet evaporator temperatures from -12°C to +3°C.
Commercial or industrial remote air-cooled chilling condensing units	Combination of one or more compressor, condensers or liquid receivers (when applicable) and the regularly furnished accessories, specifically designed to provide cooling to other equipment at -10°C evaporating temperature.
Commercial or industrial remote air-cooled freezing condensing units	Combination of one or more compressor, condensers or liquid receivers (when applicable) and the regularly furnished accessories, specifically designed to provide cooling to other equipment at -32°C evaporating temperature
COP	Coefficient of performance
Critical Point	The temperature and pressure at which the liquid and gaseous phases of a pure stable substance become identical. Also called critical state
DEC	Direct energy consumption - the energy consumed directly by the components contained with a product
Dew point temperature	Temperature at which moisture condenses.
Door type	Solid door / transparent door
Duty cycle	The proportion of time (in %) during which a component is on and drawing power (or the times a unit is switched under the operation of a thermostat)
EEI	Energy efficiency index
ESEER	European Seasonal Energy Efficiency Ratio
Freezing	Cooling or maintenance of a space and the product contained therein to temperatures below 0°C
Functional unit	The basis for comparison between similar products when performing lifecycle analysis (e.g. one unit of storage maintained at a specific temperature)
Gastronorm (size)	It is the standard size for the tray/shelf of refrigeration equipments. It can be reference for trolleys or shelves.
GWP	Global Warming Potential
HT	High temperature

Integral	A product that integrates the condesing unit within the body of the equipment
Isentropric	Ideal process with no change of entrophy of the system
Isentropic efficiency	ratio of the product of the actual mass flow and the change in isentropic enthalpy across the compressor to the power input
Lambda (λ)	Thermal conductivity factor (λ = W/m.K)
LLCC	Least lifecycle cost
Load	The demand (in %) on a compressor's cooling capacity
Load-line	For each part of the cabinet, boundary surface consisting of one or several planes within which all test packages may be stored within the temperature limits of the actual temperature class
LT	Low temperature
MEPS	Minimum energy performance standards
MT	Medium temperature
Net volume	Adjusted internal volume, used to reflect space which can in practice be used to store goods
ODP	Ozone Depleting Potential
OEM	Original equipment manufacturer
Operation temperature	Temp of storage space (target temperature/operating temperature/application temperature)
Packaged	A product that has been manufactured and provided as a single piece of equipment
Pass through	Equipments similar to roll-in, but presenting two doors, one for the loading and the other one for the unloading.
Performance parameter	The means of comparing performance of similar products, using the functional unit and product consumption/impact (e.g. annual electricity consumption of product divided by number of functional units it provides)
Plug-in	A product that operates after being plugged into the mains (i.e. no professional installation required)
Plug-in commercial blast chilling cabinet	Equipment that includes compressor, condensor, evaporator and at least one fan able to cool down the temperature of the foodstuff from +70°C to +3°C in a short period of time, i.e. 90 minutes. The foodstuff is arranged in trays within the equipment or trolleys that

are taken into the equipment.

Plug-in commercial blast chilling/freezing cabinet	Equipment that includes compressor, condensor, evaporator and at least one fan able to chill or freeze the foodstuff from 70°C to +3°C and -18°C respectively in 90 or 240 minutes. The foodstuff is arranged in trays within the equipment or trolleys that are taken into the equipment.
Plug-in commercial blast freezing cabinet	Equipment that includes compressor, condensor, evaporator and at least one fan able to freeze the temperature of the foodstuff from 70°C to -18°C in a short period of time, 240 minutes. The foodstuff is arranged in trays within the equipment or trolleys that are taken into the equipment.
Protocol	Specific door opening pattern used during testing to evaluate a product's performance under a standard
R value	Thermal resistance value (R = m^2.K/W)
Reach-in / cabinet	Refrigeration equipments where the user stands outside the appliance to load and unload the foodstuff.
REC	Refrigeration energy consumption - the energy consumed by the refrigeration system
Refrigeration	Cooling or maintenance of a space and the product contained therein to temperatures above 0°C
Remote	A product with a remote condensing unit
RCU	Remote condensing unit
Remote commercial blast chilling cabinet	Equipment that includes compressor, evaporator and at least one fan. It is connected to a remote condensing unit. This equipment is able to cool down the temperature of the foodstuff from +70°C to +3°C in a short period of time, i.e. 90 minutes. The foodstuff is arranged in trays within the equipment or trolleys that are taken into the equipment.
Remote commercial blast chilling/freezing cabinet	Equipment that includes compressor, evaporator and at least one fan. It is connected to a remote condensing unit. This equipment is able to chill or freeze the foodstuff from 70°C to +3°C and -18°C respectively in 90 or 240 minutes. The foodstuff is arranged in trays within the equipment or trolleys that are taken into the equipment.
Remote commercial blast freezing cabinet	Equipment that includes compressor, evaporator and at least one fan. It is connected to a remote condensing unit. This equipment is able to freeze the temperature of the foodstuff from 70°C to -18°C in a short period of time, 240 minutes. The foodstuff is arranged in trays within the equipment or trolleys that are taken into the equipment.

Roll-in / trolley	Refrigerating equipments of foodstuff where trolleys are wheeled-in. The load and discharge is done using the door.
SC	Service cabinet
Split system	A refrigeration system that has been split - the evaporator is separate from the refrigeration system (terminology normally used for air-conditioning)
Subcritical refrigeration	The refrigeration cycles are entirely below the critical pressure point of the refrigerant
Superheating	Superheating is referred to the process of heating a substance over its boiling point. This is reached under specific pressure conditions.
TEC	Total energy consumption; TEC = REC (refrigeration energy consumption) + DEC (direct energy consumption) for remote refrigeration systems; TEC = DEC for plug-in refrigeration systems
Testing m-package	Measurement packaged used in testing to replicate food, usually includes thermometer to measure temperature.
TEWI	Total equivalent warming impact
Transcritical	Parts of the refrigeration cycle are above and other parts are below the critical pressure point of the refrigerant.
Trigeneration	CCHP (combined cooling, heating, and power generation)
Triple point	State where co-existence of liquid-, vapour- and solid-phase is possible. This phenomenon depends on the pressure and temperature
U value	Thermal conductance factor (U = $W/m^2.K$)
US DOE	United States Department of Energy
Use pattern	The time a unit is switched 'on', providing cooling
VEPS	Voluntary efficiency performance standards
Vertical unit	Machine with a vertical design or layout.
WICR	Walk-in cold room
Water-off	Temperature of water leaving a chiller