REVIEW OF ENERGY EFFICIENCY TEST STANDARDS AND REGULATIONS IN APEC MEMBER ECONOMIES

Technical Annexes A to G

ASIA-PACIFIC ECONOMIC COOPERATION

APEC Energy Working Group

November 1999

REVIEW OF ENERGY EFFICIENCY TEST STANDARDS AND REGULATIONS IN APEC MEMBER ECONOMIES

by

Energy Efficient Strategies, Australia

with assistance from

Paul Waide Consulting, UK

George Wilkenfeld & Associates, Australia

International Institute for Energy Conservation, Bangkok

Rafael Friedmann, USA & CENEF, Russia

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APEC Secretariat
438 Alexandra Road
#14-00 Alexandra Point
Singapore 119958

Tel: +65 2761880
Fax: +65 2761775

Email: info@mail.apecsec.org.sg
Website: http://www.apecsec.org.sg

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Foreword

This project is one of a number of projects managed by the APEC Steering Group on Energy Standards (SGES) to address the requests of APEC Energy Ministers to strengthen cooperation on energy efficiency standards. The Steering Group is a task group reporting to the APEC Energy Working Group.

The Energy Working Group is one of ten APEC working groups. Its goal is to maximise the energy sector's contribution to the region's economic and social well being through activities in five areas of strategic importance:

- energy supply and demand,
- energy and the environment,
- energy efficiency and conservation,
- energy research, development and technology transfer, and
- minerals and energy exploration and development.

This report was commissioned by the APEC Steering Group on Energy Standards for the APEC Energy Working Group.

A large amount of complex analysis has been required for this report. Some errors may be included in the final report and some information is missing due to slow or incomplete responses from some parties during the data collection process. While the authors have offered their opinions on a range of issues, these are intended to illicit comment and stimulate discussion, rather than necessarily set the direction of future APEC policies in this area.

This report is available as an electronic file for distribution to interested parties via the APEC Energy Working Group web site which can be reached via the APEC Secretariat web site http://www.apecsec.org.sg

Files can be downloaded with a standard web browser – right click the mouse button on the file name at the above web site and "Save File/Link As" on your local computer. The electronic version of this report is in PDF format and has been formatted for double sided printing on A4 paper, with odd pages on the right hand side and even pages on the left. This report is in two sections:

Main report - executive summary, introduction, review of program by APEC Economy, recommendations on future directions, index of standards, references, web sites, contacts. (file EWG0398T-main.PDF)

Technical Annexes A to G - technical review of the test procedures for those products regulated in APEC Economies. (file EWG0398T-annex A-G.PDF)

This document is the Technical Annexes A to G.

Energy Efficient Strategies

Warragul, Australia, November 1999

Contents - Technical Annexes

Main report is published as a separate volume

Annex A:Refrigeration products ... *1*

A:1 Refrigerators and freezers ... **1**

A:1.1 Definitions ... 2
A:1.2 Australia ... 4
A:1.3 Canada ... 13
A:1.4 China ... 18
A:1.5 Hong Kong, China ... 23
A:1.6 Indonesia ... 23
A:1.7 Japan ... 24
A:1.8 Korea ... 29
A:1.9 Mexico ... 34
A:1.10 Philippines ... 38
A:1.11 Russia ... 39
A:1.12 Chinese Taipei ... 39
A:1.13 Thailand ... 43
A:1.14 USA ... 44
A:1.15 ISO 7371.2-95, ISO 8187-91, ISO 5155.2-95 & ISO8561/DAM 1 ... 48
A:1.16 Summary of refrigerator rating temperatures for energy ... 53

A:2 Automatic Icemakers ... **56**

A:2.1 Canada ... 56

A:3 Refrigerated Display Cabinets ... **56**

A:3.1 Canada ... 56

Annex B:Space Conditioning Equipment ... *57*

B:1 Air conditioners and heat pumps - definitions ... **57**

B:1.1 Overview of product types ... 57
B:1.2 Definitions by product type ... 58
B:1.3 Room air conditioner definitions ... 60

B:2 Room air conditioners and heat pumps ... **63**

B:2.1 Australia ... 63
B:2.2 Canada ... 65
B:2.3 China ... 72
B:2.4 Hong Kong, China ... 72
B:2.5 Japan ... 73
B:2.6 Korea ... 77
B:2.7 Mexico ... 82
B:2.8 Philippines ... 84
B:2.9 Russia ... 87
B:2.10 Chinese Taipei ... 89
B:2.11 Thailand ... 93
B:2.12 United States of America ... 95
B:2.13 ISO 5151-1994(E) – Non-ducted air conditioners ... 102
B:2.14 Summary of room air conditioner test conditions and coverage ... 106

B:3 Central and large air conditioners and heat pumps ... **112**

B:3.1 Canada ... 112
B:3.2 Japan ... 120
B:3.3 Korea ... 122
B:3.4 Mexico ... 124
B:3.5 Chinese Taipei ... 126
B:3.6 United States of America ... 128

B:3.7 ISO 13253-94 – Ducted air conditioners.....135

B:4 Non-air-source heat pumps 138

B:4.1 Canada.....138

B:5 Dehumidifiers 140

B:5.1 Canada.....140

B:6 Water Chillers 140

B:6.1 Canada.....140

B:7 Electric Space Heaters 141

B:7.1 Korea.....141
B:7.2 USA.....141
B:7.3 IEC 60675:1994 – Electric space heaters.....141

Annex C:AC Electric Motors.....142

C:1 Summary of Motor Test Procedure by Economy.....142

C:1.1 Australia.....142
C:1.2 Canada.....142
C:1.3 Mexico.....142
C:1.4 New Zealand.....143
C:1.5 Chinese Taipei.....143
C:1.6 Thailand.....143
C:1.7 USA.....144

C:2 Overview of International Standards for Motors 144

C:2.1 Comparison of IEC, JIS and IEEE.....144
C:2.2 Comparison Details.....145
C:2.3 Technical issues associated with the use of motor standards.....147

Annex D: .....Lighting Products 149

D:1 Incandescent Lamps 149

D:1.1 Canada.....149
D:1.2 Korea.....150
D:1.3 Malaysia.....151
D:1.4 Chinese Taipei.....151
D:1.5 USA.....151
D:1.6 IEC60064 – GLS Lamps.....152
D:1.7 Technical Issues Associated with the use of IEC60064.....153
D:1.8 IEC61341 – Reflector Lamps.....153
D:1.9 Technical Issues Associated with the use of IEC61341.....154

D:2 Fluorescent Lamps 154

D:2.1 Canada.....154
D:2.2 Japan.....156
D:2.3 Korea.....156
D:2.4 Malaysia.....157
D:2.5 New Zealand.....157
D:2.6 Philippines.....157
D:2.7 Chinese Taipei.....157
D:2.8 USA.....157
D:2.9 IEC60081 - Double-capped fluorescent lamps.....158
D:2.10 Technical Issues Associated with the use of IEC60081.....159
D:2.11 IEC60901 – Single capped fluorescent lamps.....159
D:2.12 Technical Issues Associated with the use of IEC60901.....160

D:3 Fluorescent Lamp Ballasts.....160

D:3.1 Australia.....160
D:3.2 Canada.....160
D:3.3 Japan.....161

D:3.4 Korea 161
D:3.5 Malaysia 162
D:3.6 Philippines 162
D:3.7 Chinese Taipei 163
D:3.8 Thailand 163
D:3.9 USA 163
D:3.10 IEC60921 – Ferromagnetic Ballasts 164
D:3.11 Technical Issues Associated with the use of IEC60921 165
D:3.12 IEC60929 – Electronic ballasts 165
D:3.13 Technical Issues Associated with the use of IEC60929 166
D:3.14 EN50294-1998 – Ballast input power method 167
D:3.15 Technical Issues Associated with the use of EN50294 168

D:4 Compact Fluorescent Lamps 168

D:4.1 Canada 168
D:4.2 Hong Kong, China 169
D:4.3 Korea 169
D:4.4 Mexico 170
D:4.5 Philippines 170
D:4.6 USA 170
D:4.7 IEC60969 – Self ballasted lamps 171
D:4.8 Technical Issues Associated with the use of IEC60969 171

D:5 Indoor Lighting Systems 172

D:5.1 Mexico 172

D:6 External Lighting Systems 172

D:6.1 Canada 172
D:6.2 Mexico 173

Annex E:Electric Water Heaters And Washing Products 174

E:1 Electric Water Heaters 174

E:1.1 Australia 174
E:1.2 Canada 177
E:1.3 Korea 178
E:1.4 Malaysia 179
E:1.5 Mexico 179
E:1.6 New Zealand 179
E:1.7 Chinese Taipei 179
E:1.8 USA 180
E:1.9 IEC 60379 – Electric storage water heaters 182
E:1.10 Technical issues associated with the use of IEC60379 182
E:1.11 AS 4234 – Water heater computer model 183
E:1.12 Technical Issues Associated with the use of AS4234 184

E:2 Clothes Washers 185

E:2.1 Australia 185
E:2.2 Canada 186
E:2.3 China 191
E:2.4 Hong Kong, China 191
E:2.5 Korea 192
E:2.6 Malaysia 192
E:2.7 Mexico 192
E:2.8 New Zealand 193
E:2.9 Philippines 193
E:2.10 Singapore 193
E:2.11 Chinese Taipei 193
E:2.12 USA 194
E:2.13 JIS C9606 – Clothes washers 195
E:2.14 IEC 60456 – Clothes washers 196
E:2.15 Technical Issues Associated with the use of IEC60456 198

E:3 Dishwashers 199
E:3.1 Australia..199
E:3.2 Canada..200
E:3.3 New Zealand..203
E:3.4 USA 203
E:3.5 IEC 60436-81 - Dishwashers..204
E:3.6 Technical Issues Associated with the use of IEC60436....................205

E:4 Clothes Dryers 207
E:4.1 Australia..207
E:4.2 Canada..210
E:4.3 New Zealand..211
E:4.4 USA 211
E:4.5 IEC 61121 – Clothes dryers..212
E:4.6 Technical Issues Associated with the use of IEC61121....................213

Annex F:Office Equipment and Consumer Electronics....................................215

F:1 Office equipment.. 215
F:1.1 Background..215
F:1.2 Product Criteria and Specific Conditions..218

F:2 Home Electronics 226

F:3 Televisions 226
F:3.1 China...226
F:3.2 Japan 227
F:3.3 Korea 228
F:3.4 Russia 228
F:3.5 The United States of America 228

F:4 Video Cassette Recorders (VCR)... 230
F:4.1 Korea 230
F:4.2 Japan 230
F:4.3 United States of America 230

F:5 Other Consumer Electronics & Equipment... 230
F:5.1 China...230
F:5.2 Russia 231
F:5.3 Russia 231
F:5.4 Russia 231
F:5.5 Russia 231
F:5.6 Russia 232
F:5.7 Russia 232
F:5.8 Russia 232

Annex G: .... Miscellaneous Appliances and Equipment 233

G:1 Cooking Equipment... 233
G:1.1 Canada..233
G:1.2 China...234
G:1.3 Korea 235
G:1.4 Russia 235
G:1.5 IEC 60350 – Cooktops and ranges 235
G:1.6 Technical Issues Associated with the use of IEC60350....................236

G:2 Electric Irons 236
G:2.1 China...236

G:3 Fans 236
G:3.1 China...236
G:3.2 Chinese Taipei...237

G:4 Pumps **237**
G:4.1 Mexico 237
G:5 Transformers **238**
G:5.1 Canada 238
G:5.2 USA 238

Index Of Tables - Technical Annexes

Table 1 Refrigerator and freezer energy efficiency regulations by member economy........................2
Table 2: Main features of the AS/NZS 4474.1-97, ISO and ANSI/AHAM test procedures 6
Table 3: Refrigerating appliance Groups, Australia..9
Table 4: Allowable operating temperatures for unfrozen food compartments, Australia..............10
Table 5: Maximum frozen food temperatures in Group 2 to 5S, Australia...11
Table 6: Maximum temperatures for compartments in group 6C, 6U and 7, Australia..................11
Table 7: Target temperatures for measurement of energy consumption, Australia..........................12
Table 8: Main features CAN/CSA-C300-M91, ISO and ANSI/AHAM test procedures...................14
Table 9: Main features of the GB 12021.2-89, ISO and ANSI/AHAM test procedures 19
Table 10: Main features of JIS C 9607, ISO and ANSI/AHAM test procedures 25
Table 11: Main features of KS C 9305-96, ISO and ANSI/AHAM test procedures..........................30
Table 12: Main features of Mexican NOM-015, ISO and ANSI/AHAM test procedures 35
Table 13: Main features of CNS 2062-95, ISO and ANSI/AHAM test procedures 40
Table 14: Main features of the US DOE, ISO and ANSI/AHAM test procedures 45
Table 15: Main features of ISO and ANSI/AHAM test procedures 49
Table 16: General refrigerator temperature requirements for various test standards (°C)...........53
Table 17: Energy consumption test requirements for household refrigerators 54
Table 18: Terms used in air conditioner and heat pump regulations within APEC 58
Table 19: Room air conditioner types and characteristics...61
Table 20: Product types included in Australian room air conditioner regulations............................64
Table 21: Product types included in Canadian room air conditioner regulations.............................65
Table 22: Product types included in Canadian packaged terminal air conditioner regulations 66
Table 23: Product types included in Canadian split-system central air conditioner regulations...66
Table 24: Test conditions for the determination of cooling capacity, Canada....................................67
Table 25: Test conditions for the determination of cooling capacity, Canada....................................69
Table 26: Test conditions for the determination of heating capacity, Canada 69
Table 27: Test conditions for the determination of cooling capacity and SEER, Canada................70
Table 28: Product types included in Chinese room air conditioner regulations 72
Table 29: Product types included in Hong Kong, China room air conditioner program................73
Table 30: Product types included in Japanese room air conditioner program...................................74
Table 31: Test conditions for the determination of cooling capacity, Japan.......................................76
Table 32: Product types included in Japanese unitary air conditioner test procedure.....................77
Table 33: Product types included in Korean room air conditioner test procedure...........................79
Table 34: Test conditions for the determination of cooling capacity, Korea......................................80
Table 35: Product types included in Korean unitary air conditioner test procedure........................81
Table 36: Product types included in Mexican room air conditioner regulations...............................83
Table 37: Test conditions for the determination of cooling capacity, Mexico.....................................84
Table 38: Product types included in Philippines room air conditioner regulations..........................85
Table 39: Test conditions for the determination of cooling capacity, Philippines 86
Table 40: Product types included in Russian room air conditioner regulations 87
Table 41: Operational temperature limits for Russian air conditioners 88
Table 42: Test conditions for the determination of cooling and heating capacity, Russia..............88
Table 43: Temperatures used in the start-up test, Russia...89
Table 44: Product types included in Chinese Taipei's room air conditioner regulations.................90
Table 45: Test conditions for the determination of cooling capacity..92
Table 46: Product types included in Chinese Taipei unitary air conditioner test procedure..........93
Table 47: Product types included in Thai room air conditioner programs 94
Table 48: Test conditions for the determination of cooling capacity, Thailand..................................95
Table 49: Product types included in USA room air conditioner regulations 96
Table 50: Product types included in USA packaged terminal air conditioner regulations 96
Table 51: Product types included in USA central air conditioner regulations 96
Table 52: Test conditions for the determination of cooling capacity, USA..98
Table 53: Test conditions for the determination of cooling capacity, USA..99
Table 54: Test conditions for the determination of heating capacity, USA 100
Table 55: Test conditions for the determination of cooling capacity and SEER, USA.................. 101
Table 56: Product types included/ excluded from ISO 5151 test procedure 103

Table 57: Test conditions for the determination of cooling capacity, ISO..104
Table 58: Test conditions for the determination of heating capacity, ISO..105
Table 59: Room air conditioner test conditions by APEC member economy..................................106
Table 60: Applicability of room air conditioner test procedures, regulations and product types 108
Table 61: Product types included in Canadian single package central air conditioner regulations 112
Table 62: Product types included in Canadian split-package central air conditioner regulations 113
Table 63: Product types included in Canadian large air conditioner regulations 113
Table 64: Product types included in Canadian large split system air conditioner regulations....114
Table 65: Test conditions for the determination of cooling capacity and SEER, Canada............115
Table 66: Test conditions for the determination of cooling capacity and SEER, Canada............117
Table 67: Test conditions for the determination of capacity, EER, COP and IPLV, Canada......120
Table 68: Product types included in the Japanese unitary air conditioner test procedure..........121
Table 69: Product types included in the Korean unitary air conditioner test procedure.............122
Table 70: Test conditions for the determination of cooling and heating capacity, Korea............124
Table 71 Product types included in Mexican central air conditioner regulations 125
Table 72: Test conditions for the determination of cooling capacity, Mexico.................................126
Table 73: Product types included in Chinese Taipei unitary air conditioner test procedure.......127
Table 74: Test conditions for the determination of cooling and heating capacity..........................128
Table 75: Product types included in USA central air conditioner and heat pump regulations ...129
Table 76: Product types included in USA small air conditioner and heat pumps regulations.....130
Table 77: Product types included in USA large air conditioner and heat pump regulations 130
Table 78: Test conditions for the determination of cooling capacity and SEER, USA.................131
Table 79: Test conditions for the determination of capacity, EER, COP and IPLV, USA..........134
Table 80: Product types included in or excluded from ISO 13253 test procedures 135
Table 81: Test conditions for the determination of cooling capacity, ISO..136
Table 82: Test conditions for the determination of heating capacity, ISO..137
Table 83: Heat sources and sinks for the basic heat pump types, Canada..138
Table 84: Rating conditions for ground-source heat pumps, Canada..140
Table 85: Summary of Electric Motor Energy Programs 142
Table 86: Summary of motor instrument accuracy..146
Table 87: Summary of Incandescent Lamp Energy Programs 149
Table 88: Summary of Fluorescent Lamp Energy Programs 154
Table 89: Summary of Fluorescent Lamp Ballast Energy Programs 160
Table 90: Summary of Compact Fluorescent Lamp Energy Programs 168
Table 91: Summary of Water Heater Test Procedures...175
Table 92: Summary of Clothes Washer Test Procedures 187
Table 93: Sample Temperature Use Factors - Canada...190
Table 94: Summary of Dishwasher Test Procedures 201
Table 95: Summary of Clothes Dryer Test Procedures 208
Table 96. Energy Star Program documents relevant to office equipment..217
Table 97. Voltage and frequency test conditions..218
Table 98. Energy Star power management requirements for computers..219
Table 99. Energy Star power management requirements for printers and fax machines 221
Table 100. Energy Star power management requirements for standard format copiers............222
Table 101. Energy Star power management requirements for large format copiers 222
Table 102. Energy Star power management requirements for standard format MFDs..............223
Table 103. Energy Star power management requirements for large format MFDs 223
Table 104. Energy Star power management requirements for standard format UDCs 224
Table 105. Energy Star power management requirements for large format UDCs 224
Table 106: Energy efficiency regulations for TVs and VCRs by member economy 226
Table 107: Summary of Cooker Energy Programs 233

ANNEX A: REFRIGERATION PRODUCTS

This Annex reviews the test procedures for refrigeration products. The types of equipment covered and the order of coverage is as follows:

- Refrigerators, refrigerator-freezers and separate freezers. These are generally for household use, but there are also some sales into the commercial sector. Reference to the term “refrigerator” generally means any or all of these combinations, unless otherwise stated.
- Automatic icemakers (commercial applications)
- Refrigerated display cabinets (commercial applications)

Refrigerators and their combinations clearly dominate the analysis as there are many different test procedures and many APEC economies regulate these products for energy efficiency. The lack of harmonisation in this area is clearly a major issue.

A:1 Refrigerators and freezers

There are no significant differences in the terminology used to describe refrigerators and freezers among APEC member economies; however, there are significant differences in the test procedures used, the performance criteria applied and the manner in which products are classified. The efficiency regulations in place by member economy are summarised in Table 1.

Table 1 Refrigerator and freezer energy efficiency regulations by member economy

	Energy labelling		MEPS	
	Refrigerators and refrigerator-freezers	Separate Freezer	Refrigerators and refrigerator-freezers	Separate Freezer
Australia	M	M	M	M
Canada	M	M	M	M
China			M	M
Hong Kong, China	V	V		
Indonesia	V			
Japan			HV from 2003	
Korea	M		M	
Malaysia		M (UC)	M (UC)	M (UC)
Mexico	M	M	M	M
New Zealand	V, M (UC)	V, M (UC)	M (UC)	M (UC)
Philippines	M	M		
Russia			M	M
Singapore				
Chinese Taipei	M (UC)	M (UC)	M	M
Thailand	V		M (UC)	
USA	M	M	M	M

A:1.1 Definitions

International Definitions

Some of the frequently used terms and definitions in this section that are relevant to the test standards (after Bansal and Kruger 1994 and from ISO standards).

Household refrigerator

A household refrigerator is defined as a cabinet or any part of a cabinet that is designed for the refrigerated storage of food at temperatures above 0 °C, has a source of refrigeration and is intended for household use. It may include a compartment for the freezing and storage of ice and/or for storage of food at temperatures below 0 °C (typically at –15 °C to –18 °C). Household refrigerators can be divided into two classes.

- *Refrigerator*
  An All-Refrigerator is a cabinet which does not include a compartment for the storage of food at temperatures below 0 °C. A refrigerator may include a

compartment with a small volume for freezing and storage of ice or a short term frozen food compartment.

- *Refrigerator-Freezer*
  A Refrigerator-Freezer is a cabinet which consists of two or more compartments, with at least one of the compartments designed for the refrigerated storage of food at temperatures above 0 °C and with at least one of the compartments designed for the freezing and long term storage of frozen food.

Household freezer

A household freezer is defined as a separate cabinet which is designed for the extended storage of frozen food generally at an average temperature of –15 °C of below. It has a source of refrigeration and is intended for household use.

Fresh-food compartment

A fresh-food compartment is intended for the storage of unfrozen food at an average temperature above 0 °C, and may be subdivided into smaller zones or compartments allocated for the storage of particular types of product.

Freezer compartment

A compartment which is intended specifically for he freezing and/or storage of frozen food, and may include an ice-making zone or function. The classification of freezer compartments according to their storage temperatures is different in most of the test standards. Thus, to have a conformity among these standards, the freezer compartments are classified in this study by using the International Standards classification, as follows:

- 'One-Star' Compartment (*)
  Compartment in which the storage temperature is not warmer than –6 °C
- 'Two-Star' Compartment (**)
  Compartment in which the storage temperature is not warmer than –12 °C
- 'Three-Star' Compartment (***)
  Compartment in which the storage temperature is not warmer than –18 °C.

Control cycle

A control cycle is the period between two successive starts or two successive stops of the compressor of a refrigerating system. Note some models may have variable speed compressors which operate continuously.

Defrost cycle

A defrost cycle is the period between two successive starts or two successive stops of a defrost heater in a refrigerator-freezer having an automatic defrost system.

Test package

Most of the standards typically use test packages in food storage tests while the ISO requires loading of the freezer compartment with test packages for the energy consumption test. The packages are used to simulate food load in the freezer compartment, Their function is to provide thermal ballast and fill up the space. The chemical composition of the packages per 1000 g is:

- 764.2 g of water
- 230.0 g of oxyethylmethylcellulose
- 5.0 g of sodium chloride
- 0.8 g of parachloromethacresol.

The freezing point of this material is –1 °C. The thermal characteristics of the packages correspond to those of lean beef.

Measurement package ('M-package')

A measurement package (also called an 'M-package') is a 500 g (50 mm × 100 mm × 100 mm) test package fitted with a temperature sensor (thermocouple) at its geometric centre which shall be in direct contact with the filling material.

M-points

'M-points' are the number of measurement points used to record the temperature of each M-pack.

Characteristic temperature

This is the temperature within the compartment of a cabinet that needs to be achieved during a test for the energy consumption measurement.

A:1.2 Australia

Program: mandatory energy labelling and MEPS for refrigerators, refrigerator-freezers and freezers

Scope

Australia has mandatory energy labelling for household refrigerators and freezers and MEPS that came into effect on 1 October 1999.

Summary of test procedure

The Australian and New Zealand test procedure, AS/NZS 4474.1-1997 *Performance of household electrical appliances – Refrigerating appliances. Part 1: Energy consumption and performance*. This standard has a number of similarities with the international standards ISO 5155, ISO 7371, ISO 8187 and ISO 8561. The main differences can be summarised as follows:

- The AS/NZS standard does not use the star system to rate frozen food compartments in terms of their design operating temperature and freezing performance
- The AS/NZS standard uses an alternative (wider) ambient temperature range during the temperature performance tests (but the test is the same)
- The ambient test temperature used during the energy test is 32°C (equivalent to ISO conditions for tropical class appliances).
- Different compartmental operating temperatures are used during the energy test

- Frozen food compartments are not loaded during energy consumption testing (after US DOE)
- There is no freezer capacity test or temperature rise time test
- There is a freezer pull-down test (from AHAM)

The detailed elements of and differences between the AS/NSZ 4474.1-97 test procedure and the ISO and ANSI/AHAM test procedures are indicated in Table 2.

AS/NZS 4474.2-97 standard deals with the energy efficiency requirements for energy labelling and MEPS of refrigerators and freezers. The adjusted volume calculations used to define energy labelling star ratings and MEPS performance levels are all based on gross volumes rather than net or storage volumes.

Table 2: Main features of the AS/NZS 4474.1-97, ISO and ANSI/AHAM test procedures

Variable	AS/NZS 4474.1-97	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	$32^oC \pm 0.5^oC$	$32.3^oC \pm 0.6^oC$	$25^oC \pm 0.5^oC$ [3]
Energy consumption fresh food temperature	3^oC	$3.3/7.22^oC$ [4]	5^oC
Energy consumption freezer temperature [5]	-15^oC	$-15/-17.8^oC$ [6]	-18^oC
Freezer for energy consumption	unloaded	sometimes loaded [7]	loaded
Operation test ambient temperatures [8]	$10/32/43^oC$	$21.1/32.2/43.3^oC$ [9]	$16/32^oC$ [10]
Operation test fresh Food temperatures [11]	0.5^oC to 6^oC	1.1^oC to 5^oC	0^oC to 5^oC [12]
Operation test freezer temperatures [13]	$\leq -15^oC$	$\leq -15/-17.8^oC$ [6]	$\leq -18^oC$ [14]
Pull down test	Yes	Yes	No
Freezing capacity test	No	No	Yes
Ice making capacity	Yes	Yes	Yes
Temperature rise time	No	No	Yes
Other performance tests	No	Yes [15]	Yes [16]
Gross volume [17]	compartment (including sub-compartment)	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	gross	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	1.6	1.63	2.15
Separate freezer energy adjustment	No	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	mains powered electric vapour compression [20]	all electric A.C. single phase systems [21]	Any [22]
Humidity	not specified	not specified [23]	45% to 75%
Anti-sweat heaters during energy consumption tests	On	average on & off	only when needed
Door openings	No	No [24]	No

[1] The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

[2] There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document (not yet published).

[3] Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

[4] AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22°C.

[5] Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. AS/NZS4474.1-97 freezer compartment temperature is determined from the average of the warmest 4 of the 5 air temperature sensors. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests (AS/NZS4474.1-97 also uses this method for loaded operation tests). ANSI/DOE compartment temperatures are the average of all temperatures points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

[6] A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers.

[7] Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm ± 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM are 130 × 100 × 40 mm and contain sawdust or spinach. Under the AHAM standard the freezer compartment is only loaded to 75% of its capacity. AHAM test packs are different from the test packs specified in ISO which are 200 × 100 × 50 mm and contain oxyethylmethylcellulose. AS/NZ4474.1 specifies test packs which are identical to ISO -1°C packs. Under ISO and ANZ the freezer compartments are fully loaded (except for specified air gaps). ANZ specifies 15mm air gaps between test packs and the freezer walls, while ISO specifies that they should be in contact.

[8] Temperature operation tests are conducted with freezer test packs for all three standards.

[9] The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS.

[10] This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

[11] Fresh food temperatures in all standards are averages. AS/NZS4474.1 specifies that thermocouples shall be placed inside copper or brass cylinders with a thermal mass of between 10 and 20g water equivalent, while ISO usually specifies cylinders which have 2.3g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent.

[12] ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

[13] Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption.

[14] Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

[15] Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

[16] Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

[17] Gross volumes for ANZ differ from ISO in a number of minor areas. However, the most significant difference is that the volume of air ducts (in a frost free system) within the liner shape is counted as part of the gross volume in ANZ but this is not allowed under ISO.

[18] The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO and ANZ. However there are minor differences in the determination of storage volume under all of these standards.

[19] The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

[20] This is the scope of AS/NZS4474.2 which covers government requirements for energy labelling and MEPS. The scope of AS/NZS4474.1 includes all electric powered units but excludes low voltage DC, portable and multi-fuel systems.

[21] This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

[22] ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

[23] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%), but not for energy consumption or operation tests.

[24] US DOE Code of Federal Regulations has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12±2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4th time for the freezer compartment, to obtain 24 fresh food and six freezer door openings in a 24 hour period.

Details

AS/NSZ 4474.1-97 categorises refrigerators and freezers into 9 groups as shown in Table 3. The following tests are required in AS/NZS 4474.1-97:

- rated storage shelf-area
- rated gross and storage volumes
- pull down test
- automatic ice-making capacity test
- operating temperature performance test
- energy consumption test

As in the ISO test procedures, the AS/NSZ 4474.1-97 requires the refrigerators to be able to maintain pre-defined interior temperatures under a range of exterior temperatures (operating temperature performance test), although the range is wider 43°C to 10°C. Unlike the ISO test procedures, AS/NSZ 4474.1-97 requires the refrigerators to be able to satisfy a pull down test where the room temperature is maintained at 43°C and the appliance has to be able to reach specified interior operating temperatures within a 6 hour period; however, there is no rise time test in AS/NSZ 4474.1-97.

Table 3: Refrigerating appliance Groups, Australia

Appliance Designation	Food storage compartment types						Configuration requirements (Refer to Note 5)	Defrost system requirements (Refer to Note 6)	Group
	Unfrozen food storage			Frozen food storage					
	Cellar	Fresh food	Chill	Ice making	Short term	Freezer			
Refrigerator	O	Y	O	N	N	N		Automatic	1
Cooled appliance	L	L	L	N	N	N			
Refrigerator	O	Y	O	O	N	N		Defrost	2
Cooled appliance	L	L	L	O	N	N			
Refrigerator	O	Y	O	O	Y	N			3
Cooled appliance	L	L	L	O	Y	N			
Refrigerator/Freezer	O	Y	O	O	O	Y		Cyclic defrost	4
Cooled appliance	L	L	L	O	O	Y			
Refrigerator/Freezer	O	Y	O	O	O	Y	Not side by side	Frost free	5
Cooled appliance	L	L	L	O	O	Y			
Refrigerator/Freezer	O	Y	O	O	O	Y	Side by side	Frost free	5S
Freezer	N	N	N	O	O	Y	Chest		6C
Cooled appliance	N	N	N	O	L	L			
Freezer	N	N	N	O	O	Y	Upright	Not frost free	6U
Cooled appliance	N	N	N	O	L	L			
Freezer	N	N	N	O	O	Y	Upright	Frost free	7
Cooled appliance	N	N	N	O	L	L			

NOTES TO Table 3

1 To define the group to which an appliance belongs, it's designation (Clause 1.3.17), constituent compartment types (Clause 1.3.11), configuration (Clause 1.3.16) and defrost system (Clause 1.3.7) must first be established. Each row of Table 1.1 is then considered until the applicable row, and hence the Group, is established.

2 If an appliance meets the requirements of more than one Group, it shall be deemed to be in the group which has the highest MEPS cut off level in accordance with Table 3.1 of AS/NZS 4474.2.

3 In defining the group of an appliance, Table 1.1 is applied to compartments only. Convenience features are not considered.

4 Requirements to be met by the appliance in question regarding food storage compartment types.

`Y' - indicates `yes'. i.e. the appliance shall have one or more of the relevant compartment types.

`N' - indicates `no'. i.e. the appliance shall have none of the relevant compartment types.

`L' - indicates `at least'. i.e. the appliance shall have one or more of the relevant compartment types.

`O' - indicates `optional'. i.e. one or more of this compartment type may be present or not.

5 This column sets out the requirements to be met by the appliance in question regarding household refrigerating appliance configuration. A blank cell in this column indicates no particular requirements regarding configuration. The entry `not side by side' indicates that the appliance shall be of any configuration except side by side.

6 This column sets out the requirements to be met by the appliance in question regarding the defrost system. A blank cell in this column indicates no particular requirements regarding the defrost system. The entry `not frost free' indicates that the appliance shall have any category of defrost system except frost free.

7 Any refrigerating appliance which is configured as a Group 4 appliance but does not meet the defrost type criteria shall be deemed to be a Group 3 appliance.

This particular requirement applies even though the appliance provides freezer space.

During the operating temperature performance test the compartments have to be able to maintain the temperatures specified in Table 4, Table 5 and Table 6.

Table 4: Allowable operating temperatures for unfrozen food compartments, Australia

Compartment or subcompartment type	Ambient temperatures at which conditions are to be met °C			Allowable range of average air temperature °C	
				Min.	Max.
Cellar	N/A	32	N/A	8	14
Fresh food space	10	32	43	0.5	6
Chill	N/A	32	N/A	-2	3
Special (unfrozen)	N/A	32	N/A	Within claimed range*	

* The claimed maximum shall not be warmer than 14°**C**. The claimed minimum shall not be colder than –2°**C**. The difference between the claimed maximum and minimum temperatures shall not exceed 6°**C**.

Table 5: Maximum frozen food temperatures in Group 2 to 5S, Australia

Compartment or subcompartment type	Ambient temperatures °C			Maximum allowable temperature of warmest test package °C
Ice making	10	32	43	-2
Short term frozen food storage	10	32	43	-9
Freezer	10	32	43	-15
Special (frozen)	10	32	43	Colder than the claimed maximum temperature*

* Claimed maximum shall not be warmer than –2°C.

Table 6: Maximum temperatures for compartments in group 6C, 6U and 7, Australia

Compartment or subcompartment type	Ambient temperatures at which conditions are to be met			Maximum allowable value of average air temperature °C	Maximum allowable temperature of warmest test package °C
Ice-making	10	32	N/A	-2	N/A
	N/A	N/A	43	N/A	-2
Short term frozen food storage	10	32	N/A	-9	N/A
	N/A	N/A	43	N/A	-9
Freezer	10	32	N/A	-15	N/A
	N/A	N/A	43	N/A	-15
Special (frozen food)	10	32	N/A	Claimed maximum temperature*	N/A
	N/A	N/A	43	N/A	Claimed maximum temperature*

* The claimed maximum shall be not warmer than –2 °C.

Test conditions and practices during the energy consumption test

The ambient temperature used during the energy consumption test is 32 ± 0.5°C and the interior temperatures have to be maintained as specified in Table 7. The temperature sensors are thermocouples placed inside, and in good thermal contact with, a metallic mass with a thermal capacity of between 10 and 20 g of water. All temperatures are recorded to an accuracy of ±0.5°C and are rounded to the nearest 0.1°C. Food packs are not used to fill frozen food or freezer compartments during the energy test (they are during the operating temperature test). The compartment temperature is defined as the arithmetic mean of the three mean sensor temperatures, except for frozen food compartments, when the coldest sensor is excluded from the calculation. In practice, this is likely to mean that a frozen food compartment temperature recorded under the AS/NZS standard would be equivalent to a higher temperature recorded under the ISO test procedures, due to the fact that test packages are not used and the compartment temperature is not deemed to be the highest temperature of any of the test packages, as in ISO.

Defrost systems, when present, are set to operate as normally intended by the manufacturer. If there are user adjustable controls up to three test runs can be conducted and the mean energy consumption value taken, otherwise a single test run is used. There is no humidity setting requirement, nor for any door openings during the test. The test duration is dependent on whether thermal stability can be attained or not and is a minimum in all cases of 6 hours. If a defrost cycle is activated the test must operate for a whole number of defrost cycles. The energy consumption is given as:

Energy consumption rate (Wh/24 h) = Energy used (Wh) $\times$ 24/Time taken (h)

Energy measurement values are rounded to the nearest Wh.

Table 7: Target temperatures for measurement of energy consumption, Australia

Compartment or subcompartment type	Target average air temperature °C
UNFROZEN FOOD TYPES	
Cellar	12
Fresh food	3
Zero degree	0
Special (unfrozen)	Mid point of claimed range
FROZEN FOOD TYPES	
Ice making	No target temperature
Short term frozen food	- 9
Freezer	-15
Special (frozen)	Claimed maximum operating temperature

NOTES:

1 Measurement of energy consumption in accordance with this Standard enables the tested energy consumption (E_t) of an appliance to be determined in Wh/day (24 hours).

2 AS/NZS4474..2 specifies how E_t is used to determine the energy consumption and efficiency figures that are presented on energy labels, compliance with Minimum Energy Performance Standards and the validity of data on energy labels.

Variables required to be declared for regulatory purposes include:

- The refrigerating appliance group
- The food storage compartment type for each compartment
- Model identification marks
- Rated gross and storage volumes

A:1.3 Canada

Program: mandatory energy labelling and MEPS for refrigerators and freezers

Scope

Canada has mandatory energy labelling for refrigerators and freezers and MEPS. Both labelling and MEPS apply to refrigerator-freezers up to 1100 litres and freezers up to 850 litres.

Summary of test procedure

The Canadian test procedure, CAN/CSA-C300-M91 *Capacity measurement and energy consumption test methods for refrigerators, combination refrigerator-freezers, and freezers* is NEQV to the US DOE test procedure in CFR Part 430 Subpart B Appendices A1 and B1 that is based on ANSI/AHAM HRF-1-1988. The test procedure is significantly different to the equivalent ISO test procedures: ISO 5155, ISO 7371, ISO 8187 and ISO 8561. The main differences from ISO can be summarised as follows:

- The CAN/CSA-C300-M91 standard does not use the star system to rate frozen food compartments in terms of their design operating temperature and freezing performance
- The CAN/CSA-C300-M91 standard has no operating temperature performance requirements
- Freezing capacity is only tested for chest and upright freezers (not freezer compartments in refrigerator-freezers)
- The ambient test temperature used during the energy test is 32.2°C (almost equivalent to ISO conditions for tropical class appliances).
- Frozen food compartments are only loaded (75% full) during energy consumption testing for freezers and for non-frost free systems (no frost systems are not loaded during testing).
- The mean compartmental temperatures during the energy test are different.
- A post hoc adjustment factor is applied to the measured energy consumption of freezers to make the values more representative of in-use values.
- There are no rise time nor ice-making capacity tests
- Gross volume is not measured
- Door openings are included for units with variable defrost control

The detailed elements of and differences between the CAN/CSA-C300-M91test procedure and the ISO test procedure are indicated in Table 8. Section 9 of the CAN/CSA-C300-M91 standard stipulates the MEPS energy efficiency requirements for refrigerators and freezers.

Table 8: Main features CAN/CSA-C300-M91, ISO and ANSI/AHAM test procedures

Variable	CAN/CSA-C300-M91	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	32.2°C ± 0.6°C	32.3°C ± 0.6°C	25°C ± 0.5°C [3]
Energy consumption fresh food temperature	3.3/7.22°C [4]	3.3/7.22°C [4]	5°C
Energy consumption freezer temperature [5]	-9.4/-15/-17.8°C [6]	-15/-17.8°C [6]	-18°C
Freezer for energy consumption	sometimes loaded [7]	sometimes loaded [7]	always loaded
Operation test ambient temperatures [8]	None	21.1/32.2/43.3°C [9]	16/32°C [10]
Operation test fresh Food temperatures [11]	None	1.1°C to 5°C	0°C to 5°C [12]
Operation test freezer temperatures [13]	None	≤-15/-17.8°C [6]	≤-18°C [14]
Pull down test	No	Yes	No
Freezing capacity test	Chest and Upright freezers only	No	Yes
Ice making capacity	No	Yes	Yes
Temperature rise time	No	No	Yes
Other performance tests	No	Yes [15]	Yes [16]
Gross volume [17]	not specified	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	storage	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	1.63	1.63	2.15
Separate freezer energy adjustment	0.7/0.85 [19]	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	all electric A.C., 60Hz, 110V within volume limits [20]	all electric A.C. single phase systems [20]	Any [21]
Humidity	not specified [22]	not specified [22]	45% to 75%
Anti-sweat heaters during energy consumption tests	average on & off	average on & off	only when needed
Door openings	for variable defrost systems [23]	no	no

[1] The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence

regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

2 There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

3 Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

4 AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22°C.

5 Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/DOE compartment temperatures are the average of all temperatures points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

6 A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers. In CAN/CSA-C300-M91 the freezer box in refrigerators with user operable controls that are not refrigerator-freezers should be regulated to operate at –9.4°C or the fresh food compartment to operate at 7.2°C, whichever setting gives the highest energy consumption.

7 Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 and CAN/CSA-C300-M91 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA and Canada) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm ± 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). In the CAN/CSA standard the metal cylinders are made of brass and of dimensions 30mm ± 5mm in diameter and height. All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM and CAN/CSA are 130 × 100 × 40 mm and contain hardwood sawdust or spinach. Under the AHAM and CAN/CSA standards the freezer compartment is only loaded to 75% of its capacity. AHAM test packs are different from the test packs specified in ISO which are 200 × 100 × 50 mm and contain oxyethylmethylcellulose. Under ISO the freezer compartments are fully loaded (except for specified air gaps). ISO specifies that the test packs should be in contact with the freezer walls and the freezer fully loaded, whereas AHAM and CAN/CSA specify that there should be an air gap of 15 to 40mm (0.5 to 1.5 inches), with the packages placed in a pyramid or tiered form if necessary to properly locate the thermocouples.

8 Temperature operation tests are conducted with freezer test packs for the AHAM and ISO standards but not the CAN/CSA standard.

9 The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS. There is no simulated load test, either normative or informative, in the CAN/CSA test procedure.

10 This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

11 Fresh food temperatures in all standards are averages. ISO usually specifies (see 12 below) that the thermocouples should be placed inside metal cylinders which have a thermal mass of 2.3 g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent. There is no temperature operation test in the CAN/CSA test procedure.

12 ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

13 Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption. There is no temperature operation test in the CAN/CSA test procedure.

14 Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

15 Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

16 Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

17 Gross volumes can differ between the standards in a number of minor areas. However, the most significant aspect is that the volume of air ducts (in a frost free system) within the liner shape is not counted as part of the gross volume under ISO.

18 The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO. However there are minor differences in the determination of storage volume under all of the standards.

19 The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

20 This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types). The CAN/CSA standard excludes appliances that are not designed to operate at 60 Hz and 110V A.C. supply and which have volumes greater than 1100 L for refrigerator-freezers and greater than 850 L for freezers.

21 ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

22 Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%) in the AHAM standard, but not for energy consumption or operation tests. Humidity conditions are not specified during the energy test in the CAN/CSA test standard except for use in an optional test for

units having variable defrost control when the ambient temperature conditions shall be 26.6±1.1°C dry bulb and 19.4±0.6°C wet-bulb.

23 CAN/CSA-C300-M91 has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12±2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4th time for the freezer compartment.

Details

The following tests are required in CAN/CSA-C300-M91:

- total refrigerated volume and total shelf area
- rated gross and storage volumes
- energy consumption test

The CAN/CSA test procedure does not require refrigerators to be able to maintain any pre-defined interior temperatures under a range of exterior temperatures nor to satisfy any other performance tests except to satisfy stated MEPS levels and for freezing capacity to be tested for upright and chest freezers only.

Test conditions and practices during the energy consumption test

The energy consumption test is almost the same as that required under US DOE CFR430. The ambient temperature used during the energy consumption test is 32.2 ± 0.6°C except for an optional test for refrigerator-freezers having variable defrost control, when the ambient temperature conditions shall be 26.6±1.1°C dry bulb and 19.4±0.6°C wet-bulb. The compartment temperatures have to be maintained at 3.3°C for pure refrigerator compartments, <7.22°C for the refrigerator compartments in refrigerator-freezers, -9.4°C for the freezer compartment in a refrigerator, -15°C for the freezer compartment in a refrigerator-freezer, and –17.8°C for a pure freezer (chest or upright).

The compartmental interior temperature is defined as the mean value of three sensor temperatures in both fresh and frozen food compartments. When food packs are not used the temperature sensors are thermocouples placed inside, and in good thermal contact with, a brass cylinder of 30 mm ± 5mm height and diameter. Food packs are not used to fill frozen food or freezer compartments during the energy test for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in Canada) and "all refrigerators" with ice makers. Freezer test packs are used to fill freezer compartments in all other appliance types. The freezer test packs used are 130 × 100 × 40 mm and contain hardwood sawdust or spinach. Thermocouples are located in the geometric centre of some of these test packs to measure the freezer temperature. The freezer compartment is only loaded to 75% of its capacity such that there should be an air gap of 15 to 40mm (0.5 to 1.5 inches), with the packages placed in a pyramid or tiered form if necessary to properly locate the thermocouples. There is an option to test chest and upright freezer compartments without test pack loading provided 'satisfactory proof of the correlation factor used to calculate the final test results as a loaded freezer is provided' and weighted thermocouples are used as described for refrigerator compartments. All temperatures are recorded to an accuracy of ±0.5°C and are rounded to the nearest 0.1°C. Sensor temperatures are recorded at least every 4 minutes during the test period. The test duration is a minimum of 1 hour and must run for a whole number of compressor cycles. For appliances with manual, semi-automatic or partial automatic defrost systems the test period is at least three hours and the compressor must complete at least 2 complete on-off cycles or remain in one on cycle. If less than 2 complete cycles occurs within 24 hours the test is terminated after 24 hours. For appliances with automatic defrost the test period shall run from one point in a defrost cycle to the same point in the next defrost cycle. Slightly different rules apply to units having: ‘long-time automatic defrost’ (where successive automatic defrost cycles are separated by a period of 14 hours or more), variable defrost control, or dual compressor automatic defrost systems. Steady-state conditions need to be attained before beginning any of the above test periods and a single test run is used. Defrost systems, when present, are set to operate as normally intended by the manufacturer.

The compartment temperature is defined as the arithmetic mean of the mean sensor temperatures. In practice, this means that a frozen food compartment temperature recorded under the CAN/CSA standard would be equivalent to a higher temperature recorded under the ISO test procedures, due to the fact that test packages are not necessarily used and the compartment temperature is not deemed to be the highest temperature of any of the test packages, as in ISO. There is no humidity setting requirement, nor for any door openings during the test except when testing appliances with a variable defrost control, when door openings lasting for 12±2 seconds are made every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4th time for the freezer compartment.

The energy consumption in kWh/day for manual, semi automatic and automatic defrost systems is given as:

$$ET = EP \times 1440 \times T \times K$$

where:

ET = test cycle energy consumption (kWh/d)

EP = energy consumed during the test period (kWh)

1440 = conversion factor to adjust to a 24 hour period in minutes per day

K = correction factor of 0.7 for chest freezers and 0.85 for upright freezers to adjust for average usage, 1.0 for refrigerators and refrigerator-freezers

T = length of time of the test period in minutes

Slightly different formulations are used for long-time automatic defrost, variable defrost control, and dual compressor with automatic defrost appliances. The K factor is the same for long-time automatic defrost systems but is set at 1 for variable defrost control and dual compressor automatic defrost systems.

Variables required to be declared for regulatory purposes include:

- The total volumes of the fresh and frozen food compartments to the nearest 1.0 litre.
- The net shelf area to the nearest 100 cm^2.
- Model identification marks and brand
- Ambient temperature
- Voltage and frequency
- Total energy consumption in kWh/24h

- The freezing capability in kg/24h per 100 litres of volume for chest and upright freezers

A:1.4 China

Program: MEPS for refrigerators and refrigerator-freezers.

Scope

China has had MEPS for refrigerators and refrigerator-freezers effective since 1990. The Chinese authorities are currently considering revising these MEPS and introducing energy labelling.

Summary of test procedure

The Chinese Energy efficiency regulations GB 12021.2-89 *The limited value and testing method of the energy consumption for household refrigerators* references 4 test procedures, the latest versions of which are:

GB/T8059.1-95 which is NEQV to ISO 7371-85

GB/T8059.2-95 which is NEQV to ISO 8187-91

GB/T8059.3 which is NEQV to ISO 5155-83

GB/T8059.4-96 - relation to other standards has not been determined.

The detailed elements of and differences between the GB 12021.2-89 procedure and the ANSI/AHAM test procedures are indicated in Table 9.

Table 9: Main features of the GB 12021.2-89, ISO and ANSI/AHAM test procedures

Variable	GB 12021.2-89	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	$25^oC \pm 0.5^oC$ [3]	$32.3^oC \pm 0.6^oC$	$25^oC \pm 0.5^oC$ [3]
Energy consumption fresh food temperature	5^oC	$3.3/7.22^oC$ [4]	5^oC
Energy consumption freezer temperature [5]	-18^oC	$-15/-17.8^oC$ [6]	-18^oC
Freezer for energy consumption	loaded	sometimes loaded [7]	loaded
Operation test ambient temperatures [8]	$16/32^oC$ [10]	$21.1/32.2/43.3^oC$ [9]	$16/32^oC$ [10]
Operation test fresh food temperatures [11]	0^oC to 5^oC [12]	1.1^oC to 5^oC	0^oC to 5^oC [12]
Operation test freezer temperatures [13]	$\leq -18^oC$ [14]	$\leq -15/-17.8^oC$ [6]	$\leq -18^oC$ [14]
Pull down test	No	Yes	No
Freezing capacity test	Yes	No	Yes
Ice making capacity	Yes	Yes	Yes
Temperature rise time	Yes	No	Yes
Other performance tests	Yes [16]	Yes [15]	Yes [16]
Gross volume [17]	total only (not specified at sub-compartment level)	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	storage in EU	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	2.15	1.63	2.15
Separate freezer energy adjustment	No	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	Any [22]	all electric A.C. single phase systems [21]	Any [22]
Humidity	45% to 75%	not specified [23]	45% to 75%
Anti-sweat heaters during energy consumption tests	only when needed	average on & off	only when needed
Door openings	No	No [24]	No

[1] The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

[2] There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

[3] Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

[4] AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22°C.

[5] Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/DOE compartment temperatures are the average of all temperatures points taken at $\leq$4 minute intervals over the test period (excluding defrost cycles).

[6] A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers.

[7] Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm $\pm$ 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM are $130 \times 100 \times 40$ mm and contain sawdust or spinach. Under the AHAM standard the freezer compartment is only loaded to 75% of its capacity. AHAM test packs are different from the test packs specified in ISO which are $200 \times 100 \times 50$ mm and contain oxyethylmethylcellulose. Under ISO and GB 12021.2 the freezer compartments are fully loaded.

[8] Temperature operation tests are conducted with freezer test packs for all three standards.

[9] The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS.

[10] This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

[11] Fresh food temperatures in all standards are averages. ISO usually specifies that thermocouples should be placed inside cylinders which have 2.3g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent.

[12] ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

[13] Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption.

[14] Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

[15] Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

[16] Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

[17] Volumes for AHAM differ from ISO in a number of minor areas.

[18] The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO and GB 12021.2. However there are minor differences in the determination of storage volume under all of these standards.

[19] The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

[21] This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

[22] ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

[23] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% $\pm$ 2%), but not for energy consumption or operation tests.

[24] US DOE Code of Federal Regulations has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12$\pm$2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12$\pm$2 seconds every 4th time for the freezer compartment, to obtain 24 fresh food and six freezer door openings in a 24 hour period.

Details

GB 12021.2 categorises appliances as refrigerators, freezers or refrigerator-freezers. There is no special test for no-frost appliances. The following tests are required in GB 12021.2:

- determination of linear dimensions, volumes and areas
- air tightness
- door opening force
- durability of hinges and handles
- mechanical strength of shelves and components
- storage temperature test (operating temperature performance test)
- water vapour condensation test
- energy consumption test
- temperature rise test
- ice-making test
- test for absence of odour and taste
- freezing test

GB 12021.2 requires the refrigerators to be able to maintain pre-defined interior temperatures under a range of ambient temperatures (storage temperature test). These ambient temperature ranges depend on the climate classification of the appliance as follows:

- SN (Extended temperate) +10 to +32°C
- N (Temperate) +16 to +32°C
- ST (Temperate) +18 to +38°C
- ST (Subtropical) +18 to +38°C
- T (Tropical) +18 to +43°C

The predefined temperatures correspond to the ISO compartment classification as follows:

- Fresh food storage compartment = +5°C
- One star compartment ≤ -6°C
- Two star compartment ≤ -12°C
- Three star compartment ≤ -18°C
- Four star compartment ≤ -18°C (but having a minimum freezing capacity of 4.5kg/100 litres/24 hours.

Test conditions and practices during the energy consumption test

The ambient temperature used during the energy consumption test is 25 ± 0.5°C for SN, N and ST class appliances and 32 ± 0.5°C for T class appliances. The interior temperatures have to be maintained at an average of 5± 0.5°C for the refrigerator compartment, -6± 0.5°C for a 1-star frozen food compartment, -12± 0.5°C for a 2-star frozen food compartment and -18± 0.5°C for a 3 or 4-star frozen food compartment. The compartmental interior temperature is defined as the mean value of three sensor temperatures in the fresh food compartments. The temperature sensors are thermocouples placed inside, and in good thermal contact with, a copper or brass cylinder having a mass of 25g and diameter and height of about 15.2mm. All temperatures are recorded to an accuracy of ±0.3°C and are rounded to the nearest 0.1°C. Frozen food compartments are tested fully loaded using freezer packs. Freezer packs are made of a mixture designed to resemble the properties of lean beef and of a size of 25×50×100mm and 125g, or 50×100×100 and 500g or 50×100×200 and 1000g.

When freezer packs are used temperature sensors are inserted in a sample of the freezer packs. The compartment temperature is defined as the arithmetic mean of the three mean sensor temperatures, except for frozen food compartments with freezer packs, when the mean of the warmest sensor reading is used.

Defrost systems, when present, are set to operate as normally intended by the manufacturer. The humidity is set at between 45% and 75% during the test. Manual anti-sweat heaters are not activated during the energy test unless they are needed to pass the water vapour condensation test. The test duration is a minimum of 24 hours and must comprise a whole number of control cycles for cyclic refrigerators without automatic defrosting and up to 48 hours for appliances with automatic defrosting.

Variables required to be declared for regulatory purposes include:

- The refrigerating appliance type
- Climate class (SN, N, ST, T)
- Model identification marks
- Electrical energy consumption (kWh/24h) to two decimal places
- storage volumes (total and by compartment) (L)
- rated total gross volume (L)

Electrical energy consumption should be no more than 115% of the declared value – if it is a sample of three appliances are tested and their mean energy consumption should be no more than 110% of the declared value.

A:1.5 Hong Kong, China

Program: Voluntary labelling for refrigerators and refrigerator-freezers.

Scope

Hong Kong, China has had voluntary labelling for refrigerators and refrigerator-freezers since 1997.

Summary of test procedure

The Hong Kong, China energy efficiency program: *The Hong Kong voluntary energy efficiency labelling scheme for household refrigeration appliances* references the 4 ISO test procedures ISO 7371, ISO 8187, ISO 5155 and ISO 8561. Details of these test procedures are given under the section for international test procedures.

A:1.6 Indonesia

Program: Voluntary labelling for refrigerators and refrigerator-freezers.

Scope

Indonesia has had voluntary labelling for refrigerators and refrigerator-freezers since 1999.

Summary of test procedure

The Indonesian voluntary efficiency regulations and test procedure *Energy consumption testing procedures of refrigerator* references the ISO test procedure ISO 7371-95(E). Details of this test procedure are given under the section for international test procedures. The only significant difference from ISO is that the Indonesian specify that the appliance should be tested at 30°C ambient and 60-75% relative humidity during the energy test. Furthermore the test is to be repeated with the thermostat set at the high, medium and low positions and the energy consumption calculated using the interpolation method specified in ISO.

A:1.7 Japan

Program: high impact voluntary targets for refrigerators and refrigerator-freezers to come into effect in 2004 - Top Runner program.

Scope

Household refrigerators and refrigerator-freezers.

Summary of test procedure

The Japanese test procedure, JIS C 9607-93 *Household electric refrigerators, refrigerator-freezers and freezers* has recently been revised to include some important amendments such that there is now a part B which is NEQV to the ISO test procedures (ISO 5155, ISO 7371, ISO 8187 and ISO 8561) and also a Part A which sets alternative test conditions and criteria.

The previously applicable Japanese standard was harmonised with the international standards ISO 5155, ISO 7371, ISO 8187 and ISO 8561; however the revised version differs in the following main respects:

- Two different ambient temperatures are used during the energy test (15°C and 30°C) and the energy consumption is reported as a weighted combination of values attained at each temperature (similar to the JIS standard prior to 1995).
- Both refrigerator and freezer doors are opened during the test.
- Frozen food compartments in no-frost refrigerator-freezers are not loaded during energy consumption testing
- There is no temperature rise time test
- There is a freezer pull-down test and compulsory noise performance limits

The detailed elements of and differences between the JIS C 9607 procedure and the ISO and ANSI/AHAM test procedures are indicated in Table 10.

Table 10: Main features of JIS C 9607, ISO and ANSI/AHAM test procedures

Variable	JIS C 9607	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	15/30°C ± 1°C	32.3°C ± 0.6°C	25°C ± 0.5°C [3]
Energy consumption fresh food temperature	3± 0.5°C	3.3/7.22°C [4]	5°C
Energy consumption freezer temperature [5]	-6/-12/-18°C	-15/-17.8°C [6]	-18°C
Freezer for energy consumption	sometimes loaded [7]	sometimes loaded [7]	loaded
Operation test ambient temperatures [8]	15/30°C	21.1/32.2/43.3°C [9]	16/32°C [10]
Operation test fresh food temperatures [11]	≤2°C or ≤5°C	1.1°C to 5°C	0°C to 5°C [12]
Operation test freezer temperatures [13]	≤-18°C/-12°C/-6°C	≤-15/-17.8°C [6]	≤-18°C [14]
Pull down test	Yes	Yes	No
Freezing capacity test	Yes	No	Yes
Ice making capacity	No	Yes	Yes
Temperature rise time	No	No	Yes
Other performance tests	Yes [15]	Yes [15]	Yes [16]
Gross volume [17]	not specified	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	storage	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	NA	1.63	2.15
Separate freezer energy adjustment	No	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	mains powered electric vapour compression [20]	all electric A.C. single phase systems [21]	Any [22]
Humidity	75±5%	not specified [23]	45% to 75%
Anti-sweat heaters during energy consumption tests	On	average on & off	only when needed
Door openings	Every 12 minutes, 50times	No [24]	No

[1] The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

[2] There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

[3] Ambient test temperature for energy consumption under ISO is 25^{o}C for all climate classes except Tropical, which is at 32^{o}C.

[4] AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3^{o}C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22^{o}C.

[5] Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/DOE compartment temperatures are the average of all temperatures points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

[6] A freezer temperature of -15^{o}C applies to refrigerator-freezers while -17.8^{o}C applies to separate freezers.

[7] Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm ± 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM are 130 × 100 × 40 mm and contain sawdust or spinach. Under the AHAM standard the freezer compartment is only loaded to 75% of its capacity. AHAM test packs are different from the test packs specified in ISO which are 200 × 100 × 50 mm and contain oxyethylmethylcellulose. JIS C 9607-93 specifies test packs which are identical to ISO -1^{o}C packs. Under ISO and JIS the freezer compartments are fully loaded (except for specified air gaps) unless the freezer compartment is no-frost when JIS C 9607 stipulates that the compartment should not be loaded. JIS C 9607 specifies 15mm air gaps between test packs and the freezer walls, while ISO specifies that they should be in contact.

[8] Temperature operation tests are conducted with freezer test packs for all three standards.

[9] The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS.

[10] This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10^{o}C/32^{o}C), Sub-tropical (18^{o}C/38^{o}C) and Tropical (18^{o}C/43^{o}C).

[11] Fresh food temperatures in all standards are averages. JIS C 9607 specifies that thermocouples shall be placed inside metal blocks with a thermal mass of 20g water equivalent, while ISO usually specifies cylinders which have 2.3g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent.

[12] ISO average fresh food compartment temperatures are to remain at less than 5^{o}C, but this may rise to 7^{o}C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0^{o}C to 10^{o}C throughout the test (so a theoretical minimum average compartment temperature is 0^{o}C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

[13] Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption.

[14] Test pack temperatures are allowed to rise to -15^{o}C during defrosting cycles.

[15] JIS C 9607 specifies tests for refrigerant leakage defrosting performance, thermal insulation, power consumption, temperature test (concerned with maximum component temperatures for safety reasons), insulation resistance, dielectric withstand voltage, voltage variation characteristics, compressor starting characteristics, leakage current, door opening force, noise. Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

[16] Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

[17] Volumes for JIS C 9607 differ from ISO in a number of minor areas.

[18] The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO and JIS. However there are minor differences in the determination of storage volume under all of these standards.

[19] The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

[20] This is the scope of JIS C 9607-93, which also only applies to refrigerators of 700 L storage volume or less freezers of 400 L storage volume or less.

[21] This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

[22] ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

[23] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%), but not for energy consumption or operation tests.

[24] US DOE Code of Federal Regulations has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12±2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4th time for the freezer compartment, to obtain 24 fresh food and six freezer door openings in a 24 hour period.

Details

JIS C 9607 categorises appliances as refrigerators, freezers or refrigerator-freezers. The following tests are required in JIS C 9607:

- refrigerant leakage
- cooling performance (operating temperature performance test)
- cooling rate (pull down test)
- freezing performance
- defrosting performance
- thermal insulation
- power consumption
- electrical energy consumption
- temperature test (concerned with maximum component temperatures for safety reasons)
- insulation resistance
- dielectric withstand voltage
- voltage variation characteristics
- compressor starting characteristics
- leakage current
- door opening force
- noise
- storage volumes

As in the ISO test procedures, the JIS C 9607 requires the refrigerators to be able to maintain pre-defined interior temperatures under a range of exterior temperatures (operating temperature performance test), although the range is narrower at 15°C to 30°C. Unlike the ISO test procedures, JIS C 9607 requires the refrigerators to be able to satisfy a pull down test where the room temperature is maintained at 30°C and the appliance has to be able to reach specified interior operating temperatures within a 3 hour period; however, there is no rise time test in JIS C 9607. Refrigerators have to be able to pass a maximum noise requirement of 43dB(A) under JIS C 9607

Test conditions and practices during the energy consumption test

The ambient temperature used during the two energy consumption tests is 30 ± 1°C and 15 ± 1°C and the interior temperatures have to be maintained at an average of 3± 0.5°C for the refrigerator compartment, -6± 0.5°C for a 1-star frozen food compartment, -12± 0.5°C for a 2-star frozen food compartment and -18± 0.5°C for a 3or 4-star frozen food compartment. The compartmental interior temperature is defined as the mean value of three sensor temperatures in both fresh and frozen food compartments. The temperature sensors are thermocouples placed inside, and in good thermal contact with, a metallic mass having a thermal capacity of 20 g of water. All temperatures are recorded to an accuracy of ±0.5°C and are rounded to the nearest 0.1°C. Food packs of an identical size and composition to those specified by ISO are used to fill frozen food or freezer compartments during the energy test except for frost-free compartments which are not loaded. When freezer packs are used temperature sensors are inserted in a sample of the freezer packs in the same manner as described in ISO. The compartment temperature is defined as the arithmetic mean of the three mean sensor temperatures, except for frozen food compartments with freezer packs, when the mean of the coldest and warmest sensor reading is used. In practice, this is likely to mean that a frozen food compartment temperature recorded under the JIS standard with or without test packs would be equivalent to a higher temperature recorded under the ISO test procedures, due to the fact that the compartment temperature is not deemed to be the highest temperature of any of the test packages, as in ISO.

Defrost systems, when present, are set to operate as normally intended by the manufacturer. Manual defrost devices are not operated, but those that are meant to activated once a day are activated 15 hours into the test. Manually operated anti-frost heaters are set to be off during the test at 15°C ambient temperature and on during the 30°C ambient temperature test. The humidity is set at 75%±5% during the test. The test duration is 24 hours at each ambient temperature. Door openings are conducted 50 times every 12 minutes for refrigerator compartments and 15 times every 40 minutes for freezer compartments. Doors are held open for 10 seconds at each opening at an angle of 90°.

The annual energy consumption, *W*, is given as:

$$W \text{ (kWh/year)} = W_{15} \text{ (kWh/24h)} \times 265 + W_{30} \text{ (kWh/24h)} \times 100$$

where W_{15} is the energy consumption (kWh/24h) measured at 15°C ambient temperature and W_{30} is the energy consumption (kWh/24h) measured at 30°C ambient temperature.

Variables required to be declared for regulatory purposes include:

- The refrigerating appliance type
- Voltage, frequency and class
- Model identification marks
- Motor and auxiliary heater power levels (W)
- Electrical energy consumption (kWh/month)
- storage volumes (total and by compartment) (L)

Electrical energy consumption should be no more than 115% of the declared value.

A:1.8 Korea

Program: Mandatory energy labelling and MEPS for household refrigerators and refrigerator-freezers.

Scope

Korea has set mandatory energy efficiency target thresholds for refrigerator and refrigerator-freezers from 1995, MEPS from 1994 and energy labelling requirements since 1992. For energy labelling, Korea has a special Standard, which is called "Power consumption and efficiency labelling program for Home Electrical Appliance", and it defines a scope for refrigerators and refrigerator-freezers. This standard specifies household electric refrigerator of storage volume 1,000L or less, with a vapour compression type refrigeration system which has the rated power consumption less than 500W and storage cabinet integrated in one body. And it also specifies household electric freezers with a vapour compression type refrigeration system which has a rated power consumption less than 500W.

Summary of test procedure

The Korean test procedure, KS C 9305-96 *Household electric refrigerators, refrigerator-freezers and freezers* is NEQV to JIS C 9607 C-93 which is itself influenced by the ISO test procedures (ISO 5155, ISO 7371, ISO 8187 and ISO 8561).

The Korean standard differs from ISO in the following main respects:

- The ambient temperature used during the energy test is 30°C.
- Frozen food compartments in no-frost refrigerator-freezers are not loaded during energy consumption testing
- There is no temperature rise time test
- There is a freezer pull-down test and compulsory noise performance limits

The detailed elements of and differences between the KS C 9305-96 procedure and the ISO and ANSI/AHAM test procedures are indicated in Table 11.

Table 11: Main features of KS C 9305-96, ISO and ANSI/AHAM test procedures

Variable	KS C 9305-96	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	$30^oC \pm 1^oC$	$32.3^oC \pm 0.6^oC$	$25^oC \pm 0.5^oC$ [3]
Energy consumption fresh food temperature	3 ± 0.5^oC	$3.3/7.22^oC$ [4]	5^oC
Energy consumption freezer temperature [5]	$-6/-12/-18^oC$	$-15/-17.8^oC$ [6]	-18^oC
Freezer for energy consumption	sometimes loaded [7]	sometimes loaded [7]	loaded
Operation test ambient temperatures [8]	$15/30^oC$	$21.1/32.2/43.3^oC$ [9]	$16/32^oC$ [10]
Operation test fresh food temperatures [11]	$\leq 5^oC$	1.1^oC to 5^oC	0^oC to 5^oC [12]
Operation test freezer temperatures [13]	$\leq -18^oC/-12^oC/-6^oC$	$\leq -15/-17.8^oC$ [6]	$\leq -18^oC$ [14]
Pull down test	Yes	Yes	No
Freezing capacity test	Yes	No	Yes
Ice making capacity	No	Yes	Yes
Temperature rise time	No	No	Yes
Other performance tests	Yes [15]	Yes [15]	Yes [16]
Gross volume [17]	not specified	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	storage	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	NA	1.63	2.15
Separate freezer energy adjustment	No	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	mains powered electric vapour compression with volume limits[20]	all electric A.C. single phase systems [21]	Any [22]
Humidity	75±5%	not specified [23]	45% to 75%
Anti-sweat heaters during energy consumption tests	On	average on & off	only when needed
Door openings	No	No [24]	No

[1] The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

[2] There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

[3] Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

[4] AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22°C.

[5] Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/DOE compartment temperatures are the average of all temperatures points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

[6] A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers.

[7] Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm ± 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM are 130 × 100 × 40 mm and contain sawdust or spinach. Under the AHAM standard the freezer compartment is only loaded to 75% of its capacity. AHAM test packs are different from the test packs specified in ISO which are 200 × 100 × 50 mm and contain oxyethylmethylcellulose. KS C 9305-96 specifies test packs which are identical to ISO -1°C packs. Under ISO and KS C 9305-96 the freezer compartments are fully loaded (except for specified air gaps) unless the freezer compartment is no-frost when KS C 9305-96 stipulates that the compartment should not be loaded. KS C 9305-96 specifies 15mm air gaps between test packs and the freezer walls, while ISO specifies that they should be in contact.

[8] Temperature operation tests are conducted with freezer test packs for all three standards.

[9] The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS.

[10] This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

[11] Fresh food temperatures in all standards are averages. KS C 9305-96 specifies that thermocouples shall be placed inside metal blocks with a thermal mass of 20g water equivalent, while ISO usually specifies cylinders which have 2.3g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent.

[12] ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

[13] Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption.

[14] Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

[15] KS C 9305-96 specifies tests for refrigerant leakage defrosting performance, thermal insulation, power consumption, temperature test (concerned with maximum component temperatures for safety reasons), insulation resistance, dielectric withstand voltage, voltage variation characteristics, compressor starting characteristics, leakage current, door opening force, noise. Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

[16] Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

[17] Volumes for KS C 9305-96 differ from ISO in a number of minor areas.

[18] The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO and KS C 9305-96. However there are minor differences in the determination of storage volume under all of these standards.

[19] The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

[20] This is the scope of KS C 9305-96, which also only applies to refrigerators of 1000 L storage volume or less freezers of 400 L storage volume or less.

[21] This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

[22] ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

[23] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%), but not for energy consumption or operation tests.

[24] US DOE Code of Federal Regulations has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12±2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4th time for the freezer compartment, to obtain 24 fresh food and six freezer door openings in a 24 hour period.

Details

KS C 9305-96 categorises appliances as refrigerators, freezers or refrigerator-freezers. The following tests are required in KS C 9305-96:

- refrigerant leakage
- cooling performance (operating temperature performance test)
- cooling rate (pull down test)
- freezing performance
- defrosting performance
- thermal insulation
- power consumption
- electrical energy consumption
- temperature test (concerned with maximum component temperatures for safety reasons)
- insulation resistance
- dielectric withstand voltage
- voltage variation characteristics
- compressor starting characteristics
- leakage current
- door opening force
- noise
- storage volumes

As in the ISO test procedures, the KS C 9305-96 requires the refrigerators to be able to maintain pre-defined interior temperatures under a range of exterior temperatures (operating temperature performance test), although the temperature range of this test, which is from 15°C to 30°C, is narrower than required by ISO. Unlike the ISO test procedures, KS C 9305-96 requires the refrigerators to be able to satisfy a pull down test where the room temperature is maintained at 30°C and the appliance has to be able to reach specified interior operating temperatures within a 3 hour period; however, there is no rise time test in KS C 9305-96. Refrigerators with storage capacities less than 700 litres have to be able to pass a maximum noise requirement of 43dB(A) and for those with storage capacities of more than 700 litres have to be able to pass a maximum noise requirement of 48dB(A).

Test conditions and practices during the energy consumption test

The ambient temperature used during the energy consumption test is 30 ± 1°C and the interior temperatures have to be maintained at an average of 3± 0.5°C for the refrigerator compartment, -6± 0.5°C for a 1-star frozen food compartment, -12± 0.5°C for a 2-star frozen food compartment and -18± 0.5°C for a 3 or 4-star frozen food compartment. The compartmental interior temperature is defined as the value of a single temperature sensor in the fresh and frozen food compartments. The temperature sensors are thermocouples placed inside, and in good thermal contact with, a metallic mass having a thermal capacity of 20 g of water. All temperatures are recorded to an accuracy of ±0.5°C and are rounded to the nearest 0.1°C.

For the energy consumption test, there is no load in either the freezer compartment nor the fresh food compartment. The electrical energy consumption per 24 hours is determined after the steady state conditions are obtained under the test conditions. The energy consumption test period is commenced with a defrost operation. The measurement period is 24 hours where 2 or more defrost operations occur within the first 24 hours. Where there are less than 2 defrost operations in the first 24 hours, the test period is increased to 48 hours. Where there are less than 2 defrost operations in the first 48 hours, the test period is increased to 72 hours. Even where 2 defrost operations are not completed within 72 hours the maximum testing period shall be 72 hours. Measured energy consumption shall be within 115% of the rated value.

The annual electrical energy consumption and the annual average electrical energy consumption per month shall be calculated from the formula given below, and the annual average electrical energy consumption per month shall be determined by rounding off the first place of decimal of the value so obtained in accordance with KS A 0021.

$$Wy = Wd \times 365$$

$$Wm = Wy / 12$$

Wy: annual electrical energy consumption (kWh/year)

Wd: daily electrical energy consumption (kWh/day)

Wm: monthly electrical energy consumption (kWh/month)

The humidity is set at 75%±5% during the test.

Variables required to be declared for regulatory purposes include:

- The refrigerating appliance type
- Voltage, frequency and class
- Model identification marks
- Motor and auxiliary heater power levels (W)
- Electrical energy consumption(kWh/month)
- Storage volumes (total and by compartment) (L)

A:1.9 Mexico

Program: mandatory energy labelling and MEPS for refrigerators, refrigerator-freezers and freezers

Scope

The scope of the Mexican program is harmonised with those in the USA and Canada.

Summary of test procedure

NOM-015-ENER-97: *Energy efficiency of household electric refrigerators and freezers* specifies both the MEPS levels, labelling requirements and the test procedure. The latter is harmonised with the US DOE test procedure given in CFR Part 430 Subpart B Appendices A1 and B1 that are based on ANSI/AHAM HRF-1-1988 and CAN/CSA-C300-M89. The test procedure is significantly different to the equivalent ISO test procedures: ISO 5155, ISO 7371, ISO 8187 and ISO 8561. The main differences from ISO can be summarised as follows:

- NOM-015-ENER-97 does not use the star system to rate frozen food compartments in terms of their design operating temperature and freezing performance
- NOM-015-ENER-97 has no operating temperature performance requirements
- Freezing capacity is not tested for any type of freezer compartment
- The ambient test temperature used during the energy test is 32.2°C (almost equivalent to ISO conditions for tropical class appliances).
- Frozen food compartments are only loaded (75% full) during energy consumption testing for freezers and for non-frost free systems (no frost systems are not loaded during testing).
- The mean compartmental temperatures during the energy test are different.
- A post hoc adjustment factor is applied to the measured energy consumption of freezers to make the values more representative of in-use values.
- There are no rise time nor ice-making capacity tests
- Gross volume is not measured
- Door openings are included

The detailed elements of and differences between the NOM-015-ENER-97 test procedure and the ISO test procedures are indicated in Table 12.

Table 12: Main features of Mexican NOM-015, ISO and ANSI/AHAM test procedures

Variable	NOM-015-ENER-97	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	32.2^{o}C ± 0.6^{o}C	32.3^{o}C ± 0.6^{o}C	25^{o}C ± 0.5^{o}C [3]
Energy consumption fresh food temperature	3.3/7.2^{o}C [4]	3.3/7.22^{o}C [4]	5^{o}C
Energy consumption freezer temperature [5]	-9.4/-15/-17.8^{o}C [6]	-15/-17.8^{o}C [6]	-18^{o}C
Freezer for energy consumption	sometimes loaded [7]	sometimes loaded [7]	always loaded
Operation test ambient temperatures [8]	None	21.1/32.2/43.3^{o}C [9]	16/32^{o}C [10]
Operation test fresh Food temperatures [11]	None	1.1^{o}C to 5^{o}C	0^{o}C to 5^{o}C [12]
Operation test freezer temperatures [13]	None	≤-15/-17.8^{o}C [6]	≤-18^{o}C [14]
Pull down test	No	Yes	No
Freezing capacity test	No	No	Yes
Ice making capacity	No	Yes	Yes
Temperature rise time	No	No	Yes
Other performance tests	No	Yes [15]	Yes [16]
Gross volume [17]	not specified	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	storage	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	1.63	1.63	2.15
Separate freezer energy adjustment	0.7/0.85 [19]	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	all electric A.C., 60Hz, 115V [20]	all electric A.C., 60Hz, 115V single phase systems [20]	Any [21]
Humidity	not specified [22]	not specified [22]	45% to 75%
Anti-sweat heaters during energy consumption tests	average on & off	average on & off	only when needed
Door openings	no	no	no

[1] The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performed under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

[2] There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

[3] Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

[4] AHAM and NOM-015-ENER-97 regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.2°C.

[5] Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/AHAM and NOM-015-ENER-97 compartment temperatures are the average of all temperatures points taken at $\leq$ 4 minute intervals over the test period (excluding defrost cycles).

[6] A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers. In NOM-015-ENER-97 standard the freezer box in refrigerators with user operable controls that are not refrigerator-freezers should be regulated to operate at –9.4°C or the fresh food compartment to operate at 7.2°C, whichever setting gives the highest energy consumption.

[7] Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the NOM-015-ENER-97 test procedure specifies that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm $\pm$ 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM and NOM-015-ENER-97 (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM and NOM-015-ENER-97 are 130 $\times$ 100 $\times$ 40 mm and contain hardwood sawdust or spinach. Under the AHAM and NOM-015-ENER-97 standards the freezer compartment is only loaded to 75% of its capacity. AHAM/ NOM-015-ENER-97 test packs are different from the test packs specified in ISO which are 200 $\times$ 100 $\times$ 50 mm and contain oxyethylmethylcellulose. Under ISO the freezer compartments are fully loaded (except for specified air gaps). ISO specifies that the test packs should be in contact with the freezer walls and the freezer fully loaded, whereas AHAM/ NOM-015-ENER-97 specify that there should be an air gap of 15 to 40mm (0.5 to 1.5 inches), with the packages placed in a pyramid or tiered form if necessary to properly locate the thermocouples.

[8] Temperature operation tests are conducted with freezer test packs for the AHAM and ISO standards but not NOM-015-ENER-97.

[9] The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS. There is no simulated load test, either normative or informative, in the NOM-015-ENER-97 test procedure.

[10] This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

[11] Fresh food temperatures in all standards are averages. ISO usually specifies (see 12 below) that the thermocouples should be placed inside metal cylinders which have a thermal mass of 2.3 g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent. There is no temperature operation test in the NOM-015-ENER-97 test procedure.

[12] ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

[13] Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption. There is no temperature operation test in the NOM-015-ENER-97 test procedure.

[14] Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

[15] Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

[16] Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

[17] Gross volumes can differ between the ISO standard and AHAM/ NOM-015-ENER-97 in a number of minor areas. However, the most significant aspect is that the volume of air ducts (in a frost free system) within the liner shape is not counted as part of the gross volume under ISO.

[18] The only volume specified in AHAM and NOM-015-ENER-97 ("refrigerated volume") is essentially a storage volume equivalent under ISO. However there are minor differences in the determination of storage volume under all of the standards.

[19] The US DOE Code of Federal Regulations and NOM-015-ENER-97 specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

[20] This is the scope of the NOM-015-ENER-97 for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

[21] ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

[22] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% $\pm$ 2%) in the AHAM standard, but not for energy consumption or operation tests. Humidity conditions are not specified during the energy test in the NOM-015-ENER-97 test standard.

Details

The following tests are required in the NOM-015-ENER-97:

- total refrigerated volume and total shelf area
- rated gross and storage volumes
- energy consumption test

The NOM-015-ENER-97 test procedure does not require refrigerators to be able to maintain any pre-defined interior temperatures under a range of exterior temperatures nor to satisfy any other performance tests except to satisfy stated MEPS levels.

Test conditions and practices during the energy consumption test

The ambient temperature used during the energy consumption test is 32.3 ± 0.6°C including for refrigerator-freezers having variable defrost control (this is not the same as in Canada or the USA). The compartment temperatures have to be maintained at 3.3°C for pure refrigerator compartments, <7.2°C for the refrigerator compartments in refrigerator-freezers, -9.4°C for the freezer compartment in a refrigerator, -15°C for the freezer compartment in a refrigerator-freezer, and –17.8°C for a pure freezer (chest or upright).

The compartmental interior temperature is defined as the mean value of three sensor temperatures in both fresh and frozen food compartments. When food packs are not used the temperature sensors are thermocouples placed inside, and in good thermal contact with, a brass cylinder of 29 mm ± 6mm height and diameter. Food packs are not used to fill frozen food or freezer compartments during the energy test for automatic defrost (frost free) refrigerator-freezers and “all refrigerators” with ice makers. Freezer test packs are used to fill freezer compartments in all other appliance types. The freezer test packs used are 130 × 100 × 40 mm and contain hardwood sawdust or spinach. Thermocouples are located in the geometric centre of some of these test packs to measure the freezer temperature. The freezer compartment is only loaded to 75% of its capacity such that there should be an air gap of 15 to 40mm (0.5 to 1.5 inches), with the packages placed in a pyramid or tiered form if necessary to properly locate the thermocouples.

All temperatures are recorded to an accuracy of ±0.6°C. Sensor temperatures are recorded at least every 4 minutes during the test period. The test duration is a minimum of 1 hour and must run for a whole number of compressor cycles. For appliances with manual, semi-automatic or partial automatic defrost systems the test period is at least three hours and the compressor must complete at least 2 complete on-off cycles or remain in one on cycle. If less than 2 complete cycles occurs within 24 hours the test is terminated after 24 hours. For appliances with automatic defrost the test period shall run from one point in a defrost cycle to the same point in the next defrost cycle. Slightly different rules apply to units having: ‘long-time automatic defrost’ (where successive automatic defrost cycles are separated by a period of 14 hours or more), variable defrost control, or dual compressor automatic defrost systems. Steady-state conditions need to be attained before beginning any of the above test periods. Defrost systems, when present, are set to operate as normally intended by the manufacturer. Anti-sweat heaters are set to be on in one test and off in another.

The compartment temperature is defined as the arithmetic mean of the mean sensor temperatures. In practice, this means that a frozen food compartment temperature recorded under the NOM-015-ENER-97 standard would be equivalent to a higher temperature recorded under the ISO test procedures, due to the fact that test packages are not necessarily used and the compartment temperature is not deemed to be the highest temperature of any of the test packages, as in ISO. There is no humidity setting requirement, nor for any door openings during the test.

The energy consumption in kWh/day for manual, semi automatic and automatic defrost systems is given as:

$ET = EP \times 1440 \times T \times K$

where:

ET = test cycle energy consumption (kWh/d)

EP = energy consumed during the test period (kWh)

1440 = conversion factor to adjust to a 24 hour period in minutes per day

K = correction factor of 0.7 for chest freezers and 0.85 for upright freezers to adjust for average usage

T = length of time of the test period in minutes

Slightly different formulations are used for long-time automatic defrost, variable defrost control, and dual compressor with automatic defrost appliances. The K factor is the same for long-time automatic defrost systems but is set at 1 for variable defrost control and dual compressor automatic defrost systems.

Measured energy consumption must not be less than 3% of the declared value.

A:1.10 Philippines

Program: Mandatory labelling for refrigerators and refrigerator-freezers.

Scope

The Philippines is proposing mandatory labelling for household refrigerators and refrigerator-freezers in 1999.

Summary of test procedure

The Philippines energy efficiency regulations specify the use of four test procedures that are equivalent to the ISO procedures as follows:

PNS 1474-97 which is NEQV to ISO 5155-95

PNS 1475-97 which is NEQV to ISO 7371-95

PNS 1476-97 which is NEQV to ISO 8187-91

PNS 1477-97 which is NEQV to ISO 8561-95

Details of these test procedures are given under the section for international test procedures.

A:1.11 Russia

Program: MEPS for refrigerators, refrigerator-freezers and freezers

Scope

The current set of Russian MEPS for refrigerators, refrigerator-freezers and freezers have been in place since 1987. The MEPS and test procedures apply to vapour compression and absorption appliances rated at 220V and 50 Hz.

Summary of test procedure

The Russian energy efficiency regulations and test procedure, GOST 16317-87 *Electric domestic refrigerators. General Specifications* references the ISO procedures ISO 5155-83 and ISO 7371-85. Details of these test procedures are given under the section for international test procedures. The Russian test procedure is NEQV to these procedures but does not appear to differ significantly in any way that would effect the rated energy consumption.

A:1.12 Chinese Taipei

Program: MEPS for refrigerators, refrigerator-freezers and freezers.

Scope

Chinese Taipei has had MEPS for refrigerators, refrigerator-freezers and freezers since 1995. The regulations apply to electric refrigerators with a net volume of 700 L or less and to freezers with a net volume of 400 L or less.

Summary of test procedure

The Chinese Taipei test procedure, CNS 2062 (Classified No C4048) *Electric refrigerators and freezers* and the procedure, CNS 9577 (Classified No. C3164) *Method of test for electric refrigerators and freezers* are similar to JIS C 9607 C-93 which is itself influenced by the ISO test procedures (ISO 5155, ISO 7371, ISO 8187 and ISO 8561).

The Chinese Taipei standard differs from ISO in the following main respects:

- The ambient temperature used during the energy test is 30°C
- Refrigerator compartments operate at 3°C and there is a Super –2-star compartment that operates at –15°C
- There is no temperature rise time test
- There is a freezer pull-down test

The detailed elements of and differences between the CNS 2062-95 procedure and the ISO and ANSI/AHAM test procedures are indicated in Table 13.

Table 13: Main features of CNS 2062-95, ISO and ANSI/AHAM test procedures

Variable	CNS 2062-95	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	$30^{o}C \pm 1^{o}C$	$32.3^{o}C \pm 0.6^{o}C$	$25^{o}C \pm 0.5^{o}C$ [3]
Energy consumption fresh food temperature	$3 \pm 0.5^{o}C$	$3.3/7.22^{o}C$ [4]	$5^{o}C$
Energy consumption freezer temperature [5]	$-6/-12/-15/-18^{o}C$	$-15/-17.8^{o}C$ [6]	$-18^{o}C$
Freezer for energy consumption	loaded	sometimes loaded [7]	loaded
Operation test ambient temperatures [8]	$15/30^{o}C$	$21.1/32.2/43.3^{o}C$ [9]	$16/32^{o}C$ [10]
Operation test fresh food temperatures [11]	$\leq 5^{o}C$	$1.1^{o}C$ to $5^{o}C$	$0^{o}C$ to $5^{o}C$ [12]
Operation test freezer temperatures [13]	$\leq -18^{o}C/-15^{o}C$ / $-12^{o}C/-6^{o}C$	$\leq -15/-17.8^{o}C$ [6]	$\leq -18^{o}C$ [14]
Pull down test	Yes	Yes	No
Freezing capacity test	Yes	No	Yes
Ice making capacity	No	Yes	Yes
Temperature rise time	No	No	Yes
Other performance tests	Yes [15]	Yes [15]	Yes [16]
Gross volume [17]	not specified	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	storage	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	1.778	1.63	2.15
Separate freezer energy adjustment	No	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	mains powered electric vapour compression with volume limits[20]	all electric A.C. single phase systems [21]	Any [22]
Humidity	75±5%	not specified [23]	45% to 75%
Anti-sweat heaters during energy consumption tests	On	average on & off	only when needed
Door openings	No	No [24]	No

[1] The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

[2] There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

[3] Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

[4] AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22°C.

[5] Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/DOE compartment temperatures are the average of all temperatures points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

[6] A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers.

[7] Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm ± 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM are 130 × 100 × 40 mm and contain sawdust or spinach. Under the AHAM standard the freezer compartment is only loaded to 75% of its capacity. AHAM test packs are different from the test packs specified in ISO which are 200 × 100 × 50 mm and contain oxyethylmethylcellulose. CNS 2062-95 specifies test packs which are identical to ISO -1°C packs. Under ISO and CNS 2062-95 the freezer compartments are fully loaded (except for specified air gaps). CNS 2062-95 specifies 15mm air gaps between test packs and the freezer walls, while ISO specifies that they should be in contact.

[8] Temperature operation tests are conducted with freezer test packs for all three standards.

[9] The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS.

[10] This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

[11] Fresh food temperatures in all standards are averages. CNS 2062-95 specifies that thermocouples shall be placed inside metal blocks with a thermal mass of 20g water equivalent, while ISO usually specifies cylinders which have 2.3g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent.

[12] ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

[13] Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption.

[14] Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

[15] CNS 2062-95 specifies tests for refrigerant leakage defrosting performance, thermal insulation, power consumption, temperature test (concerned with maximum component temperatures for safety reasons), insulation resistance, dielectric withstand voltage, voltage variation characteristics, compressor starting characteristics, leakage current, door opening force. Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

[16] Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

[17] Volumes for CNS 2062-95 differ from ISO in a number of minor areas.

[18] The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO and CNS 2062-95. However there are minor differences in the determination of storage volume under all of these standards.

[19] The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

[20] This is the scope of CNS 2062-95, which also only applies to refrigerators of 700 L storage volume or less freezers of 400 L storage volume or less.

[21] This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

[22] ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

[23] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%), but not for energy consumption or operation tests.

[24] US DOE Code of Federal Regulations has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12±2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4th time for the freezer compartment, to obtain 24 fresh food and six freezer door openings in a 24 hour period.

Details

CNS 2062 categorises appliances as refrigerators, freezers or refrigerator-freezers. The following tests are required in CNS 2062:

- refrigerant leakage
- cooling performance (operating temperature performance test)
- cooling rate (pull down test)
- temperature distribution in the fresh food compartment
- freezing performance
- defrosting performance
- thermal insulation
- power consumption
- electrical energy consumption
- temperature test (concerned with maximum component temperatures for safety reasons)
- insulation resistance
- dielectric withstand voltage
- voltage variation characteristics
- compressor starting characteristics
- leakage current
- door opening force
- storage volumes

As in the ISO test procedures, the CNS 2062-95 procedure requires the refrigerators to be able to maintain pre-defined interior temperatures under a range of exterior temperatures (operating temperature performance test), although the range is narrower at 15°C to 30°C. Unlike the ISO test procedures, CNS 2062-95 requires the refrigerators to be able to satisfy a pull down test where the room temperature is maintained at 30°C and the appliance has to be able to reach specified interior operating temperatures within a 3 hour period; however, there is no rise time test in CNS 2062-95.

Test conditions and practices during the energy consumption test

The ambient temperature used during the energy consumption test is 30 ± 1°C and the interior temperatures have to be maintained at an average of 3± 0.5°C for the refrigerator compartment, -6± 0.5°C for a 1-star frozen food compartment, -12± 0.5°C for a 2-star frozen food compartment, -15± 0.5°C for a Super 2-star frozen food compartment and -18± 0.5°C for a 3 or 4-star frozen food compartment. The compartmental interior temperature is defined as the mean value of three sensor temperatures in both fresh and frozen food compartments. The temperature sensors are thermocouples placed inside, and in good thermal contact with, a metallic mass having a thermal capacity of 20 g of water. All temperatures are recorded to an accuracy of ±0.5°C and are rounded to the nearest 0.1°C. Food packs of an identical size and composition to those specified by ISO are used to fill frozen food or freezer compartments during the energy test. When freezer packs are used temperature sensors are inserted in a sample of the freezer packs in the same manner as described in ISO. The compartment temperature is defined as the arithmetic mean of the three mean sensor temperatures, except for frozen food compartments with freezer packs, when the mean of the coldest and warmest sensor reading is used. In practice, this is likely to mean that a frozen food compartment temperature recorded under CNS 2062-95 would be equivalent to a higher temperature recorded under the ISO test procedures, due to the fact that the compartment temperature is not deemed to be the highest temperature of any of the test packages, as in ISO.

Defrost systems, when present, are set to operate as normally intended by the manufacturer. Manual defrost devices are not operated, but those that are meant to activated once a day are activated 14 hours into the test. The humidity is set at 75%±5% during the test. The test duration is 24 hours at each ambient temperature. The monthly energy consumption, W, is given as:

W (kWh/month) = W_{30} (kWh/24h)×30

where W_{30} is the energy consumption (kWh/24h) measured at 30°C ambient temperature.

Variables required to be declared for regulatory purposes include:

- The refrigerating appliance type
- Voltage, frequency and class
- Model identification marks
- Motor and auxiliary heater power levels (W)
- Electrical energy consumption (kWh/month)
- storage volumes (total and by compartment) (L)

Electrical energy consumption should be no more than 115% of the declared value.

A:1.13 Thailand

Program: Voluntary labelling for refrigerators and refrigerator-freezers.

Scope

Thailand has had a voluntary energy labelling scheme in place for household refrigerators and refrigerator freezers since 1994. This became mandatory in 1999 and they are currently considering MEPS.

Summary of test procedure

The Thai test procedure, TIS 455-2537 (1994) *Household refrigerators.* references the ISO procedure ISO 7371-85. Details of this test procedure is given under the section for international test procedures. The Thai test procedure is NEQV to this procedure but does not appear to differ significantly in any way that would effect the rated energy consumption.

A:1.14 USA

Program: mandatory energy labelling and MEPS for refrigerators, refrigerator-freezers and freezers

Scope

The USA has mandatory energy labelling for refrigerators and freezers and MEPS. MEPS applies to refrigerator-freezers up to 1104 litres and freezers up to 850 litres.

Summary of test procedure

The US DOE specifies the test procedure, in the CFR Part 430 Subpart B Appendices A1 and B1 *Uniform test method for measuring the energy consumption of electric refrigerators and electric refrigerator-freezers* and *Uniform test method for measuring the energy consumption of freezers* respectively that are based on ANSI/AHAM HRF-1-1988. The test procedure is significantly different to the equivalent ISO test procedures: ISO 5155, ISO 7371, ISO 8187 and ISO 8561. The main differences from ISO can be summarised as follows:

- The US DOE standard does not use the star system to rate frozen food compartments in terms of their design operating temperature and freezing performance
- The US DOE standard has no operating temperature performance requirements
- Freezing capacity is not tested for any type of freezer compartment
- The ambient test temperature used during the energy test is 32.3°C (almost equivalent to ISO conditions for tropical class appliances).
- Frozen food compartments are only loaded (75% full) during energy consumption testing for freezers and for non-frost free systems (no frost systems are not loaded during testing).
- The mean compartmental temperatures during the energy test are different.
- A post hoc adjustment factor is applied to the measured energy consumption of freezers to make the values more representative of in-use values.
- There are no rise time nor ice-making capacity tests
- Gross volume is not measured
- Door openings are included for units with variable defrost control

The detailed elements of and differences between the US DOE test procedure and the ISO test procedure are indicated in Table 14.

Table 14: Main features of the US DOE, ISO and ANSI/AHAM test procedures

Variable	US DOE	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	32.3^{o}C ± 0.6^{o}C	32.3^{o}C ± 0.6^{o}C	25^{o}C ± 0.5^{o}C [3]
Energy consumption fresh food temperature	3.3/7.22^{o}C [4]	3.3/7.22^{o}C [4]	5^{o}C
Energy consumption freezer temperature [5]	-9.4/-15/-17.8^{o}C [6]	-15/-17.8^{o}C [6]	-18^{o}C
Freezer for energy consumption	sometimes loaded [7]	sometimes loaded [7]	always loaded
Operation test ambient temperatures [8]	None	21.1/32.2/43.3^{o}C [9]	16/32^{o}C [10]
Operation test fresh Food temperatures [11]	None	1.1^{o}C to 5^{o}C	0^{o}C to 5^{o}C [12]
Operation test freezer temperatures [13]	None	≤-15/-17.8^{o}C [6]	≤-18^{o}C [14]
Pull down test	No	Yes	No
Freezing capacity test	No	No	Yes
Ice making capacity	No	Yes	Yes
Temperature rise time	No	No	Yes
Other performance tests	No	Yes [15]	Yes [16]
Gross volume [17]	not specified	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels	all levels
Volume used for MEPS and energy labelling	storage	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	1.63	1.63	2.15
Separate freezer energy adjustment	0.7/0.85 [19]	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	all electric A.C., 60Hz, 115V [20]	all electric A.C., 60Hz, 115V single phase systems [20]	Any [21]
Humidity	not specified [22]	not specified [22]	45% to 75%
Anti-sweat heaters during energy consumption tests	average on & off	average on & off	only when needed
Door openings	for variable defrost systems [23]	no	no

1 The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

2 There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

3 Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

4 AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22°C.

5 Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/DOE compartment temperatures are the average of all temperatures points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

6 A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers. In US DOE standard the freezer box in refrigerators with user operable controls that are not refrigerator-freezers should be regulated to operate at –9.4°C or the fresh food compartment to operate at 7.2°C, whichever setting gives the highest energy consumption.

7 Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedure specifies that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA and Canada) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm ± 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM and US DOE standard are 130 × 100 × 40 mm and contain hardwood sawdust or spinach. Under the AHAM and US DOE standards the freezer compartment is only loaded to 75% of its capacity. AHAM/US DOE test packs are different from the test packs specified in ISO which are 200 × 100 × 50 mm and contain oxyethylmethylcellulose. Under ISO the freezer compartments are fully loaded (except for specified air gaps). ISO specifies that the test packs should be in contact with the freezer walls and the freezer fully loaded, whereas AHAM/US DOE specify that there should be an air gap of 15 to 40mm (0.5 to 1.5 inches), with the packages placed in a pyramid or tiered form if necessary to properly locate the thermocouples.

8 Temperature operation tests are conducted with freezer test packs for the AHAM and ISO standards but not US DOE.

9 The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS. There is no simulated load test, either normative or informative, in the US DOE test procedure.

10 This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

11 Fresh food temperatures in all standards are averages. ISO usually specifies (see 12 below) that the thermocouples should be placed inside metal cylinders which have a thermal mass of 2.3 g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent. There is no temperature operation test in the US DOE test procedure.

12 ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

13 Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption. There is no temperature operation test in the US DOE test procedure.

14 Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

15 Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

16 Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

17 Gross volumes can differ between the ISO standard and AHAM/US DOE in a number of minor areas. However, the most significant aspect is that the volume of air ducts (in a frost free system) within the liner shape is not counted as part of the gross volume under ISO.

18 The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO. However there are minor differences in the determination of storage volume under all of the standards.

19 The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

20 This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

21 ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

22 Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%) in the AHAM standard, but not for energy consumption or operation tests. Humidity conditions are not specified during the energy test in the US DOE test standard except for use in an optional test for units having variable defrost control when the ambient temperature conditions shall be 26.6±1.1°C dry bulb and 19.4±0.6°C wet-bulb.

23 US DOE has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12±2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4th time for the freezer compartment, to obtain 24 fresh food and six freezer door openings in a 24 hour period.

Details

The following tests are required in the US DOE CFR Part 430 Subpart B Appendices A1 and B1:

- total refrigerated volume and total shelf area
- rated gross and storage volumes
- energy consumption test

The US DOE test procedure does not require refrigerators to be able to maintain any pre-defined interior temperatures under a range of exterior temperatures nor to satisfy any other performance tests except to satisfy stated MEPS levels.

Test conditions and practices during the energy consumption test

The ambient temperature used during the energy consumption test is 32.3 ± 0.6°C except for an optional test for refrigerator-freezers having variable defrost control, when the ambient temperature conditions shall be 26.6±1.1°C dry bulb and 19.4±0.6°C wet-bulb. The compartment temperatures have to be maintained at 3.3°C for pure refrigerator compartments, <7.22°C for the refrigerator compartments in refrigerator-freezers, -9.4°C for the freezer compartment in a refrigerator, -15°C for the freezer compartment in a refrigerator-freezer, and –17.8°C for a pure freezer (chest or upright).

The compartmental interior temperature is defined as the mean value of three sensor temperatures in both fresh and frozen food compartments. When food packs are not used the temperature sensors are thermocouples placed inside, and in good thermal contact with, a brass cylinder of 29 mm ± 6mm height and diameter. Food packs are not used to fill frozen food or freezer compartments during the energy test for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA) and "all refrigerators" with ice makers. Freezer test packs are used to fill freezer compartments in all other appliance types. The freezer test packs used are 130 × 100 × 40 mm and contain hardwood sawdust or spinach. Thermocouples are located in the geometric centre of some of these test packs to measure the freezer temperature. The freezer compartment is only loaded to 75% of its capacity such that there should be an air gap of 15 to 40mm (0.5 to 1.5 inches), with the packages placed in a pyramid or tiered form if necessary to properly locate the thermocouples.

All temperatures are recorded to an accuracy of ±0.6°C. Sensor temperatures are recorded at least every 4 minutes during the test period. The test duration is a minimum of 1 hour and must run for a whole number of compressor cycles. For appliances with manual, semi-automatic or partial automatic defrost systems the test period is at least three hours and the compressor must complete at least 2 complete on-off cycles or remain in one on cycle. If less than 2 complete cycles occurs within 24 hours the test is terminated after 24 hours. For appliances with automatic defrost the test period shall run from one point in a defrost cycle to the same point in the next defrost cycle. Slightly different rules apply to units having: 'long-time automatic defrost' (where successive automatic defrost cycles are separated by a period of 14 hours or more), variable defrost control, or dual compressor automatic defrost systems. Steady-state conditions need to be attained before beginning any of the above test periods. Defrost systems, when present, are set to operate as normally intended by the manufacturer. Anti-sweat heaters are set to be on in one test and off in another. The quick freeze option is switched off unless otherwise specified.

The compartment temperature is defined as the arithmetic mean of the mean sensor temperatures. In practice, this means that a frozen food compartment temperature recorded under the US DOE standard would be equivalent to a higher temperature recorded under the ISO test procedures, due to the fact that test packages are not necessarily used and the compartment temperature is not deemed to be the highest temperature of any of the test packages, as in ISO. There is no humidity setting requirement, nor for any door openings during the test except when testing appliances with a variable defrost control, when door openings lasting for 12±2 seconds are made every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4^{th} time for the freezer compartment.

The energy consumption in kWh/day for manual, semi automatic and automatic defrost systems is given as:

$ET = EP \times 1440 \times T \times K$

where:

ET = test cycle energy consumption (kWh/d)

EP = energy consumed during the test period (kWh)

1440 = conversion factor to adjust to a 24 hour period in minutes per day

K = correction factor of 0.7 for chest freezers and 0.85 for upright freezers to adjust for average usage

T = length of time of the test period in minutes

Slightly different formulations are used for long-time automatic defrost, variable defrost control, and dual compressor with automatic defrost appliances. The K factor is the same for long-time automatic defrost systems but is set at 1 for variable defrost control and dual compressor automatic defrost systems.

A:1.15 ISO 7371.2-95, ISO 8187-91, ISO 5155.2-95 & ISO8561/DAM 1

Summary of test procedures

These four test procedures address: refrigerators with or without low-temperature compartment, refrigerator-freezers, frozen food storage cabinets and food freezers, and refrigerators, refrigerator-freezers, frozen food storage cabinets and food freezers cooled by internal forced air circulation, respectively.

The detailed elements of and differences between the ISO test procedures and the ANSI/AHAM test procedures are indicated in Table 15.

Table 15: Main features of ISO and ANSI/AHAM test procedures

Variable	ANSI/AHAM [1]	ISO [2]
Energy consumption ambient temperature	$32.3^oC \pm 0.6^oC$	$25^oC \pm 0.5^oC$ [3]
Energy consumption fresh food temperature	$3.3/7.22^oC$ [4]	5^oC
Energy consumption freezer temperature [5]	$-15/-17.8^oC$ [6]	-18^oC
Freezer for energy consumption	sometimes loaded [7]	loaded
Operation test ambient temperatures [8]	$21.1/32.2/43.3^oC$ [9]	$16/32^oC$ [10]
Operation test fresh food temperatures [11]	1.1^oC to 5^oC	0^oC to 5^oC [12]
Operation test freezer temperatures [13]	$\leq -15/-17.8^oC$ [6]	$\leq -18^oC$ [14]
Pull down test	Yes	No
Freezing capacity test	No	Yes
Ice making capacity	Yes	Yes
Temperature rise time	No	Yes
Other performance tests	Yes [15]	Yes [16]
Gross volume [17]	not specified	total only (not specified at sub-compartment level)
Storage volume [18]	all levels	all levels
Volume used for MEPS and energy labelling	storage	storage in EU
Freezer compartment adjustment factor (adjusted volume)	1.63	2.15
Separate freezer energy adjustment	0.7/0.85 [19]	No
Energy sources and refrigeration systems covered	all electric A.C. single phase systems [21]	Any [22]
Humidity	not specified [23]	45% to 75%
Anti-sweat heaters during energy consumption tests	average on & off	only when needed
Door openings	No [24]	No

1 The current AHAM refrigerator standard is AHAM HRF-1-1988. However, most energy consumption data in the USA is performance under the US Department of Energy Code of Federal Regulations (CFR Part 430 Subpart B Appendices A1 and B1) which draws in parts of the AHAM standard but also modifies parts. DOE regulations have precedence regarding all mandatory US government requirements for energy labelling and MEPS. Note that DOE regulations cite AHAM HRF-1-1979 and not the current version.

2 There are 4 main ISO standards for refrigerator performance and energy consumption. These are ISO 5155 (freezers), ISO 7371 (refrigerators without freezers), ISO 8187 (refrigerator-freezers) and ISO 8561 (forced air/frost free units). In 1996 ISO accepted a new work item proposal to combine these 4 standards into a single document.

[3] Ambient test temperature for energy consumption under ISO is 25°C for all climate classes except Tropical, which is at 32°C.

[4] AHAM and DOE regulations only specify a fresh food compartment temperature of 3.3°C for "all refrigerators" (i.e. fresh food compartments with either no freezer or a small ice-making sub-compartment of less than 14.2 litres). For tests on refrigerator-freezers, the fresh food temperature has only to be below 7.22°C.

[5] Freezer compartments in this table refer to compartments intended for the long term storage of frozen food. There are numerous other frozen and unfrozen compartment types not covered by this table. ISO report compartment temperatures as the warmest test package position at the warmest part of the cycle for all tests. ANSI/DOE compartment temperatures are the average of all temperatures points taken at ≤ 4 minute intervals over the test period (excluding defrost cycles).

[6] A freezer temperature of -15°C applies to refrigerator-freezers while -17.8°C applies to separate freezers.

[7] Note that HRF-1-1979 specifies that for energy consumption tests all freezer compartments shall be loaded. However, the DOE CFR 430 test procedures specify that freezer packs are not to be used in the determination of energy consumption for automatic defrost (frost free) refrigerator-freezers (the most common appliance type in the USA) and "all refrigerators" with ice makers. In these cases, freezer compartment temperatures are measured with thermocouples inside metallic cylinders of 29mm ± 6mm (the metal is not specified, but if it were copper, this would equate to a thermal mass of between 8g and 28g water equivalent). All other appliance types under AHAM (including all separate freezers) are tested with the freezer compartment loaded. The freezer test packs used under AHAM are 130 × 100 × 40 mm and contain sawdust or spinach. Under the AHAM standard the freezer compartment is only loaded to 75% of its capacity. AHAM test packs are different from the test packs specified in ISO which are 200 × 100 × 50 mm and contain oxyethylmethylcellulose. Under ISO and GB 12021.2 the freezer compartments are fully loaded.

[8] Temperature operation tests are conducted with freezer test packs for all three standards.

[9] The "simulated load test" under AHAM has only recommended levels of performance and is not a mandatory requirement for refrigerators in the USA under DOE regulations for labelling or MEPS.

[10] This is the temperature range for ISO Temperate, which is the most common climate rating in Europe. Other ISO climate ratings include Extended Temperate (10°C/32°C), Sub-tropical (18°C/38°C) and Tropical (18°C/43°C).

[11] Fresh food temperatures in all standards are averages. ISO usually specifies that thermocouples should be placed inside cylinders which have 2.3g water equivalent. AHAM allows thermocouples to be weighted or unweighted, but where weighted, the thermal mass shall not be greater than 20g of water equivalent.

[12] ISO average fresh food compartment temperatures are to remain at less than 5°C, but this may rise to 7°C during defrosting in a frost free appliance. In addition to this requirement, the temperatures at each of the measuring points in the fresh food compartment (generally three points) must remain within the range 0°C to 10°C throughout the test (so a theoretical minimum average compartment temperature is 0°C, but in practice the actual minimum achievable would be higher). Note that fresh food compartment temperatures in ISO are measured with single suspended M freezer packages in ISO 8561 while they are measured with copper or brass masses in ISO 7371 and ISO 8187.

[13] Allowable freezer pack temperature ranges for an operation test are generally less than or equal to the target temperature for energy consumption.

[14] Test pack temperatures are allowed to rise to -15°C during defrosting cycles.

[15] Other AHAM tests for performance are related to durability and include handling and storage test (for packaging), external surface condensation test, internal moisture accumulation test, environmental cracking resistance test and bottom breaker strip impact test. AHAM does not recommend minimum levels of performance for these tests.

[16] Other ISO performance tests include door air tightness, door opening force, durability of hinges and doors and mechanical strength of shelves. ISO does specify minimum requirements for each of these performance tests.

[17] Volumes for AHAM differ from ISO in a number of minor areas.

[18] The only volume specified in AHAM ("refrigerated volume") is essentially a storage volume equivalent under ISO and GB 12021.2. However there are minor differences in the determination of storage volume under all of these standards.

[19] The US DOE Code of Federal Regulations specifies that the measured energy consumption is adjusted by a factor of 0.7 for chest freezers and 0.85 for vertical freezers "to adjust for average household usage".

[21] This is the scope of the US DOE Code of Federal Regulations for the purposes of energy labelling and MEPS. The AHAM standard includes all electric units (but specifically excludes gas powered types).

[22] ISO 8561 (forced air/frost free units) covers electric refrigerators only. The other three ISO standards include products using any fuel type.

[23] Humidity is specified for some of the other performance tests such as external condensation and internal moisture accumulation (at 75% ± 2%), but not for energy consumption or operation tests.

[24] US DOE Code of Federal Regulations has an optional test for refrigerator-freezers having variable defrost control that requires door openings for 12±2 seconds every 60 minutes for the fresh food compartment and a simultaneous 12±2 seconds every 4^{th} time for the freezer compartment, to obtain 24 fresh food and six freezer door openings in a 24 hour period.

Details

The ISO procedures categorise appliances as refrigerators, freezers or refrigerator-freezers or any of these cooled by internal forced air circulation.

The following tests are required:

- determination of linear dimensions, volumes and areas
- air tightness
- door opening force
- durability of hinges and handles
- mechanical strength of shelves and components
- storage temperature test (operating temperature performance test)
- water vapour condensation test
- energy consumption test
- temperature rise test
- ice-making test
- test for absence of odour and taste
- freezing test

The ISO procedure requires the refrigerators to be able to maintain pre-defined interior temperatures under a range of ambient temperatures (storage temperature test). These ambient temperature ranges depend on the climate classification of the appliance as follows:

SN (Extended temperate) +10 to +32°C

N (Temperate) +16 to +32°C

ST (Temperate) +18 to +38°C

ST (Subtropical) +18 to +38°C

T (Tropical) +18 to +43°C

The predefined temperatures correspond to the ISO compartment classification as follows:

Fresh food storage compartment = +5°C

One star compartment ≤ -6°C

Two star compartment ≤ -12°C

Three star compartment ≤ -18°C

Four star compartment ≤ -18°C (but having a minimum freezing capacity of 4.5kg/100 litres/24 hours.

Test conditions and practices during the energy consumption test

The ambient temperature used during the energy consumption test is 25 ± 0.5°C for SN, N and ST class appliances and 32 ± 0.5°C for T class appliances. The interior temperatures have to be maintained at an average of 5± 0.5°C for the refrigerator compartment, -6± 0.5°C for a 1-star frozen food compartment, -12± 0.5°C for a 2-star frozen food compartment and -18± 0.5°C for a 3 or 4-star frozen food compartment. The compartmental interior temperature is defined as the mean value of three sensor temperatures in the fresh food compartments. The temperature sensors are thermocouples placed inside, and in good thermal contact with, a copper or brass cylinder having a mass of 25g and diameter and height of about 15.2mm. All temperatures are recorded to an accuracy of ±0.3°C and are rounded to the nearest 0.1°C. Frozen food compartments are tested fully loaded using freezer packs. Freezer packs are made of a mixture designed to resemble the properties of lean beef and of a size of 25x50x100mm and 125g, or 50×100×100 and 500g or 50×100×200 and 1000g.

When freezer packs are used temperature sensors are inserted in a sample of the freezer packs. The compartment temperature is defined as the arithmetic mean of the three mean sensor temperatures, except for frozen food compartments with freezer packs, when the mean of the warmest sensor reading is used.

Defrost systems, when present, are set to operate as normally intended by the manufacturer. The humidity is set at between 45% and 75% during the test. Manual anti-sweat heaters are not activated during the energy test unless they are needed to pass the water vapour condensation test. The test duration is a minimum of 24 hours and must comprise a whole number of control cycles for cyclic refrigerators without automatic defrosting and up to 48 hours for appliances with automatic defrosting.

Variables required to be declared for regulatory purposes include:

- The refrigerating appliance type
- Climate class (SN, N, ST, T)
- Model identification marks
- Electrical energy consumption (kWh/24h) to two decimal places
- storage volumes (total and by compartment) (L)
- rated total gross volume (L)

Electrical energy consumption should be no more than 115% of the declared value – if it is a sample of three appliances are tested and their mean energy consumption should be no more than 110% of the declared value.

A:1.16 Summary of refrigerator rating temperatures for energy

Table 16: General refrigerator temperature requirements for various test standards (°C)

Cabinet type			AS/NZS	ISO	ANSI/AHAM	JIS[a]	CNS
All-Refrigerators		Ambient	32 ± 0.5°C	25/32 ± 0.5°C	32.2 ± 0.6°C	15/30 ± 1°C	30 ± 1°C
		Fresh food	3 ± 0.5°C	5°C	3.3°C	3 ± 0.5°C	3 ± 0.5°C
		Freezer	–	–	–	–	–
Refrigerator-Freezers[b]	*	Ambient	32 ± 0.5°C	25/32 ± 0.5°C	32.2 ± 0.6°C	15/30 ± 1°C	–
		Fresh food	3 ± 0.5°C	5°C	7.2°C	3 ± 0.5°C	–
		Freezer	–9 ± 0.5°C	–6°C	–9.4°C	–6 ± 0.5°C	–
	**	Ambient	32 ± 0.5°C	25/32 ± 0.5°C	32.2 ± 0.6°C	15/30 ± 1°C	30 ± 1°C
		Fresh food	3 ± 0.5°C	5°C	7.2°C	3 ± 0.5°C	3 ± 0.5°C
		Freezer	–15 ± 0.5°C	–12°C	–15°C	–12 ± 0.5°C	–12/–15 ± 0.5°C
	***	Ambient	–	25/32 ± 0.5°C	–	15/30 ± 1°C	30 ± 1°C
		Fresh food	–	5°C	–	3 ± 0.5°C	3 ± 0.5°C
		Freezer	–	–18°C	–	–18 ± 0.5°C	–18 ± 0.5°C
Freezers		Ambient	32 ± 0.5°C	25/32 ± 0.5°C	32.2 ± 0.6°C	15/30 ± 1°C	30 ± 1°C
		Fresh food	–	–	–	–	–
		Freezer	15 ± 0.5°C	–18°C	–17.8°C	–18 ± 0.5°C	–18 ± 0.5°C

[a] 73% of the consumption is weighted at an ambient of 15°C and 27% at 30°C.
[b] For star ratings (*, **, ***), refer to section 3.4.
Data from Bansal & Kruger (1994)

Table 17: Energy consumption test requirements for household refrigerators

	AS/NZS	ISO	ANSI/AHAM	JIS	CNS
Installation of the refrigerator	Such that any shielding on either side of the cabinet is 300 ± 10 mm	On a wooden platform	Such that the distance from the wall is ≥254 mm	–	See manual[12]
Stable operating conditions	$\Delta T_{FF} \leq 0.5$°C/6 h $\Delta T_{FR} \leq 0.5$°C/6 h Over more than two cycles	$\Delta T_{FF} \leq 0.5$°C/24 h $\Delta T_{FR} \leq 0.5$°C/24 h	$\Delta T_{FF} \leq 0.023$°C/h $\Delta T_{FR} \leq 0.023$°C/h		$\Delta T_{FF} \leq 1$°C/24 h $\Delta T_{FR} \leq 1.25$°C/24 h
Humidity	Needs not to be controlled	45–75%	Needs not to be controlled	75 ± 5%	75 ± 5%
Ambient temperature					
Max vertical temp gradient	1°C/m from floor to 2 m height	2°C/m from platform to 2 m height	0.9°C/m from 51 mm above the floor	3°C from 50 mm above the floor	3°C from 50 mm above the floor to 2 m height
No of M points	1	3	2	1	1
Location of M points	250–350 mm from the front mid-height position	350 mm from the side/front walls	915 mm above the floor and 254 mm from the centre of the two sides	Either side of refrigerator to get a mean value	See manual[12]
Calculation	$T_A = T(T_{A1})^a$	$T_A = T(T_{A1}, T_{A2}, T_{A3})^a$	$T_A = T(T_{A1}, T_{A2})^a$	$T_A = ½(T_{Amax} + T_{Amin})$	$T_A = ½(T_{Amax} + T_{Amin})$
Fresh-food compartment					
No. Of M points	3	3	3	3	1
Compartment temperature	$T_{FF} = T(T_{FF1}, T_{FF2}, T_{FF3})$ i.e. mean of the average of all measured temperatures at that point	$T_{FF} = T(T_{FF1}, T_{FF2}, T_{FF3})$ with $T_{FFi} = ½(T_{FFimax} + T_{FFimin})$ where i = 1, 2, 3	$T_{FF} = T(T_{FF1}, T_{FF2}, T_{FF3})$	$T_{FF} = T(T_{FF1}, T_{FF2}, T_{FF3})$ with $T_{FFi} = ½(T_{FFimax} + T_{FFimin})$ where i = 1, 2, 3	$T_{FF} = ½T(T_{FFmax} + T_{Amin})$ i.e. mean of the highest and the lowest recorded temperature
Freezer compartment					
Test load	No	Yes (100%)	Yes (75%); no load in automatic defrost models	No	No

Table 17: Energy consumption test requirements for household refrigerators (continued)

	AS/NZS	ISO	ANSI/AHAM	JIS	CNS
No. Of M points	5	4–6	3–12	1	1
Size of M packs	–	50 × 100 × 100 mm	40 × 100 × 130 mm	–	–
Compartment temperature	T_{FR} = T(T_{FRi}), where i = 1–5 without the coldest sensor, i.e. mean of all recorded temperatures	T_{FR} = T_{FRmax}, i.e. maximum temperature of the warmest M package	T_{FR} = T(T_{FRi}), mean of all the recorded temperatures	T_{FR} = ½(T_{FRmax} + T_{FRmin}), i.e. mean of the highest and the lowest measured values	T_{FR} = ½(T_{FRmax} + T_{FRmin}), mean of the highest and the lowest measured values
Auto defrost operates.	Yes	Yes	Yes (manual defrost also)	Yes (not manual defrost)	Yes (not man. defrost)
Door openings	–	–	–	During first 10 h of test: a) FF every 12 min for 10 seconds b) FR every 40 min for 10 seconds **	–
Temperature readings	At least every 30 min for at least every 3 h		At least every 4 min		
Test period					
General	≥16 h but only until 1 kWh of energy is consumed	≥24 h	≥3 h and ≤24 h, so that compressor completes two or more whole cycles	= 24 h1	= 24 h
With automatic defrost	From a point in one defrost cycle to a corresponding point in another cycle	Complete defrost cycles (if no defrost cycle starts during 24 h, the test period shall be 48 h)	From one point during a defrost period to the same point during the next defrost period	a) If defrosting once a day, start after 14 h after commencement of the test b) Others shall start > 5 h	a) If defrosting once a day, shall start > 14 h after commence the test b) Others to start > 5 h
Without automatic defrost	Between two compressor switch-off cycles	Whole number of control cycles	Whole number of control cycles		

[a] Mean of the average of all recorded temperatures. ** Freezer door shall not be opened when it is inside the cabinet

A:2 Automatic Icemakers

A:2.1 Canada

Program: mandatory MEPS for automatic icemakers

Summary of Test Procedure

Energy efficiency requirements are set in out in the Canadian regulations and the Guide to Canada's Energy Efficiency Regulations. Icemakers are intended for commercial use with a capacity of 23 kg and 1000 kg per day (residential units are exempt). The test procedure is set out in CAN/CSA-C742-98 and is equivalent to ARI 810/820 and ASHRAE 29. Test conditions are:

- Ambient temperature 32^{o}C
- Water inlet temperature 21^{o}C
- Water pressure 207 kPa
- Initial ice temperature 0^{o}C

Capacity is defined in terms of kg per 24 hours. Energy consumption is defined as kJ per kg of ice harvested. Limits on energy input are defined in the standard, as well as a measure of storage effectiveness (maximum allowable proportion of ice melted over a 4 hour period after product when bins are exposed to ambient conditions for 2 hours prior to ice production).

Canada is the only economy to regulate automatic icemakers and already uses a relevant regional test procedure.

A:3 Refrigerated Display Cabinets

A:3.1 Canada

Program: mandatory MEPS for refrigerated display cabinets

Summary of Test Procedure

Energy efficiency requirements are proposed by one province in Canada (New Brunswick) but as of early 1999 no regulations were in force. Efficiency requirements and the test procedure are set out in CAN/CSA-C657-95. The nature of this test procedure has not been determined for this report.

ANNEX B: SPACE CONDITIONING EQUIPMENT

This Annex reviews the test procedures for space conditioning equipment. The types of equipment covered and the order of coverage is as follows:

- Room air conditioners – air source heat exchangers of the vapour compression type. These include non ducted (small unitary, split and multi-split) spot systems and small ducted systems. Includes cooling only, reverse cycle and heat pump.
- Central air conditioners – air source heat exchangers of the vapour compression type. Includes large central air conditioners (usually commercial systems) and large packaged systems. Includes cooling only, reverse cycle and heat pump.
- Other air conditioners – non-air source types. Includes cooling only, reverse cycle and heat pump.
- Dehumidifiers
- Water chillers (commercial applications)
- Electric resistance space heaters.

Note that evaporative air conditioners are not regulated in APEC economies, so these are not included. Also, a number of APEC economies are considering the regulation of various air conditioner type, but the details of these test procedures have not been included in some cases.

The first section is on product definitions, as these vary considerably across APEC economies, as well as internationally.

B:1 Air conditioners and heat pumps - definitions

B:1.1 Overview of product types

The terms used to define air conditioner and heat pump product types used in the APEC member economy energy efficiency regulations are shown in Table 18; however, these terms do not always refer to the same product types and do not always correspond to the definition given in the associated test procedures. APEC member economies use a variety of different definitions for air conditioner and heat pump equipment that reflects the different traditions and prevalent equipment types found in each economy. These differences considerably complicate the interpretation of the energy efficiency regulations applicable to specific types of air conditioning equipment and necessitates that a section is dedicated to explaining the terminology commonly used in APEC economies.

Table 18: Terms used in air conditioner and heat pump regulations within APEC

Type of air conditioner	Australia	Canada	Hong Kong	Japan	Korea	Mexico	Philippines	Chinese Taipei	Thailand	USA
Room	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Packaged terminal[1]		✓								✓
Unitary					✓			✓		
Central						✓				
Single-package central[1]		✓								✓
Split-system central[1]		✓								✓
Large-air conditioners[1]		✓								
Large condensing units		✓								
Water-source heat pumps		✓								
Ground-source heat pumps		✓								
Internal water-loop heat Pumps		✓								
Dehumidifiers		✓								

1 including heat pumps

As a result of the difficulties in definition, the descriptions of the various test procedures and their applicability will be grouped into the following product types: room air conditioners and heat pumps, central and large air conditioners and heat pumps, non-air-source heat pumps and dehumidifiers. Each of these sections will be addressed in turn.

B:1.2 Definitions by product type

International definitions

Non-ducted air conditioner: An encased assembly or assemblies designed as a unit, primarily for mounting in a window, or through a wall, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration for cooling and dehumidification and may also include means for heating other than a heat pump, and means for the circulation and the cleaning of air. It may also include means for heating, humidifying, ventilating or exhausting air. Where such equipment is provided in more than one assembly, the separated assemblies (split-systems) are to be designed to be used together, and the rating requirements based on the use of the matched assemblies.

Non-ducted heat pump: An encased assembly or assemblies designed as a unit, primarily for mounting in a window, or through a wall, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration for heating which takes heat from a heat source. It may be constructed to remove heat from the conditioned space and discharge it to a heat sink if cooling and dehumidification are desired from the same equipment. It may also include means for the circulation and the cleaning of air, humidifying, ventilating or exhausting air.

Single-packaged unit: A factory assembly of components of refrigeration system fixed on a common mounting to form a discrete unit.

Split-packaged unit: A factory assembly of components of refrigeration system fixed on two or more mountings to form a discrete matched functional unit.

Single-duct air conditioner: An air conditioner for comfort cooling in which the condenser intake air is introduced from the conditioned space and discharged outside this space.

Multi-split system: a) Basic system: a split system incorporating a single refrigerant, a single speed compressor, multiple evaporators (indoor units), one condenser (outdoor coil) and is capable of operating either as an air-conditioner or a heat pump b) Multiple circuit multi-split system: a split system incorporating multiple refrigerant circuits, two or more single speed compressors, multiple evaporators (indoor units) and an integrated heat exchanger in a single outdoor unit and is capable of operating either as an air conditioner or a heat pump.

Spot air conditioner: An air conditioner that cools a zone within a space. The condenser intake air is introduced from that space and discharged back into the same space

Air-to-air heat pump: A heat pump which takes heat from the outside air and delivers it to the conditioner space when heating is desired, or takes heat from the conditioned space and delivers it to the outside air when cooling is desired.

North American definitions (NAFTA)

The following definitions are generally from CFR430 (1998)

Central air conditioner means a product, other than a packaged terminal air conditioner, which is powered by single phase electric current, air cooled, rated below 65,000 Btu per hour (19kW), not contained within the same cabinet as a furnace, the rated capacity of which is above 225,000 Btu per hour (65.9kW), and is a heat pump or a cooling unit only.

Packaged terminal air conditioner: a factory selected combination of heating and cooling components, assemblies or sections, intended to serve an individual room or zone.

Room air conditioner: An encased assembly designed as a unit, primarily for mounting in a window or through the wall as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone. It includes a prime source of refrigeration and dehumidification and means for circulating and cleaning air and may also include means for heating and ventilating.

Split system air conditioner: ‘‘Split system’’ means any central air conditioner in which one or more of the major assemblies are separate from the others. This is an area of common confusion between NAFTA and international definitions. A split system is typically a cooling module that is added to an existing air duct system which is used for heating. The cooling system itself may be either “unitary” or “split” in that the evaporator and condenser units may or may not be separate, but the system is treated as a central air conditioner as the cooled air is distributed via a duct.

Unitary air conditioner: A mechanical-compression air conditioner consisting of one or more assemblies which include an indoor air coil, a compressor, and an outdoor coil. Where such equipment is provided in more than one assembly, the separate assemblies are designed to be used together.

B:1.3 Room air conditioner definitions

In general terms “room air conditioners” are air conditioners that are designed to cool individual rooms; however, there are a number of basic types found on the international market as described in Table 19. All of these types will be considered to be ‘room air conditioners’ for the purposes of this report as they are all termed room air conditioners in some part of the world; however, economy definitions of room air conditioners, especially those used for efficiency regulations often conflict with these definitions. As a result the section entitled *scope* beneath each economy heading will describe whether each of the basic room air conditioner types listed in Table 19 are included in the specific economy ‘room air conditioner’ efficiency regulation and/or test procedures. It is also made plain whether the following types of units are included:

- ducted-units (ducted air conditioners or heat pumps)
- non-ducted units (non-ducted air conditioners or heat pumps)
- cooling-only units (pure air conditioners – no heat pump function)
- reverse-cycle (reversible) units (heat pumps that are also used as air conditioners and perhaps are primarily used as air conditioners)
- water-cooled units (air conditioners or heat pumps that use water as the main condenser cooling medium)
- air-cooled units (air conditioners or heat pumps that use air as the main condenser cooling medium)
- single-phase units (units powered by a single-phase mains supply)
- three-phase units (units powered by a three-phase mains supply)

In addition to these basic types the regulations and/or test procedures often only apply to appliances within stated cooling or heating capacity limits and for those conforming to prescribed mains frequency and voltage ratings. All such limits of applicability are indicated. Finally, packaged terminal air conditioner and heat pumps could potentially be classified as room air conditioners in most regions outside North America and thus it is also indicated whenever the regulations and/or test procedures also apply to this type of product.

Table 19: Room air conditioner types and characteristics

Room air conditioner types	Alternative names	Mounting configurations: Indoor unit	Mounting configurations: Outdoor unit	Ducting types	Condenser cooling medium	Current phase	Cooling/ Heating	Voltage
Split packaged unit (includes cabinet room air conditioners that are found in SE Asia)								
	Split room air conditioners mini-splits (NAFTA)	high wall floor mounted cassette ceiling-suspended built-in horizontal built-in vertical mobile	fixed mobile	non-ducted ducted	Air Water Evaporative	Mono Three	Cooling only Reversible	100 115 200 230 240 415 430
Multi-split packaged unit								
	multi-split room air conditioners	Typically up to 4, but may be more	fixed or mobile	either	Air	mono three	Cooling only Reversible	100 115 200 230 240 415 430
Single packaged unit								
	window or wall room air conditioners room air conditioner (NAFTA)	Through window Through wall	through window through wall	none none	air water	mono three	Cooling only Reversible	100 115 200 230 240 415 430
Single duct air conditioner								
	single duct room air conditioner	Mobile	none		air water	mono	Cooling only	100 115 200 230 240
Spot air conditioner								
		Mobile	none		air	mono		100 115 200 230 240

Differences in product definition and classification

There are a great many terms to define air conditioners and/or heat pumps in use which appear to mean different things in different member economies. Some of these are: 'room', 'split', 'unitary', 'packaged', 'central' and 'ducted'.

Ducted and non-ducted

The international, ISO, air conditioner and air-source heat pump test procedures only distinguish between a product based on whether it is ducted, non-ducted or a multi-split system. These test procedures are used in many APEC economies, so the definition of a room air conditioner used in some of the efficiency regulations corresponds to the definition of a non-ducted air conditioner in the ISO test procedures.

Split packaged units and 'mini-splits'

Practically, the largest source of difference is in how split packaged room air conditioners are defined in the NAFTA member economies (USA, Canada and Mexico) compared to other APEC member economies. In the NAFTA member economies a split packaged room air conditioner or heat pump is known as a 'mini-split' and is regulated in the same manner as a ducted central air conditioner (even though there is no duct). This means that they are tested according to procedures normally applied to significantly larger types of air conditioners and that their energy performance is defined using a seasonal energy efficiency rating. In all other APEC member economies and seemingly the rest of the world these appliances are called "split system room air conditioners" and are regulated and tested in a similar manner to other room air conditioners (such as window wall units). The origin of this difference is that small capacity split packaged air conditioners were not common in NAFTA economies, where single packaged (window or wall) units have historically dominated the room air conditioner market, and hence when they first arrived on the market (mostly as imported appliances) they were classified as central air conditioners because they have an extended refrigerant line running between the condenser and evaporator units, which was viewed as being equivalent to ducted air conditioners.

Single packaged units, packaged terminal units and 'window/wall' units

According to the definitions employed in ISO 5151 (non-ducted air conditioners and heat pumps – testing and rating for performance) and ISO 13253 (ducted air conditioner and air-to-air heat pumps - testing and rating for performance) term 'single package' air conditioner or heat pump is the same as a 'through-the-window' or 'through-the-wall' air conditioner or heat pump commonly known as window or wall units. In the USA and Canada the term single packaged is more often used to refer to a type of central air conditioner. The unit typically sits on cement pad outside the house or on the roof of a house or office. Both the return and supply air ducts penetrate the house's shell (whether through an exterior wall or through the roof) and are directly linked to the single-package system. US & Canadian single-package systems are typically fairly large in cooling capacity. The smallest capacity systems are approximately 36,000 Btu/h (10550 watts) but a more typical size is with cooling capacities of 60,000 Btu/h (17600 watts).

In the NAFTA member economies the term 'room' air conditioner or heat pump is applied to window or wall units, which ISO would term single packaged units, but does not apply to 'packaged terminal units'.

Packaged terminal units are generally larger capacity floor-mounted through-the-wall air conditioners or heat-pumps that are necessarily hard-wired (i.e. they are not plug-in air conditioners) and can have a three-phase power supply. By contrast ‘room’ air conditioner and heat pumps in NAFTA are distinguished as being single-phase plug-in through-the-window or through-the-wall units. No such distinctions exist in APEC member economies outside of NAFTA where a ‘Packaged Terminal’ unit would be generally classified as a ‘room’ air conditioner or heat pump perhaps depending on its cooling capacity.

Multi-split packaged units

At the current time there is no ISO test procedure for multi-split packaged air conditioners or heat pumps and as a result these appliances are often not subject to air conditioner efficiency regulations in APEC member economies that have regulations in place for other types of room air conditioner. The NAFTA member economies are the exception to this as multi-split units are treated as ‘split-system central air conditioners’. A draft test procedure has been produced , ISO CD 150432-1, and is sometimes used by manufacturers to rate the performance of their products but is not yet internationally accepted.

Unitary air conditioners

Certain types of unitary air conditioner as defined in Japanese, Korean and Chinese Taipei regulations and test procedures could be classified as room air conditioners elsewhere, although not in these economies. The main distinction between the definition of a room air conditioner and a unitary air conditioner used in Japan, Korea and Chinese Taipei is the rated cooling (and/or heating) capacity and sometimes the electrical power consumption of the appliance. Room air conditioners and heat pumps have smaller capacity/electrical consumption levels than the unitary air conditioners.

B:2 Room air conditioners and heat pumps

B:2.1 Australia

Program: mandatory energy labelling of room air conditioners

Scope

The applicability of Australian room air conditioners regulations is indicated in Table 20. Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners at part load.

Table 20: Product types included in Australian room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✓	✓	✗	✗		✓	✓	✓	✓	✓[1]	<7.5kW[2]	None

1 Heat pumps with water cooled condensers are excluded.
2 Cooling capacity constraints only apply in the energy labelling regulations, not the test procedure.

Summary of test procedure

The Australian and New Zealand test procedure, AS/NZS 3823.1.1-1998: *Performance of household electrical appliances – Room air conditioners. Part 1.1: Non-ducted air conditioners and heat pumps – testing and rating for performance* is and is based directly on ISO 5151-1994(E).

Details

The procedure is printed in such a way that any deviations to ISO 5151 are added as an appendix at the end of the document and is therefore extremely straightforward to establish (ISO "clone"). The majority of the deviations from the international standard pertain to requiring the use of SI energy units and specifying voltage rating requirements specific to Australian needs (these do not impose any voltage constraints on the equipment).

The only deviations that have a significance for energy testing and rating are: to specify that filters and grills should be in place and that maximum fan speed settings should be used during the cooling test, to set maximum dry-bulb test tolerances for individual readings during capacity testing of ±0.6°C (as opposed to ±0.5°C in ISO5151), and to specify rated standard cooling and heating capacities to an accuracy of 10W (rather than 100W in ISO5151). It is debatable whether these deviations are equivalent (EQV) or not (NEQ), although in reality a full ISO would probably give the same results and vice versa even though they may not be acceptable for regulatory purposes. Most of the changes adopted in AS/NZS3823.1.1 are in fact changes which are due for inclusion into the next version of ISO5151 in any case.

Part 2 of the AS/NZS 3823-1998 standard deals with the energy efficiency requirements for energy labelling of room air conditioners. Three units are to be tested for an energy labelling application. Only the calorimeter method of test is acceptable for energy labelling applications. Only units with a cooling capacity of less than 7.5kW are required to carry a label. Units can be air or water cooled, cooling-only or reversible, single-packaged, split-packaged or packaged terminal (this last RAC type is not acknowledged as a separate category in the Australian regulations).

B:2.2 Canada

Program: mandatory energy labelling and MEPS for room air conditioners

Scope

Canada, in keeping with the other NAFTA economies, uses a different system to classify room air conditioners than is used internationally. Under the NAFTA system, the classification of a room air conditioner is confined to a window/wall (single-packaged) unit, which can be cooling only or reversible (but the latter only in the USA), but must be air cooled and have a single phase a.c. supply. Furthermore, a room air conditioner must have a cooling capacity of no more than 10.55 kW in Canada, no more than 10.548 kW in Mexico and has no capacity constraints in the USA. Units with larger capacities and split-system air conditioners (of a cooling or heating capacity of up to 19kW) are classed as central air conditioners. Finally, a separate category is created for 'Packaged terminal air conditioners'. These are packaged (i.e. enclosed in a single unit) air conditioners or heat pumps designed to be fitted through a wall using a wall sleeve, that have a prime source of refrigeration, separable outdoor louvres, forced ventilation and include a separate heating source of either steam, hot water or electrical resistance heat. A packaged terminal air conditioner need not include a heating source providing the basic configuration is otherwise identical to a model which does. Under the international system of definitions a room air conditioner could be classified under any of the above categories, therefore each of the three relevant test procedures are addressed in turn.

The applicability of Canadian *room air conditioner* regulations is indicated in Table 21. The applicability of Canadian *packaged terminal air conditioner* regulations is indicated in Table 22. The applicability of Canadian *split-system central air conditioner* regulations is indicated in Table 23.

Table 21: Product types included in Canadian room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✗	✓	✗	✗	✗		✗	✓	✗	✓	✗	≤10.55 kW[1]	NA

1 = 36 000 Btu/h

Table 22: Product types included in Canadian packaged terminal air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	None	None

Table 23: Product types included in Canadian split-system central air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✓	✗	<19 kW[1]	<19 kW[1]

1 = 65 000 Btu/h

Summary of test procedure for *room air conditioners*

The Canadian test procedure and standards regulation, CAN/CSA-C368.1-M90 *Performance standard for room air conditioners:* uses the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ASHRAE-16-69 *Method of testing for rating room air conditioners*. The CAN/CSA-C368.1-M90 standard excludes fan-coil air conditioning units, heat pumps, unit ventilators, packaged-terminal air conditioners, or water-cooled units. Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners.

Details

The test procedure consists of the following cooling tests.

- rated cooling capacity,
- maximum high temperature operation test,
- freeze-up operation test
- enclosure sweat and condensate disposal tests,

There are no heating tests.

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are preferred (but not required as in ISO 5151), one on the indoor-side and one on the outdoor side. If simultaneous determinations are used their values must be within 4% of each other. Stable test conditions have to be maintained, for a series of eight readings taken at 15 minute intervals with a maximum temperature variation of 0.56°C before capacity data can begin to be recorded. The capacity tests last for not less than 1 hour with readings taken every 10 minutes for a total of 7 readings.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 24 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. It is clear that the Canadian room air conditioner rating conditions are the same as the ISO 5151 standard except that they are based on values rounded to the nearest whole degree Fahrenheit rather than Celsius.

Table 24: Test conditions for the determination of cooling capacity, Canada

Parameter	Standard test conditions	
	C368.1-M90	**ISO T1**
Temperature of air entering indoor side (°C)		
dry-bulb	26.7±0.56(0.28)	27±1(0.3)
wet-bulb	19.4±0.34(0.17)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±0.56(0.28)	35±1(0.3)
wet-bulb	23.9±0.34(0.17)	24±0.5(0.2)

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.01 kW) expressed in W or Btu/h
- EER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

Summary of test procedure for *packaged terminal air conditioners and heat pumps*

The Canadian test procedure and standards regulation, CAN/CSA-C744-93 *Standard for packaged terminal air-conditioners and heat pumps* uses the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ASHRAE-16-88 *Method of testing for rating room air conditioners and packaged terminal air conditioners*. ASHRAE-37 is also referenced.

Details

The test procedure consists of the following tests.

- standard rated cooling and heating capacities,
- maximum high temperature operation test,
- low-temperature operation test (cooling-mode) (an optional rating condition)
- high-temperature heat pump (heating mode)
- low temperature operation test (heating-mode) (an optional rating condition)
- part-load rating test (variable capacity units only)
- insulation effectiveness test
- condensate disposal test,

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are preferred (but not required as in ISO 5151), one on the indoor-side and one on the outdoor side. If simultaneous determinations are used their values must be within 4% of each other. Stable test conditions have to be maintained, for a series of eight readings taken at 15 minute intervals with a maximum temperature variation of 0.56°C before capacity data can begin to be recorded. The capacity tests last for not less than 1 hour with readings taken every 10 minutes for a total of 7 readings.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 25 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Canadian packaged terminal air conditioner cooling rating conditions are the same as in the ISO 5151 standard except that they are based on values rounded to the nearest whole degree Fahrenheit rather than Celsius and the tolerances differ. Water-cooled units are excluded from the definition of a packaged terminal air conditioner or heat pump applied in the standard. The heating conditions differ from ISO 5151 by up to 1.4°C as shown in Table 26.

Table 25: Test conditions for the determination of cooling capacity, Canada

Parameter	Standard test conditions	
	C744-93	ISO T1
Temperature of air entering indoor side (°C)		
dry-bulb	26.7±0.56(0.28)	27±1(0.3)
wet-bulb	19.4±0.34(0.17)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±0.56(0.28)	35±1(0.3)
wet-bulb	23.9±0.34(0.17)	24±0.5(0.2)

Table 26: Test conditions for the determination of heating capacity, Canada

Parameter	Standard test conditions	
	C744-93	ISO
Temperature of air entering indoor side (°C)		
dry-bulb	21.1±0.56(0.28)	20±1(0.3)
wet-bulb		15±0.5(0.2)
Temperature of air entering outdoor side (°C)		
high temperature rating test		
dry-bulb	8.3±0.56(0.28)	7±1(0.3)
wet-bulb	6.1±0.34(0.17)	6±0.5(0.2)
low (extra-low in ISO) temperature rating test		
dry-bulb	-8.3±0.56(0.28)	-7±1(0.3)
wet-bulb	-9.4±0.34(0.17)	-8±0.5(0.2)

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.03 kW) expressed in W or Btu/h
- EER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

Summary of test procedure for split-system central air conditioners and heat pumps

A split-system central air conditioner or heat pump is defined as a split-system unit (other than a packaged terminal air conditioner), which is powered by single phase electric current, air cooled, and has a rated capacity of below 19 kW.

Canada has based its standard, CAN/CSA C273.3-M91, on the US DOE test procedure for central air conditioners. The official US test procedure is contained in

DOE regulations Code of Federal Regulations 430 Appendix M, the Energy Policy Act 1992 and standards ARI 210/240-89 & ASHRAE 37.

Details

The test procedure consists of the following heating and cooling tests.

- cooling capacity tests (A, B, C, D)
- intermediate cooling test for units with variable speed compressors
- high temperature, cyclic, frost accumulation and low temperature heating tests,

Testing is to be done using the air enthalpy approach with the test chamber configured in one of the following arrangements: the tunnel air enthalpy method arrangement, the loop air enthalpy arrangement, the calorimeter air enthalpy method arrangement or the room air enthalpy method arrangement. In practice this test method constrains the cooling equipment to have a cooling capacity of less than 39 560W.

All types of central air conditioners are rated using a seasonal energy efficiency ratio (SEER). The SEER units are in Btu per Wh. For determination of the SEER there 4 different temperature rating points. These are called DOE “A” to “D”. Point “A” is essentially the same as the ISO 5151 T1 condition with minor differences and is used to rate the cooling capacity. Points “C” and “D” are used to determine a degradation co-efficient C_D which is used to measure the efficiency loss as a result of cycling. These conditions apply to single speed compressors. If there is a 2 speed or variable speed compressor, there are additional rating points at part load. Note that many manufacturers now also publish EER information recorded under the “A” condition in addition to the mandatory SEER information, to assist in comparison of products.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 27 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses.

Table 27: Test conditions for the determination of cooling capacity and SEER, Canada

Parameter	Standard test conditions				
	A	B	C	D	ISO T1
Temperature of air entering indoor side (°C)					
dry-bulb	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±1(0.5)
wet-bulb	19±0.34(0.17)	19±0.34(0.17)	14±0.34(0.17)	14±0.34(0.17)	19±0.3(0.2)
Temperature of air entering outdoor side (°C)					
dry-bulb	35±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	35±1(0.5)
wet-bulb					24±0.3(0.2)

Testing to conditions “C” and “D” are optional in that if the tests are not done, a value of 0.25 is assigned for the degradation co-efficient C_D. Only four tests are required for single speed compressors. Where there is a two speed compressor, tests at condition “A” and “B” are to be done for each speed.

For variable speed compressors, up to seven tests are required as follows:

- “A” and “B” wet coil tests at maximum compressor speed
- “B” wet coil is tested at minimum speed
- Low temperature wet coil test is conducted at minimum speed (indoor and outdoor 19.4/13.9^{o}C dry/wet)
- Final wet coil test is conducted at an intermediate speed
- if a value for C_D of 0.25 is not used, dry coil tests “C” and “D” at minimum speed.

All single speed units are subject to four performance tests:

- high temperature test,
- cyclic test,
- frost accumulation test
- low temperature test.

Variable speed units are subject to: high temperature test (one maximum speed, two at minimum speed), cyclic test (minimum speed), frost accumulation test (maximum and intermediate speeds).

For single speed compressors, the Seasonal Energy Efficiency Ratio (SEER) is calculated via the following steps:

$CLF = Q_{“D”} / Q_{“C”}$

(Q = “average” capacity measured over a complete compressor on and off cycle)

$C_D = (1 - EER_D/EER_C) / (1 - CLF)$

C_D is the degradation coefficient (or 0.25 if not tested to conditions “C” and “D”)

$PLF = 1 - (0.5 \times C_D)$

$SEER = PLF \times EER_B$

Where:EER_B is the EER to condition “B”.

For variable speed compressors, the calculations are much more complex. Essentially, the method involves the estimation of the performance of the system (cooling capacity and electrical energy) at 8 outdoor temperature points ranging 39^{o}C down to 19.4^{o}C based on test data for various conditions and averaging these as weighted by specified bin weightings for assumed hours of operation.

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.01 kW) expressed in W or Btu/h
- SEER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

S*plit-system central* air conditioners and heat pumps are not subject to labelling, even though they include split-package air conditioners and heat pumps of a small to medium sized cooling or heating capacity.

B:2.3 China

Program: mandatory MEPS for room air conditioners

Scope

The applicability of Chinese room air conditioners regulations is indicated in Table 28. Single-packaged and split system room air conditioners, of cooling-only or reverse-cycle and air or water-cooled are covered by MEPS regulations that apply to the cooling-mode only. Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners.

Table 28: Product types included in Chinese room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✓	✓	✗	✗		✓	✓	✓	✓	✓[1]	≤9.0kW[2]	None

1 Heat pumps with water cooled condensers are excluded.
2 Cooling capacity constraints only apply in the MEPS regulations not the test procedure.

Summary of test procedure

The Chinese test procedure, GB/T7725-1996 is not equivalent to (NEQ) ISO 5151-94(E). The source of the non equivalence is not known at the time of writing; however, the cooling capacity tests are conducted at the ISO 5151-94(E) T1 test condition.

B:2.4 Hong Kong, China

Program: voluntary energy labelling of room air conditioners

Scope

The applicability of Hong Kong, China’s room air conditioners regulations is indicated in Table 29. Air-cooled single-packaged (window/wall) and split system room air conditioners, of cooling-only or reverse-cycle are covered by a voluntary labelling program that applies to the cooling-mode only. Water-cooled units are excluded although they can be tested in the test procedure. Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners.

Table 29: Product types included in Hong Kong, China room air conditioner program

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓[1]	✓	✓	✗	✗		✓	✓[2]	✓[2]	✓	✗[3]	≤10kW[4]	NA

1 The heating-mode of reversible units is excluded from labelling, not the test procedure.
2 Equipment shall be tested at a rated voltage of 380V or 220V and at 50Hz.
3 Units with water cooled condensers are only excluded from labelling, not the test procedure.
4 Cooling capacity constraints only apply in the energy labelling regulations not the test procedure.

Summary of test procedure

Hong Kong, China uses the international test procedure ISO 5151-1994(E).

B:2.5 Japan

Program: Voluntary efficiency targets and Top Runner program for room air conditioners

Scope

Japan uses a different system to classify room air conditioners than is used internationally. Under the Japanese system, the classification of a room air conditioner is confined to an *integral* type (where the compressor refrigerating unit, fans, etc. are accommodated in a cabinet) or *separate* type (where the compressor refrigerating unit, fans, etc. are accommodated in two cabinets) with a rated cooling capacity not exceeding 10 kW and a rated cooling power consumption not exceeding 3 kW. Cooling-only and reverse-cycle units are included, as are single-phase or three-phase units and air-cooled or water-cooled units. Ducted units are not excluded from the above definitions. In practice, this means that most types of air conditioning equipment are classified as a room air conditioner provided it satisfies the capacity constraints and is of a packaged-type. Constraints are also imposed on the rated voltage, which must be less than 300V, and the rated frequency, which must be either 50 Hz, or 60 Hz. Larger room air conditioners, of a packaged type, are classified as *unitary air conditioners.* Both room and unitary type air conditioners and heat pumps are both subject to energy efficiency targets. The existing targets differentiate depending on whether an appliance is integral (windows) or split-type and whether it is cooling-only or reversible. The targets for reversible units are a combination of

EER and COP targets. Multi-split systems are currently excluded but are about to be included into new energy efficiency target regulations (Top Runner program), due to come into effect between 2004 and 2007, which implies that either the draft international test procedure for multi-split units is to be adopted or that a new procedure will be created. Single-duct air conditioners will also be subject to efficiency targets in the future and may also require modifications to be made to the JIS test procedures to allow proper performance measurements to be made.

The applicability of Japan's *room air conditioner* regulations is indicated in Table 30.

Table 30: Product types included in Japanese room air conditioner program

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓ 1	✓ 2	✗ 3	✓ 1		✓ 1	✓ 4	✓ 4	✓	✓	≤10kW 5	✓

1 Called 'integral type' units in the test procedure.
2 Called 'separate type' units in the test procedure.
3 Multi-split systems will be the subject of efficiency targets from 2004 (reversible type) to 2007 (cooling-only type) which implies a new test procedure must be adopted.
4The rated a.c. supply should have a voltage of 300V or less and a frequency of 50Hz or 60Hz
5 In addition, the rated cooling power consumption must not exceed 3 kW.

Summary of test procedure (room air conditioners)

The Japanese room air conditioner test procedure, JIS C 9612-94 *Room air conditioners* differs from the international non-ducted air conditioner test procedure in a number of key areas.

- The rated heating and cooling capacities are prescribed at set values.
- Rated voltages and frequencies are prescribed.
- The performance tests include a refrigerant leakage inspection test, an insulation resistance test, a dielectric withstand voltage test, an insulation performance under water spray test, and a noise test. All these tests specify minimum performance requirements that must be passed. There are also a number of construction requirements designed to meet safety needs.

Details

The test procedure consists of the following cooling tests:

- cooling capacity,
- cooling power consumption,

- cooling overload performance
- enclosure sweat and condensate disposal tests
- freezing test,

and the following heating tests:

- heating capacity,
- heating power consumption,
- power consumption of electric heater (for models with a separate resistance heater),
- heating overload performance,
- automatic defrosting test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. For cooling and heating capacity measurements made with the air-enthalpy method, see below, the measuring device has to be one of: tunnel-type, loop-type, calorimeter-type or room-type. The cooling and heating capacities can be calculated by either the direct (calorimeter) method or the in-direct (air-enthalpy) method. For the calorimeter method two simultaneous determinations of the cooling or heating capacities are required, one on the indoor-side and one on the outdoor side. These two simultaneous determinations have to agree with each other by within 4% for the test to be deemed valid. The cooling and heating capacities are calculated from the measurements in the same way as specified in ISO 5151-94(E). In the case of units with water cooled condensers the heat flow rejected via the cooling water is measured instead of the outdoor side compartment.

A maximum refrigerant piping length of 5m is specified for split-system units.

Equilibrium test conditions have to be maintained for a minimum of 1 hour before capacity data can begin to be recorded. The capacity tests last for 35 minutes with readings taken every 5 minutes.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 31, which also shows the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Japanese *room air conditioner* rating conditions are harmonised with the ISO 5151 T1 condition except for an insignificant difference in the tolerances for water-cooled units. The heating capacity test conditions are also identical to ISO 5151-94 except for the overload and defrosting tests.

The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected. Two informative references are included in the procedure. One provides a simple calculation method to determine the cooling and heating loads in typical Japanese houses and the other provides a test method to determine a seasonal performance factor. This latter, which is optional, defines a complex set of test and calculation criteria that can be used to compute seasonal heating and cooling performance factors. The procedure treats part load performance and is appropriate for testing variable and multiple-speed drive room air conditioners.

Table 31: Test conditions for the determination of cooling capacity, Japan

Parameter	Standard test conditions	
	JIS C 9612-94	**ISO T1**
Temperature of air entering indoor side (°C)		
dry-bulb	27±1(0.3)	27±1(0.3)
wet-bulb	19±0.5(0.2)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±1(0.3)	35±1(0.3)
wet-bulb	24±0.5(0.2)	24±0.5(0.2)
Condenser water temperature[2)] (°C)		
inlet	30±0.3	30±0.2(0.1)
outlet	35±0.3	35±0.2(0.1)

Variables required to be measured, determined or declared for regulatory purposes:

- Product classification according to its function
- Rated cooling capacity (kW)
- Standard heating capacity (kW)
- Heating capacity at low temperature (kW)
- Classification according to the condenser cooling system
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption and heating power consumption at low temperature
- Cooling performance factor (the EER)
- Heating performance factor (the COP)

The heating and cooling capacities must be not less than 95% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 110% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER or COP of 15%.

Summary of test procedure (unitary air conditioners)

The Japanese unitary air conditioner test procedure, JIS B 8616-93

Package air conditioners

replaces and unifies the previous two standards JIS B 8616-84 and JIS B 8615-83 dealing with unitary air conditioners. Unitary air conditioners can be ducted or non-ducted and hence the provisions in this standard are simultaneously comparable to both ISO 5151-94(E) (non-ducted air conditioners) and ISO 13253-93 (ducted air conditioners). Under the Japanese definition unitary air conditioners are packaged (in one assembly or are designed to be used in one assembly), can be single-packaged or split packaged, as shown in Table 32.

Table 32: Product types included in Japanese unitary air conditioner test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓[1]	✓[2]	✗	✓[1]	✗	✓[1]	✓[3]	✓[3]	✓	✓	CC ≤ 28kW	

1 Called 'integral type' units in the test procedure.
2 Called 'separate type' units in the test procedure.
3 The rated a.c. supply should have a voltage of 100V or 200V and a frequency of 50Hz or 60Hz
4 In addition, the rated cooling power consumption must exceed 3 kW.

Variables required to be measured, determined or declared for regulatory purposes:

- Product classification according to its function
- Rated cooling capacity (W)
- Standard heating capacity (W)
- Classification according to the condenser cooling system
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption
- Energy Efficiency Ratio, EER, (W/W)

The heating and cooling capacities must be not less than 95% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 110% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER or COP of 14%.

B:2.6 Korea

Program: mandatory energy labelling and MEPS for room air conditioners

Scope

Korea uses a different system to classify room air conditioners than is used internationally. Under the Korean system, the classification of a room air conditioner is confined to an *integral* type (where the compressor refrigerating unit, fans, etc. are accommodated in a cabinet) or *separate* type (where the compressor refrigerating unit, fans, etc. are accommodated in two cabinets) with a rated cooling capacity not exceeding 9000 kCal/h (10.5 kW) and a rated cooling power consumption not exceeding 3 kW (KS C 9306). Larger room air conditioners (exceeding 3kW cooling electrical power consumption and a rated cooling capacity not exceeding 23,000 kcal/h (26.7 kW)) of the packaged type are classified as *unitary air conditioners* (KS B 6368).

For energy labelling, Korea has a special Standard, which is called "Power consumption and efficiency labelling program for Home Electrical Appliance", and it defines the scope for air conditioners. This standard specifies air conditioners (room or unitary) of integral type (where compressor refrigerating unit, fans, etc are accommodated in a cabinet) or separate type (compressor refrigerating unit, fans, etc are accommodated in two cabinets) with a rated power consumption for cooling not exceeding 7.5kW in air conditioners which carry out cooling (models that carry out dehumidifying or heating are also included), circulation of air and removal of dust for the purpose of increasing comfort and air quality. It also specifies air conditioners with cooling capacity not exceeding 15,000 kCal/h (17.4kW).

Cooling-only and reverse-cycle units are included, as are single phase or three-phase units and air-cooled units. Ducted units are not excluded from the above definitions. In practice, this means that most types of air conditioning equipment are classified as a room air conditioners provided they satisfy the capacity constraints and they are of the packaged-type. Multi-split systems and water cooled condenser type are excluded. Constraints are also imposed on the rated voltage, which must be 220V or 220V/380V, or 380V and the rated frequency, which must be 60 Hz. Unlike any APEC economy Korea, has devised efficiency standards and targets that treat constant speed air conditioners (those using single-speed compressors) differently than those using a variable speed. Both the fixed and variable-speed air conditioners (either room or unitary) must satisfy MEPS and energy labelling and are subject to efficiency targets. The variable speed units are tested and rated using a seasonal energy efficiency ratio (SEER) similar to Japanese specifications. Reverse cycle units are not subject to COP requirements for heating but are required to satisfy the cooling-mode performance requirements.

The applicability of Korean room air conditioners regulations is indicated in Table 33.

Table 33: Product types included in Korean room air conditioner test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓ [1]	✓ [2]	✗	✓ [1]	✗	✓ [1]	✓ [3]	✓ [4]	✓	✗	≤9000 kcal/h [5]	None

1 Called 'integral type' units in the test procedure.
2 Called 'separate type' units in the test procedure.
3 Mono phase a.c. supply of 220V, 60Hz.
4 Three phase a.c. supply of 220V, 60Hz.
5 Equivalent to a maximum cooling capacity of 10.465 kW.
Although an English version of KS C9306 is available, this was not supplied for the study. However, this data has been checked by Korean testing personnel.

Summary of test procedure (room air conditioners)

The Korean room air conditioner test procedure, KS C 9306-97 *Room air conditioners* differs from the international test procedure in a number of key areas.

- The rated cooling capacities are prescribed at set values.
- Rated voltages and frequencies are prescribed.
- The performance tests include a mandatory noise requirement test.

Details

The test procedure consists of the following cooling tests:

- cooling capacity,
- cooling power consumption,
- cooling overload performance
- enclosure sweat and condensate disposal tests
- freezing test,

and the following heating tests:

- heating capacity,
- heating power consumption,
- power consumption of electric heater (if there is a separate resistance heater),
- heating overload performance,
- automatic defrosting test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. Heating and cooling capacity measurements can also be made with the air-enthalpy method. The cooling and heating capacities can be calculated by either the direct (calorimeter) method or the in-direct (air-enthalpy) method. For the calorimeter method two simultaneous determinations of the cooling or heating capacities are required, one on the indoor-side and one on the outdoor side. The two simultaneous determinations have to agree with each other by within 4% for the test to be deemed valid. The cooling and heating capacities are calculated from the measurements in the same way as specified in ISO 5151-94(E).

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 34, which also shows the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Korean *room air conditioner* rating conditions are almost harmonised with the ISO 5151 T1 condition except for a half degree difference in the indoor side wet-bulb temperature and wider tolerances for all measurements. The heating capacity test conditions are also similar to ISO 5151-94 although the indoor side dry-bulb temperature is 21°C (as opposed to 20°C) and there is no indoor wet-bulb requirement[1]. The temperature conditions for the defrosting and overload tests are also slightly different. The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected[2].

Table 34: Test conditions for the determination of cooling capacity, Korea

Parameter	Standard test conditions		
	KS C 9306-97	**Efficiency labelling**[1]	**ISO T1**
Temperature of air entering indoor side (°C) dry-bulb wet-bulb	 27±1 19.5±1	 27±0.5 19.5±0.3	 27±1(0.3) 19±0.5(0.2)
Temperature of air entering outdoor side (°C) dry-bulb wet-bulb	 35±1 24±1	 35±0.5 27±0.3	 35±1(0.3) 24±0.5(0.2)
Condenser water temperature[2)] (°C) inlet outlet	 30±0.5 35±0.5	 -	 30±0.2(0.1) 35±0.2(0.1)

1. Standard of Power consumption and efficiency labelling program for Home Electrical Appliance, and this standard is not available in English
2. Water cooled condenser type is excluded from Efficiency labelling.

Variables required to be measured, determined or declared for regulatory purposes include:

- Product classification according to its function
- Rated cooling capacity (kcal/h or W)
- Standard heating capacity (kcal/h or W)

1 The requirement of 21°C indoor temperature for heating test with no web bulb requirement is common throughout the world as this is the condition previously specified in ISO859 which was replaced by ISO5151 in 1994. Some economies have either been slow to change the test condition or have chosen not to do so.

2 Note that an English version of KS C9306 was not supplied but the data above has been checked.

- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power and heating power at low temperature (kW)

The heating and cooling capacities must be not less than 92% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. EER must be within ±10% of their rated values, that implies a maximum permitted deviation in the EER 20%. But, there is no maximum permitted deviation for COP.

Summary of test procedure (unitary air conditioners)

The Korean unitary air conditioner test procedure, KS B 6369-95 *Testing methods for unitary air conditioners* references KS B 6368 and appears to be a corollary of the Japanese unitary air conditioner test procedures JIS B 8616-84 and JIS B 8615-83. Unitary air conditioners can be ducted or non-ducted and hence the provisions in this standard are simultaneously comparable to both ISO 5151-94(E) (non-ducted air conditioners) and ISO 13253-93 (ducted air conditioners). Under the Korean definition unitary air conditioners are packaged (in one assembly or are designed to be used in one assembly), can be single-packaged or split packaged, air or water cooled, single or three phase but must have a cooling capacity of greater than 3 kW.

Table 35: Product types included in Korean unitary air conditioner test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓ 1	✓ 2	✗	✓ 1	✗	✓ 1	✓ 3	✓ 4	✓	✗	✓ 5	None

1 Called 'integral type' units in the test procedure.
2 Called 'separate type' units in the test procedure.
3 Mono phase a.c. supply of 220V,60Hz.
4 Three phase a.c. supply of 220V, 220/380V, 380V 60Hz.
5 Maximum cooling capacity of ≤22400 kCal/h (≤26,744 kW).

The test procedure consists of the following cooling tests:

- cooling capacity,
- cooling power consumption,
- cooling overload performance
- enclosure sweat and condensate disposal tests
- freezing test

and the following heating tests:

- heating capacity,

- heating power consumption,
- power consumption of electric heater (if there is a separate resistance heater),
- heating overload performance,
- automatic defrosting test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. Heating and cooling capacity measurements can also be made with the air-enthalpy method. The cooling and heating capacities can be calculated by either the direct (calorimeter) method or the in-direct (air-enthalpy) method. The cooling and heating capacities are calculated from the measurements in the same way as specified in ISO 5151-94(E).

Variables required to be measured, determined or declared for regulatory purposes:

- Product classification according to its function
- Rated cooling capacity (kCal/h or W)
- Standard heating capacity (kCal/h or W)
- Classification according to the condenser cooling system
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption (kW)
- Energy Efficiency Ratio, EER, (kCal/h/W or W/W)

The heating and cooling capacities must be not less than 92% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. EER must be within ±10% of their rated values, that implies a maximum permitted deviation in the EER 20%. But, there is no maximum permitted deviation for COP.

B:2.7 Mexico

Program: mandatory energy labelling and MEPS for room air conditioners

Scope

Mexico in keeping with the other NAFTA economies uses a different system to classify room air conditioners than is used internationally. Under the NAFTA system, the classification of a room air conditioner is confined to a window/wall (single-packaged) unit, which can be cooling only or reversible (although only cooling-only models are regulated in Mexico), but must be air cooled and have a single phase a.c. supply. Furthermore, a room air conditioner must have a cooling capacity of no more than 10.548 kW in Mexico. In Mexico units with larger capacities (a cooling or heating capacity of from 10.548 kW to 17.580 kW), including split-system air conditioners, are classed as central air conditioners. Under the international system of definitions it is possible a room air conditioner could be classified under either of the above categories, although in practice room air conditioners are seldom of a size above 10.5 kW. As a result the Mexican central air conditioner details will only be listed in the central air conditioner section of this report.

The applicability of Mexican room air conditioners regulations is indicated in Table 36.

Table 36: Product types included in Mexican room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✓	✗	✗	✗		✗	✓	✗	✓	✗	≤10.548 kW	None

Summary of test procedure

The Mexican test procedure and standards regulation, NOM-073-SCFI-94 *Energy efficiency of room air conditioners* uses ostensibly the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ASHRAE-16-69 *Method of testing for rating room air conditioners*.

The NOM-073-SCFI-94 standard excludes heat pumps and water-cooled units. The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected.

Details

The test procedure consists of the following cooling tests.

- rated cooling capacity and cooling electrical power consumption

There are no heating tests.

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are required, as in ISO 5151, one on the indoor-side and one on the outdoor side. If simultaneous determinations are used their values must be within 4% of each other. Stable test conditions have to be maintained for 1 hour before capacity data can begin to be recorded. The capacity tests last for not less than 1 hour with readings taken every 10 minutes for a total of 7 readings.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 37 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Mexican room air conditioner rating conditions are almost fully harmonised with the

ISO 5151 T1 test condition except for almost insignificant differences in the tolerances and very small differences in the main indoor and outdoor temperatures. These differences have their origin in the test conditions used in other NAFTA economies, although the Mexican values are not fully identical to those.

Table 37: Test conditions for the determination of cooling capacity, Mexico

Parameter	Standard test conditions	
	NOM-073-SCFI-94	ISO T1
Temperature of air entering indoor side (°C)		
dry-bulb	26.6±0.55(0.28)	27±1(0.3)
wet-bulb	19.4±0.33(0.17)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	34.9±0.55(0.28)	35±1(0.3)
wet-bulb	23.8±0.33(0.17)	24±0.5(0.2)

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacity
- EER (W/W or Btu/Wh)
- Cooling-mode electrical power consumption

The cooling capacity must be not less than 95% of its rated value while the electrical power consumption in the cooling-mode shall be within 0.5% of its rated value. These tolerances imply a maximum permitted deviation in the EER of 5.5%.

B:2.8 Philippines

Program: mandatory energy labelling and MEPS for room air conditioners

Scope

The definition of a room air conditioner used in the Philippines test procedure corresponds to that given for a non-ducted air conditioner in ISO 5151-94(E); however, the energy efficiency regulations define them more narrowly as windows room air conditioners with rated capacities up to 26000 kJ/h (6.2 kW). Furthermore models should have a rated voltage of 230V and frequency of 60 Hz.

The applicability of the Philippines room air conditioners regulations is indicated in Table 38.

Table 38: Product types included in Philippines room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
NA	✓	✓	✓[1]	✓	✗[2]	✗	✗		✓	✓	✓	✓	✓[1]	≤26000kJ /h[3]	None

1 The heating performance of reversible units is not included.
2 Split packaged units are excluded from the energy labelling regulations but not the test procedure.
3 Cooling capacity constraints only apply in the energy labelling regulations not the test procedure.

Summary of test procedure

The Philippines test procedure, PNS 240-89 *Method of testing and rating room air conditioners* uses ostensibly the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ISO 5151-94(E).

The PNS 240-89 standard excludes any heating tests but does not exclude heat pumps and water-cooled units operating in the cooling-mode. The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part load performance of variable or multiple speed drive units is not reflected.

Details

The test procedure consists of the following cooling tests:

- rated cooling capacity,
- maximum operating conditions test,
- minimum operating conditions test,
- enclosure sweat and condensate disposal test,
- freeze-up test,
- cooling electrical power consumption

There are no heating tests.

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are required, as in ISO 5151, one on the indoor-side and one on the outdoor side. If simultaneous determinations are used their values must be within 4% of each other. Stable test conditions have to be maintained for 1 hour before capacity data can begin to be recorded. The capacity tests last for not less than 1 hour with readings taken every 10 minutes for a total of 7 readings.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode for the energy efficiency declaration are indicated in Table 39 with the ISO 5151 T1 rating point for comparison (the ISO T1, T2 and T3 conditions are optional test conditions within the PNS 240-89 test standard). The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Philippine room air conditioner rating conditions are fully harmonised with the ISO 5151 T1 test condition except for an appreciably higher wet-bulb temperature for the outdoor unit that is designed to represent typical Philippine conditions. The test conditions used for water-cooled condensers are also significantly higher than those in the ISO 5151 T1 condition. These differences mean that it is not appropriate to compare EER ratings recorded under the ISO 5151 test with those recorded under the Philippine test conditions.

Table 39: Test conditions for the determination of cooling capacity, Philippines

Parameter	Standard test conditions	
	PNS 240-89	**ISO T1**
Temperature of air entering indoor side (°C)		
dry-bulb	27±0.5(0.3)	27±1(0.3)
wet-bulb	19±0.3(0.2)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±0.5(0.3)	35±1(0.3)
wet-bulb	27±0.3(0.2)	24±0.5(0.2)
Condenser water temperature[2)] (°C)		
inlet	31±0.2(0.1)	30±0.2(0.1)
outlet	37±0.2(0.1)	35±0.2(0.1)

Variables required to be measured, determined or declared for regulatory purposes include:

- Phase
- Climate type
- Total cooling capacity
- EER (kJ/Wh)
- Cooling-mode electrical power consumption

The cooling capacity must be not less than 90% of its rated value while the electrical power consumption in the cooling-mode shall be not greater than 110% of its rated value. The computed EER shall be not less than 95% of its published rating.

B:2.9 Russia

Program: mandatory MEPS for room air conditioners

Scope

The definition of a room air conditioner used in the Russian test procedure corresponds to that given for a non-ducted air conditioner in ISO 5151-94(E); however, the energy efficiency regulations define them more narrowly as windows room air conditioners with rated capacities up to 5.6 kW.

The applicability of the Russian room air conditioners regulations is indicated in Table 40.

Table 40: Product types included in Russian room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
NA	✓	✓	✓	✓	✗ [1]							✓		≤5.6 kW[2]	None

1 Split packaged units are excluded from the MEPS regulations but not the test procedure.

2 Cooling capacity constraints only apply in the MEPS regulations not the test procedure.

Summary of test procedure

The Russian test procedure, GOST 26963-86, *Self contained room air conditioner* uses ostensibly the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ISO 5151-94(E).

The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part load performance of variable or multiple speed drive units is not reflected.

Details

The test procedure defines three main climatic types to rate air conditioners and heat pumps – U2(U3), T2(T3) and HL2(HL3). Air conditioners are defined as type A or B depending on the maximum external temperature at which they can maintain a given internal temperature as defined in Table 41. The same table shows how air conditioners are classified according to their functionality. The temperature limits are established by GOST.

Table 41: Operational temperature limits for Russian air conditioners

<table>
<tr><td>Type</td><td>Functions</td><td colspan="2">cooling-mode</td><td colspan="2">heating-mode</td></tr>
<tr><td></td><td></td><td>high</td><td>low</td><td>high</td><td>low</td></tr>
<tr><td>KB-1</td><td>cooling, drying, automatic maintenance of conditions set, ventilation, dust removing</td><td rowspan="3">+43 for A-type
+52 for B-type</td><td rowspan="3">+21 all</td><td>-</td><td>-</td></tr>
<tr><td>KB-2</td><td>cooling or heating with refrigerant flow reverse (heat pump mode), automatic maintenance of conditions set, ventilation, dust removing</td><td></td><td></td></tr>
<tr><td>KB-3</td><td>Same as KB2, heating with in-built electric heaters, working independently or in combination with refrigerant flow reverse</td><td>+24</td><td>+2 with reverse
-10 with no reverse</td></tr>
</table>

The nominal cooling capacity must be rated according to the temperatures given in Table 42. Type A units correspond to those rated under the ISO 5151 T1 condition except the external dry bulb temperature is significantly lower at only 19°C. Type B units correspond to those rated under the ISO 5151 T2 condition except the external dry bulb temperature is significantly lower at only 19°C. The heating capacity test for reversible units is identical to ISO 5151 conditions except for the indoor dry-bulb temperature being 1°C higher and the outdoor wet bulb being 0.4°C higher. The tolerances are maximum values and differ slightly from ISO 5151.

Table 42: Test conditions for the determination of cooling and heating capacity, Russia

<table>
<tr><td rowspan="2">Type</td><td rowspan="2">Mode</td><td colspan="2">indoor temperature</td><td colspan="2">outdoor temperature</td></tr>
<tr><td>dry bulb</td><td>wet bulb</td><td>dry bulb</td><td>wet bulb</td></tr>
<tr><td>A</td><td>cooling</td><td>27±0.5</td><td rowspan="2">19±0.5</td><td>35±0.5</td><td rowspan="2">19±0.5</td></tr>
<tr><td>B</td><td></td><td>29±0.5</td><td>46±0.5</td></tr>
<tr><td>A,B</td><td>heating</td><td>21±0.5</td><td>15±0.5</td><td>7±0.5</td><td>6.4±0.5</td></tr>
</table>

Room air conditioners must be able to start when voltage is within 85% to 110% of nominal rated voltage and under the temperature conditions specified in Table 43.

Table 43: Temperatures used in the start-up test, Russia

Mode	Type	indoor temperature		Outdoor temperature	
		dry bulb	wet bulb	dry bulb	wet bulb
cooling	A (high temperature)	32±0.5	23±0.5	43±0.5	26±0.5
	B (high temperature)			52±0.5	31±0.5
	A,B (low temperature)	21±0.5	15±0.5	21±0.5	15±0.5
heating	A,B (high temperature)	27±0.5	18±0.5	24±0.5	18±0.5
	A,B (low temperature)	21±0.5	16±0.5	2±0.5	1±0.5

The rating plate labels should be attached to both the internal and external sides of the air conditioner and contain information on: the air conditioner type, block type, name of producer, date of production, quality mark (if any), symbol of water resistance, type and mass of the refrigerant.

The test procedure consists of the following cooling tests:

- rated cooling capacity,
- rated heating capacity,
- maximum operating conditions test,
- cooling and heating electrical power consumption.

B:2.10 Chinese Taipei

Program: mandatory MEPS for room air conditioners

Scope

Chinese Taipei in keeping with some other South East Asian economies uses a different system to classify room air conditioners than is used internationally. Under the Taipei system, the classification of a room air conditioner is confined to those where the compression type refrigeration system, blower and electric heater, etc. are installed in one enclosure or separate enclosures and the power consumption is less than 3 kW. Cooling-only and reverse-cycle units are included, as are single-phase or three-phase units and air-cooled or water-cooled units. Ducted units are not excluded from the above definitions. In practice, this means that most types of air conditioning equipment are classified as a room air conditioner provided it satisfies the cooling power consumption constraints (there are no cooling capacity limits) and is of a packaged-type. Multi-split systems are excluded. Constraints are also imposed on the rated voltage, which must be either 100 V or 220V, and the rated frequency, which must be 60 Hz. Larger room air conditioners, of a packaged type, are classified as *unitary air conditioners.* Both room (split, windows, air-cooled and water-cooled) and unitary air conditioners (air-cooled and water-cooled) are subject to energy efficiency targets. Reversible units are not subject to COP requirements but are required to satisfy the cooling-mode performance requirements.

The applicability of Chinese Taipei's room air conditioners regulations is indicated in Table 44.

Table 44: Product types included in Chinese Taipei's room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
NA	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓ [1]	✓ [2]	✓	✓	9000 kcal/h [3]	None

1 The rated voltage can be 100V or 220V and the rated frequency must be 60Hz.
2 The rated voltage is 220V and the rated frequency 60Hz.
3 This is a de facto limit implied by the maximum permissible rated cooling capacity. In addition, the electrical power consumption must be less than 3 kW

Summary of test procedure (room air conditioners)

The Chinese Taipei room air conditioner test procedure, CNS 3615 (classified B7048) *Room air conditioners* differs from the international test procedure in a number of key areas.

- The rated cooling capacities are prescribed at set values.
- Rated voltages and frequencies are prescribed.
- The performance tests include a mandatory noise requirement test and refrigerant leakage test.

Details

The test procedure consists of the following cooling tests:

- cooling capacity,
- cooling power consumption,
- cooling overload performance
- enclosure sweat and condensate disposal tests
- freezing test,

and the following heating tests:

- heating capacity,
- heating power consumption,
- power consumption of electric heater (for models with a separate resistance heater),

- heating overload performance,
- automatic defrosting test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. For cooling and heating capacity measurements made with the air-enthalpy method, see below, the measuring device has to be one of: tunnel-type, loop-type, calorimeter-type or room-type. The cooling and heating capacities can be calculated by either the direct (calorimeter) method or the in-direct (air-enthalpy) method. For the calorimeter method two simultaneous determinations of the cooling or heating capacities are required, one on the indoor-side and one on the outdoor side. These two simultaneous determinations have to agree with each other by within 10% for the test to be deemed valid (as opposed to 4% in ISO 5151). The cooling and heating capacities are calculated from the measurements in the same way as specified in ISO 5151-94(E).

Equilibrium test conditions have to be maintained for a minimum of 1 hour before capacity data can begin to be recorded. Thereafter, seven measurements are carried out at 10 minutely intervals.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 45, which also shows the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Chinese Taipei *room air conditioner* rating conditions are almost harmonised with the ISO 5151 T1 condition except for a half degree difference in the indoor side wet-bulb temperature and wider tolerances for all measurements. The heating capacity test conditions are also similar to ISO 5151-94 although the indoor side dry-bulb temperature is 21°C (as opposed to 20°C) and there is no indoor wet-bulb requirement. The temperature conditions for the defrosting and overload tests are also slightly different.

The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions during the capacity and power rating tests, thus the part-load performance of variable or multiple speed drive units is not reflected.

Table 45: Test conditions for the determination of cooling capacity

Parameter	Standard test conditions	
	KS C 9306-97	ISO T1
Temperature of air entering indoor side (°C)		
dry-bulb	27±1	27±1(0.3)
wet-bulb	19.5±1	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±1	35±1(0.3)
wet-bulb	24±1	24±0.5(0.2)
Condenser water temperature[2)] (°C)		
inlet	30±0.5	30±0.2(0.1)
outlet	35±0.5	35±0.2(0.1)

Variables required to be measured, determined or declared for regulatory purposes include:

- Product classification according to its function
- Rated cooling capacity (kcal/h)
- Standard heating capacity (kcal/h)
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption (kW)
- EER (kcal/Wh)

The heating and cooling capacities must be not less than 95% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER or COP of 20%.

Summary of test procedure (unitary air conditioners)

The Chinese Taipei test procedure for unitary air conditioner and heat pumps is, CNS 2725 (classified no. B4008) *Unitary air conditioner* Unitary air conditioners can be ducted or non-ducted and hence the provisions in this standard are simultaneously comparable to both ISO 5151-94(E) (non-ducted air conditioners) and ISO 13253-93 (ducted air conditioners). Under the Chinese Taipei definition unitary air conditioners have a power input of more than 3 kW and rated cooling capacity of less than 22400 kcal/h. The compressor, condenser, evaporator, air blower and electric heater, etc. can be installed in one (single-packaged) or two (split-packaged) containers. Multi-split units are therefore excluded as are special air conditioning appliances such as spot conditioners.

Table 46: Product types included in Chinese Taipei unitary air conditioner test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓[1]	✓[1]	✓	✓	≤ 22400 kcal/h[3]	

1 The rated a.c. supply should have a voltage of 110V or 220V and a frequency of 60Hz
2 The rated a.c. supply should have a voltage of 220V or 440V and a frequency of 60Hz
3 In addition, the rated cooling power consumption must exceed 3 kW.

Variables required to be measured, determined or declared for regulatory purposes:

- Product classification according to its function
- Rated cooling capacity (kcal/h)
- Rated heating capacity (kcal/h)
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption (kW)
- Energy Efficiency Ratio, EER, (kcal/Wh)

The cooling capacities must be not less than 95% of its rated value (92% for the heating capacity) while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER of 20% and in the COP of 23%.

B:2.11 Thailand

Program: voluntary energy labelling of room air conditioners

Scope

Thailand has developed its room air conditioner test standard from an amalgamation of ISO/R 859-68, ARI 210/240-84 and JIS B 8615-84 and JIS B 8616-84. The classification of a room air conditioner is confined to air-cooled split-type units, while the Thai room air conditioner efficiency requirements (a voluntary labelling scheme) currently only applies to air-cooled split-units with a cooling capacity of between 7000 and 30000 Btu/h. Reversible units, tested in the cooling-mode only, are not excluded but are not common in Thailand.

The applicability of Thai room air conditioners requirement is indicated in Table 47.

Table 47: Product types included in Thai room air conditioner programs

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗ [1]	✓	✗	✗	✗	✗			✓	✗	7000-30000 Btu/h[2]	None

1 Only the cooling-mode performance is tested in the test procedure.
2 Cooling capacity constraints only apply in the energy labelling regulations not the test procedure.

Summary of test procedure

The Thai test procedure is, TIS 1155-2536(1993) *Air-cooled split type room air conditioners* The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected.

Details

The test procedure consists of the following cooling tests.

- rated cooling capacity and cooling electrical power consumption

There are no heating tests.

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are required, as in ISO 5151, one on the indoor-side and one on the outdoor side.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 48 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Thai room air conditioner rating conditions are fully harmonised with the ISO 5151 T1 test condition except for almost insignificant differences in the tolerances (no mean variation value is specified).

Table 48: Test conditions for the determination of cooling capacity, Thailand

Parameter	Standard test conditions	
	TIS 1155-2536	ISO T1
Temperature of air entering indoor side (°C)		
dry-bulb	267±1	27±1(0.3)
wet-bulb	19±0.5	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±1	35±1(0.3)
wet-bulb	24±0.5	24±0.5(0.2)

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacity
- EER
- Cooling-mode electrical power consumption

The cooling capacity must be not less than 95% of its rated value while the electrical power consumption in the cooling-mode shall be within 115% of its rated value. The EER must be no less than 85% of the rated value.

B:2.12 United States of America

Program: mandatory energy labelling and MEPS for room air conditioners

Scope

The USA in keeping with the other NAFTA economies uses a different system to classify room air conditioners than is used internationally. Under the NAFTA system, the classification of a room air conditioner is confined to a single-phase window/wall (single-packaged) unit. In the US regulations these can be cooling-only or reversible type and can be air or water cooled. Units with larger capacities and split-system air conditioners (of any cooling capacity) are classed as central air conditioners. Finally, a separate category is created for ‘Packaged terminal air conditioners’. These are packaged (i.e. enclosed in a single unit) air conditioners or heat pumps designed to be fitted through a wall using a wall sleeve, that have a prime source of refrigeration, separable outdoor louvres, forced ventilation and include a separate heating source of either steam, hot water or electrical resistance heat. A packaged terminal air conditioner need not include a heating source providing the basic configuration is otherwise identical to a model which does. Under the international system of definitions a room air conditioner could be classified under any of the above categories, therefore each of the three relevant test procedures are addressed in turn.

The applicability of US *room air conditioners* regulations is indicated in Table 49.

The applicability of US *packaged terminal air conditioner* regulations is indicated in Table 50.

The applicability of US *central air conditioner* regulations is indicated in Table 51.

Table 49: Product types included in USA room air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✓	✗	✗	✗		✗	✓	✗	✓	✗	≤10.55 kW	NA

Table 50: Product types included in USA packaged terminal air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✗	✓	✗	None	None

Table 51: Product types included in USA central air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✓	✗	<19.05 kW[1]	<19.05 kW[1]

1 = 65 000 Btu/h

Summary of test procedure for *room air conditioners*

The US test procedure and standards regulation, CFR 430 Subpart B, Appendix F *Uniform test method for measuring the energy consumption of room air conditioners* specifies that cooling capacity, power input and energy efficiency ratio(s) be measured at the conditions specified in ANS Z234.1-72 *Room air conditioners* according to the method in ASHRAE-16-69 *Method of testing for rating room air conditioners*. In practice ANS Z234.1-72 has been superseded by its revision known as ANSI/AHAM-RAC-1-82, although this is not stipulated in the US regulations.

The room air conditioner regulations in CFR 430 Subpart B apply to single phase window/wall room air conditioners (i.e. single-packaged units) but exclude split-packaged air conditioners (mini-splits), and packaged-terminal air conditioners. Cooling-only and reversible units are included as are air and water cooled units. Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners.

Details

The test procedure consists of the following cooling tests:

- rated cooling capacity,
- heating capacity,
- moisture removal capacity,
- recirculating air quantity,
- ventilating air quantity,
- exhaust air quantity,
- electrical input.

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are preferred (but not required as in ISO 5151), one on the indoor-side and one on the outdoor side. If simultaneous determinations are used their values must be within 4% of each other. Stable test conditions have to be maintained for a series of eight readings taken at 15 minute intervals with a maximum temperature variation of 0.56°C before capacity data can begin to be recorded. The capacity tests last for not less than 1 hour with readings taken every 10 minutes for a total of 7 readings.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 52, which also shows the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The US *room air conditioner* rating conditions are harmonised with the ISO 5151 T1 condition except that they are based on values rounded to the nearest whole degree Fahrenheit rather than Celsius for all points except the condenser water inlet temperature for water cooled units, which is significantly cooler than the ISO 5151 value.

Table 52: Test conditions for the determination of cooling capacity, USA

Parameter	Standard test conditions	
	ANSI/AHAM RAC-1-1982	ISO T1
Temperature of air entering indoor side (°C)		
dry-bulb	26.7±0.56(0.28)	27±1(0.3)
wet-bulb	19.4±0.34(0.17)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±0.56(0.28)	35±1(0.3)
wet-bulb	23.9±0.34(0.17)	24±0.5(0.2)
Condenser water temperature[2)] (°C)		
inlet	23.9±0.22(0.11)	30±0.2(0.1)
outlet	35±0.22(0.11)	35±0.2(0.1)

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling and heating capacities (sensible, latent and total, rounded to the nearest 0.01 kW) expressed in Btu/h
- Cooling-mode EER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption (W)

Summary of test procedure for packaged terminal air conditioners and heat pumps

The US test procedure and standards regulation, Energy Policy Act 1992 references ASHRAE 90.1 which in turn references ARI-310/380-93 *Standard for packaged terminal air-conditioners and heat pumps* and uses the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ASHRAE-16-88 *Method of testing for rating room air conditioners and packaged terminal air conditioners*. ASHRAE-37 is also referenced.

Details

The test procedure consists of the following tests.

- standard rated cooling and heating capacities,
- maximum high temperature operation test,
- low-temperature operation test (cooling-mode) (an optional rating condition)
- high-temperature heat pump (heating mode)
- low temperature operation test (heating-mode) (an optional rating condition)
- part-load rating test (variable capacity units only)
- insulation effectiveness test

- condensate disposal test,

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are preferred (but not required as in ISO 5151), one on the indoor-side and one on the outdoor side. If simultaneous determinations are used their values must be within 4% of each other. Stable test conditions have to be maintained, for a series of eight readings taken at 15 minute intervals with a maximum temperature variation of 1°F (0.56°C) before capacity data can begin to be recorded. The capacity tests last for not less than 1 hour with readings taken every 10 minutes for a total of 7 readings.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 53 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The US packaged terminal air conditioner cooling rating conditions are the same as in the ISO 5151 standard except that they are based on values rounded to the nearest whole degree Fahrenheit rather than Celsius and the tolerances differ. Water-cooled units are excluded from the definition of a packaged terminal air conditioner or heat pump applied in the standard. The heating conditions differ from ISO 5151 by up to 1.4 °C.

Table 53: Test conditions for the determination of cooling capacity, USA

Parameter	**Standard test conditions**	
	ARI-310/380-83	**ISO T1**
Temperature of air entering indoor side (°C)		
dry-bulb	26.7±0.56(0.28)	27±1(0.3)
wet-bulb	19.4±0.34(0.17)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	35±0.56(0.28)	35±1(0.3)
wet-bulb	23.9±0.34(0.17)	24±0.5(0.2)

Table 54: Test conditions for the determination of heating capacity, USA

Parameter	Standard test conditions	
	C744-93	ISO T1
Temperature of air entering indoor side (°C) dry-bulb wet-bulb	21.1±0.56(0.28)	20±1(0.3) 15±0.5(0.2)
Temperature of air entering outdoor side (°C)		
high temperature rating test dry-bulb wet-bulb	8.3±0.56(0.28) 6.1±0.34(0.17)	7±1(0.3) 6±0.5(0.2)
low (extra-low in ISO) temperature rating test dry-bulb wet-bulb	-8.3±0.56(0.28) -9.4±0.34(0.17)	-7±1(0.3) -8±0.5(0.2)

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.03 kW) expressed in W or Btu/h
- EER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

Summary of test procedure for central air conditioners and heat pumps

A central air conditioner or heat pump is defined as a 'product other than a packaged terminal air conditioner, which is powered by single phase electrical current, air cooled, rated below 65000 Btu/h (19.05 kW), not contained within the same cabinet as a furnace, the rated capacity of which is above 225000 Btu/hr and is a heat pump or cooling only unit'. This definition includes split-packaged room air conditions (mini splits).

The official US test procedure is contained in DOE CFR 430 Appendix M:

Test method for measuring the energy consumption of central air conditioners, the *Energy Policy Act of 1992* and the methodological standards *ARI 210/240-89 & ASHRAE 37.*

Details

The test procedure consists of the following heating and cooling tests.

- cooling capacity tests (A, B, C, D)
- intermediate cooling test for units with variable speed compressors
- high temperature, cyclic, frost accumulation and low temperature heating tests,

Testing is to be done using the air enthalpy approach with the test chamber configured in one of the following arrangements: the tunnel air enthalpy method arrangement, the loop air enthalpy arrangement, the calorimeter air enthalpy method arrangement or the room air enthalpy method arrangement. In practice this test method constrains the cooling equipment to have a cooling capacity of less than 39 560W.

All types of central air conditioners are rated using a seasonal energy efficiency ratio (SEER). The SEER units are in Btu per Wh. For determination of the SEER there 4 different temperature rating points. These are called DOE “A” to “D”. Point “A” is essentially the same as the ISO 5151 T1 condition with minor differences and is used to rate the cooling capacity. Points “C” and “D” are used to determine a degradation co-efficient C_D which is used to measure the efficiency loss as a result of cycling. These conditions apply to single speed compressors. If there is a 2 speed or variable speed compressor, there are additional rating points at part load. Note that many manufacturers now also publish EER information recorded under the “A” condition in addition to the mandatory SEER information, to assist in comparison of products.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 55 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses.

Table 55: Test conditions for the determination of cooling capacity and SEER, USA

Parameter	**Standard test conditions**				
	A	**B**	**C**	**D**	**ISO T1**
Temperature of air entering indoor side (°C)					
dry-bulb	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±1(0.5)
wet-bulb	19±0.34(0.17)	19±0.34(0.17)	14±0.34(0.17)	14±0.34(0.17)	19±0.3(0.2)
Temperature of air entering outdoor side (°C)					
dry-bulb	35±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	35±1(0.5)
wet-bulb					24±0.3(0.2)

Testing to conditions “C” and “D” are optional in that if the tests are not done, a value of 0.25 is assigned for the degradation co-efficient C_D. Only four tests are required for single speed compressors. Where there is a two speed compressor, tests at condition “A” and “B” are to be done for each speed.

For variable speed compressors, up to seven tests are required as follows:

- “A” and “B” wet coil tests at maximum compressor speed
- “B” wet coil is tested at minimum speed
- Low temperature wet coil test is conducted at minimum speed (indoor and outdoor 19.4/13.9^{o}C dry/wet)
- Final wet coil test is conducted at an intermediate speed

- if a value for C_D of 0.25 is not used, dry coil tests “C” and “D” at minimum speed.

All single speed units are subject to four performance tests:

- high temperature test,
- cyclic test,
- frost accumulation test
- low temperature test.

Variable speed units are subject to: high temperature test (one maximum speed, two at minimum speed), cyclic test (minimum speed), frost accumulation test (maximum and intermediate speeds).

For single speed compressors, the Seasonal Energy Efficiency Ratio (SEER) is calculated via the following steps:

CLF = $Q_{“D”} / Q_{“C”}$

(Q = “average” capacity measured over a complete compressor on and off cycle)

C_D = $(1 - EER_D/EER_C) / (1 - CLF)$

C_D is the degradation coefficient (or 0.25 if not tested to conditions “C” and “D”)

PLF = $1 - (0.5 \times C_D)$

SEER = $PLF \times EER_B$

Where:EER_B is the EER to condition “B”.

For variable speed compressors, the calculations are much more complex. Essentially, the method involves the estimation of the performance of the system (cooling capacity and electrical energy) at 8 outdoor temperature points ranging 39^{o}C down to 19.4^{o}C based on test data for various conditions and averaging these as weighted by specified bin weightings for assumed hours of operation.

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total) expressed in Btu/h or W
- SEER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

B:2.13 ISO 5151-1994(E) – Non-ducted air conditioners

Scope

The applicability of the ISO 5151 test procedure for room air conditioners is indicated in Table 56. The procedure applies to air conditioners of any capacity and type provided they are non-ducted including cooling-only and reversible, single-phase and three-phase, and air-cooled or water-cooled units. The test procedure excludes single-duct room air conditioners and multi-split systems. Water-cooled heat-pumps are not included. Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners.

Table 56: Product types included/ excluded from ISO 5151 test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✓	✓	✗	✗		✓	✓	✓	✓	✓[1]	None	None

1 Heat pumps with water cooled condensers are excluded.

Summary of test procedure

The international test procedure consists of a series of cooling and heating (for reversible units only) tests as follows.

Cooling tests:

- rated cooling capacity,
- maximum cooling test,
- minimum cooling test,
- enclosure sweat and condensate disposal test,
- freeze-up test.

Heating tests:

- rated heating capacity,
- maximum heating test,
- minimum heating test,
- automatic defrost test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter[3]. The cooling and heating capacities can be calculated by either the calorimeter method or the air-enthalpy method. For the calorimeter method two simultaneous determinations of the cooling or heating capacities are required, one on the indoor-side and one on the outdoor side. These two simultaneous determinations have to agree with each other by within 4% for the test to be deemed valid. In the case of units with water cooled condensers the heat flow rejected via the cooling water is

3 In practical terms, there is a limit on the size of unit that can be tested using a calorimeter. This tends to be around 10kW to 15kW cooling or heating capacity, but the precise limit depends on the particular test facility.

measured instead of the outdoor side compartment. Test conditions have to be maintained for a minimum of 1 hour before capacity data can begin to be recorded. The capacity tests last for 30 minutes with readings taken every 5 minutes.

The rated cooling performance of the air conditioner can be tested at one or more of three different sets of test conditions that are designed to represent performance under a moderate, cool or hot climate. The designated climate type must be indicated on the air conditioner. In practice the T1 test condition, indicating performance under a moderate climate, is the world standard condition for rating air conditioners. The standard test conditions for the cooling capacity test are shown in Table 57. The test conditions are always at full-load and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected.

Table 57: Test conditions for the determination of cooling capacity, ISO

Parameter	**Standard test conditions**		
	T1	**T2**	**T3**
Temperature of air entering indoor side (°C)			
dry-bulb	27	21	29
wet-bulb	19	15	19
Temperature of air entering outdoor side (°C)			
dry-bulb	35	27	46
wet-bulb[1)]	24	19	24
Condenser water temperature[2)] (°C)			
inlet	30	22	30
outlet	35	27	35
T1 = Standard cooling capacity rating conditions for **moderate** climates			
T2 = Standard cooling capacity rating conditions for **cool** climates			
T3 = Standard cooling capacity rating conditions for **hot** climates			
1) The wet-bulb temperature is not required when testing air-cooled condensers which do not evaporate the condensate.			
2) Representative of equipment working with cooling towers. For equipment designed for other uses, the manufacturer shall designate the condenser water inlet and outlet temperatures or the water flow rates and the inlet temperature in the ratings			

The standard test conditions for the heating capacity test are shown in Table 58. The heating capacity of reversible air conditioners must be tested at a minimum of the high and low heating conditions, while the extra-low test condition is optional.

Table 58: Test conditions for the determination of heating capacity, ISO

Parameter	Standard test conditions
Temperature of air entering indoor side (°C)	
dry-bulb	20±1(0.3)
wet-bulb (maximum)	15±0.5(0.2)
Temperature of air entering outdoor side (high) (°C)	
dry-bulb	7±1(0.3)
wet-bulb	6±0.5(0.2)
Temperature of air entering outdoor side (low) (°C)	
dry-bulb	2±1(0.3)
wet-bulb	1±0.5(0.2)
Temperature of air entering outdoor side (extra low) (°C)	
dry-bulb	-7±1(0.3)
wet-bulb	-8±0.5(0.2)

Variables required to be measured, determined or declared are:

- Climate classification types
- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.1 kW)
- EER (expressed in multiples of 0.05)
- Heating capacity (as appropriate, rounded to the nearest 0.1 kW)
- COP (only applicable to reversible units operating in the heating-mode and expressed in multiples of 0.05)
- Rated voltages and frequencies
- Cooling power consumption
- Refrigerant designation and refrigerant mass charge

There is no constraint imposed over the maximum permissible uncertainty in the declared cooling capacity. The electrical power must be measured within a maximum uncertainty of ±0.5%.

B:2.14 Summary of room air conditioner test conditions and coverage

Table 59: Room air conditioner test conditions by APEC member economy

Economy	Test procedure name	Test point name	Similarity to ISO 5151 point T1	Stated climate type	Air temperature entering the indoor side		Air temperature entering the outdoor side		Condenser water temperature	
					Dry-bulb	Wet-bulb	Dry-bulb	Wet-bulb	Inlet	Outlet
Australia	AS/NZS 3823.1.1-98	T1	T1 except wet-bulb tolerances	Moderate	27±1(0.3)	19±0.6(0.2)	35±1(0.3)	24±0.6(0.2)	30±0.2(0.1)	35±0.2(0.1)
Canada	CAN/CSA-C368.1-M90	none	close to T1 excluding water cooled units	Not stated	26.7±0.56(0.28)	19.4±0.34(0.17)	35±0.56(0.28)	23.9±0.34(0.17)	NA	NA
	CAN/CSA-C273.3-M91	A	T1 excluding water cooled units	Steady State Wet Coil Test A	27±1(0.3)	19±0.5(0.2)	35±1(0.3)	28±0.5(0.2)	NA	NA
	CAN/CSA-C744-93	none	close to T1 excluding water cooled units	Not stated	26.7±0.56(0.28)	19.4±0.34(0.17)	35±0.56(0.28)	23.9±0.34(0.17)	NA	NA
China	GB 7725-96	T1	T1	Moderate	27±1(0.3)	19±0.5(0.2)	35±1(0.3)	24±0.5(0.2)	30±0.2(0.1)	35±0.2(0.1)
Hong Kong	ISO 5151-94(E)	T1	T1	Moderate	27±1(0.3)	19±0.5(0.2)	35±1(0.3)	24±0.5(0.2)	30±0.2(0.1)	35±0.2(0.1)
Japan	JIS C9612-94	none	T1 (except water temperature tolerances)	Not stated	27±1(0.3)	19±0.5(0.2)	35±1(0.3)	24±0.5(0.2)	30±0.3	35±0.3
	JIS B8616-93									
Korea	KS C 9306-97	NA	T1		27±1	19.5±1	35±1	24±0.5	30±0.5	35±0.5
	KS B 6369-95	NA	T1		27±1	19.5±1	35±1	24±0.5	30±0.5	35±0.5
Mexico	NOM-073-SCFI-94	none	close to T1 except for water condenser units	Not stated	26.6 ±0.55(0.28)	19.4 ±0.33(0.17)	34.9 ±0.55(0.28)	23.8 ±0.33(0.17)	NA	NA
International	ISO 5151-94(E)	T1	T1	Moderate	27±1(0.3)	19±0.5(0.2)	35±1(0.3)	24±0.5(0.2)	30±0.2(0.1)	35±0.2(0.1)

Tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses

Table 59: Room air conditioner test conditions by APEC member economy (continued)

Philippines	PNS 240-89	D	close to T1 except outdoor wet-bulb and differences for water condenser units	Philippines	27±0.5(0.3)	19±0.3(0.2)	35±0.5(0.3)	27±0.3(0.2)	31±0.2(0.1)	37±0.2(0.1)
Chinese Taipei	CNS 3615–95	Cooling condition	very close to T1	Not stated	27±1	19.5±0.5	35±1	24±1	30±0.5	35±0.5
	CNS 2725-95	Cooling condition	close to T1 except for water condenser units	Not stated	27±1	19.5±0.5	35±1	24±0.5	30±0.5	30±0.6
Thailand	TIS 1155-2536 (1993)		T1 except for exclusion of arithmetic mean tolerances	Not stated	27±1	19.±0.5	35±1	24±0.5	NA	NA
USA	10 CFR 430 Subpart B, Appendix F, ANSI/AHAM RAC-1-82 & ASHRAE 16-83-RA88	none	close to T1 except for water condenser units	Not stated	26.7±0.56(0.28)	19.4±0.34(0.17)	35±0.56(0.28)	23.9±0.34(0.17)	23.9±0.22(0.11)	35±0.22(0.11)
	10 CFR 430 Subpart B, Appendix M &ARI 210/240-94	A	T1 excluding water cooled units	Steady State Wet Coil Test A	26.7±1.1(0.28)	19.4[2] ±0.56 (0.17)	35±1.1(0.28)	23.9 ±0.56(0.17)	29.4±0.28(0.11)	35±0.28(0.11)
	ARI 310/380-93	none	close to T1 excluding water cooled units	Not stated	26.7±0.56(0.28)	19.4±0.34(0.17)	35±0.56(0.28)	23.9±0.34(0.17)	NA	NA
International	ISO 5151-94(E)	T1	T1	Moderate	27±1(0.3)	19±0.5(0.2)	35±1(0.3)	24±0.5(0.2)	30±0.2(0.1)	35±0.2(0.1)

Tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses

2 There is an apparent typographical error in the US Code of Federal Regulations, 10 CFR 430 Subpart B, Appendix M, Section 3.1.1 p 198, which states that this value (the indoor side wet-bulb temperature) should be 87°F (equivalent to 30.6°C) as opposed to the 67°F (19.4°C) stated in ARI 210/240-94 and consistent with the ISO 5151 T1 test condition. It appears that the ARI 210/240-94 values are used in practice.

Table 60: Applicability of room air conditioner test procedures, regulations and product types

Economy	Test procedure name	Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	a.c. Frequency limits (Hz)	a.c. Voltage limits (V)	Air-cooled condenser	Water-cooled condenser (Cooling only units)	Water-cooled condenser (reversible units)	Cooling capacity limit	Cooling-mode electrical power limit	Heating capacity limit
Australia	AS/NZS 3823.1.1-98	✗	✓	✓	✓	✓	✓	✗	✗		✓	✓	✓	✗	✗	✓	✓	✗	<7.5kW[1]	None	None
Canada	CAN/CSA-C368.1-M90	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✓	✗	✗	✗	✓	✗	✗	≤10.55 kW	None	None
	CSA-C273.3-M91	✓	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✓	✗	✗	✓	✗	✗	<19 kW	None	<19 kW
	CAN/CSA-C744-93	✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✓	✗	✗	None	None	None
China	GB 7725-96	✗	✓	✓	✓	✓	✓	✗	✗		✓	✓	✓	✗	✗	✓	✗	✗	≤9.0kW[2]	None	None
Hong Kong	ISO 5151-94(E)	✗	✓	✓	✓[3]	✓	✓	✗	✗		✓	✓[2]	✓[2]	50	380/ 320	✓	✗[2]	✗	≤10kW[1]	None	NA[1]

1 Included in the efficiency regulation but not the test procedure
2 Included in the test procedure but excluded from the efficiency regulation
3 Only the cooling mode performance is tested for the efficiency regulations
4 Theoretically included, but the test procedure is not adequate to test these appliances

Table 60: Applicability of room air conditioner test procedures, regulations and product types (continued)

Economy	Test procedure name	Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	a.c. Frequency limits (Hz)	a.c. Voltage limits (V)	Air-cooled condenser	Water-cooled condenser (Cooling only units)	Water-cooled condenser (reversible units)	Cooling capacity limit	Cooling-mode electrical power limit	Heating capacity limit
Japan	JIS C9612-94	✓	✓	✓	✓	✓	✓	✗	✓[4]		✓	✓	✓	50 /60	<300	✓	✓	✓	≤10kW	≤3kW	≤18kW
	JIS B8616-93	✓	✓	✓	✓	✓	✓	✗	✓[4]	✗	✓	✓	✓	50 /60	100/ 200	✓	✓	✓	≤23000 kcal/h	>3kW	yes
Korea	KS C 9306-97	✓	✓	✓	✓	✓	✓	✗	✓[4]		✓	✓	✓	60	220	✓	✓	✓	≤9000 kcal/h[5]	≤3kW	None
	KS B 6369-95	✓	✓	✓	✓	✓	✓	✗	✓[4]	✗	✓	✓	✓			✓	✓	✓		>3kW	yes
Mexico	NOM-073-SCFI-94	✗	✓	✓	✓	✓	✗	✗	✗		✗	✓	✗			✓	✗	✗	≤10.548 kW		None

1 Included in the efficiency regulation but not the test procedure
2 Included in the test procedure but excluded from the efficiency regulation
3 Only the cooling mode performance is tested for the efficiency regulations
4 Theoretically included, but the test procedure is not adequate to test these appliances

Table 60: Applicability of room air conditioner test procedures, regulations and product types (continued)

Economy	Test procedure name	Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	a.c. Frequency limits (Hz)	a.c. Voltage limits (V)	Air-cooled condenser	Water-cooled condenser (Cooling only units)	Water-cooled condenser (reversible units)	Cooling capacity limit	Cooling-mode electrical power limit	Heating capacity limit
Philippines	PNS 240-89	NA	✓	✓	✓ [3]	✓	✗ [2]	✗	✗ [4]		✓	✓	✓	60[1]	230[1]	✓	✓	✓ [3]	≤26000kJ/h[1]	None	None
Chinese Taipei	CNS 3615–95	✓	✓	✓	✓	✓	✓	✗	✗	✗	✓	✓	✓	60	100/ 220	✓	✓	✓	9000 kcal/h[3]	<3kW	None
	CNS 2725-95	✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓	✓	60	110/ 220/ 440	✓	✓	✓	22400 kcal/h[3]	>3kW	None
Thailand	TIS 1155-2536 (1993)	✓	✓	✓	✓ [3]	✗	✓	✗	✗	✗	✗			✗	✗	✓	✗	✗	7000-30000 Btu/h[1]	None	None

1 Included in the efficiency regulation but not the test procedure
2 Included in the test procedure but excluded from the efficiency regulation
3 Only the cooling mode performance is tested for the efficiency regulations
4 Theoretically included, but the test procedure is not adequate to test these appliances

Table 60: Applicability of room air conditioner test procedures, regulations and product types (continued)

Economy	Test procedure name	Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	a.c. Frequency limits (Hz)	a.c. Voltage limits (V)	Air-cooled condenser	Water-cooled condenser (Cooling only units)	Water-cooled condenser (reversible units)	Cooling capacity limit	Cooling-mode electrical power limit	Heating capacity limit
USA	10 CFR 430 Subpart B, Appendix F, ANSI/AHAM RAC-1-82 & ASHRAE 16-83-RA88	✗	✓	✓	✓	✓	✗	✗	✗	✗	✗	✓	✗ [2]	✗	✗	✓	✓	✓	None	None	None
	10 CFR 430 Subpart B, Appendix M &ARI 210/240-94	✓	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗ [2]	✗	✗	✓	✓	✓	<65000 Btu/h[1] <135000 Btu/h[2]	None	<65000 Btu/h[1] <135000 Btu/h[2]
	ARI 310/380-93	✗	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✗	✗	✓	✗	✗	None	None	None
International	ISO 5151-94(E)	✗	✓	✓	✓	✓	✓	✗	✗		✓	✓	✓	✗	✗	✓	✓	✗	None	None	None

1 Included in the efficiency regulation but not the test procedure
2 Included in the test procedure but excluded from the efficiency regulation
3 Only the cooling mode performance is tested for the efficiency regulations
4 Theoretically included in the test procedure although it is not adequate to test these appliances. Excluded from the efficiency regulations

B:3 Central and large air conditioners and heat pumps

B:3.1 Canada

Program: voluntary energy labelling and MEPS for central air conditioners

Scope

Canada has an extensive MEPS program for air conditioners and heat pumps, that includes the following product types:

- single-package central air conditioners and heat pumps
- split-system central air-conditioners and heat pumps
- large air-conditioners and heat pumps
- large split-system air-conditioners and heat pumps

Central air conditioners in Canada and the USA include both large ducted systems and ductless split systems (i.e., mini-splits or split-packaged units). The predominant type of central air conditioner in Canada and the USA is the ducted system. Ducted systems are either split systems or single package systems. The Canadian efficiency regulations classify a central air conditioner according to whether it is single-package or split and depending on its cooling (or heating capacity). Units cooling or heating capacities above 19kW are classed as large. All central air conditioners, including split-packaged (mini-split) systems, are rated using a seasonal energy efficiency ratio, SEER, that is based on the amalgamated results of testing cooling capacity at 4 different test conditions. All central heat pumps are rated using a similar approach to produce a heating seasonal performance factor, HSPF. A voluntary labelling program for single and three phase systems of the single package and split system type is also in place.

The applicability of Canadian *single package central air conditioner and heat pump* regulations is indicated in Table 61.

Table 61: Product types included in Canadian single package central air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓	✗	✓	✗	≤19 kW[1]	≤19 kW[1]

1 = 65 000 Btu/h

The applicability of Canadian *split-package central air conditioner and heat pump* regulations is indicated in Table 62.

Table 62: Product types included in Canadian split-package central air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗	✓	✗	≤19 kW[1]	≤19 kW[1]

1 = 65 000 Btu/h

The applicability of Canadian *large air conditioner and heat pump* regulations is indicated in Table 63.

Table 63: Product types included in Canadian large air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓	✓	✗	>19 kW <73 kW[1]	>19 kW <73 kW[1]

1 = 250 000 Btu/h

The applicability of Canadian *large split-system air conditioner and heat pump* regulations is indicated in Table 64.

Table 64: Product types included in Canadian large split system air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✓	✓	>19 kW <73 kW[1]	>19 kW <73 kW[1]

1 = 250 000 Btu/h

Summary of test procedure for single-package central air conditioners and heat pumps

The Canadian test procedure and standards regulation, CAN/CSA-C656-M92 *Performance standard for single package central air-conditioners and heat pumps* uses the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ASHRAE-37-88 *Methods of testing for rating unitary air conditioning and heat pump equipment*.

The CAN/CSA-C656-M92 standard excludes water sink or source units and three phase units. It only applies to units rated at 230 V, 60 Hz. Part-load conditions are tested through the use of multiple test rating conditions and therefore this test could give a reasonable performance rating for variable or multiple speed drive air conditioners and heat pumps.

Canada has based its standard, CAN/CSA C656-M92, on the US DOE test procedure for central air conditioners. The official US test procedure is contained in DOE regulations Code of Federal Regulations 430 Appendix M, the Energy Policy Act 1992 and standards ARI 210/240-89 & ASHRAE 37.

Details

The test procedure consists of the following heating and cooling tests.

- cooling capacity tests (A, B, C, D)
- intermediate cooling test for units with variable speed compressors
- high temperature, cyclic, frost accumulation and low temperature heating tests,

Testing is to be done using the air enthalpy approach with the test chamber configured in one of the following arrangements: the tunnel air enthalpy method arrangement, the loop air enthalpy arrangement, the calorimeter air enthalpy method arrangement or the room air enthalpy method arrangement. In practice this test method constrains the cooling equipment to have a cooling capacity of less than 39 560W.

All types of central air conditioners are rated using a seasonal energy efficiency ratio (SEER). The SEER units are in Btu per Wh. For determination of the SEER there 4 different temperature rating points. These are called DOE “A” to “D”. Point “A” is essentially the same as the ISO 5151 T1 condition with minor differences and is used to rate the cooling capacity. Points “C” and “D” are used to determine a degradation co-efficient C_D which is used to measure the efficiency loss as a result of cycling. These conditions apply to single speed compressors. If there is a 2 speed or variable speed compressor, there are additional rating points at part load. Note that many manufacturers now also publish EER information recorded under the “A” condition in addition to the mandatory SEER information, to assist in comparison of products.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 65 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses.

Table 65: Test conditions for the determination of cooling capacity and SEER, Canada

Parameter	Standard test conditions				
	A	**B**	**C**	**D**	**ISO T1**
Temperature of air entering indoor side (°C)					
dry-bulb	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±1(0.5)
wet-bulb	19±0.34(0.17)	19±0.34(0.17)	14±0.34(0.17)	14±0.34(0.17)	19±0.3(0.2)
Temperature of air entering outdoor side (°C)					
dry-bulb	35±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	35±1(0.5)
wet-bulb					24±0.3(0.2)

Testing to conditions “C” and “D” are optional in that if the tests are not done, a value of 0.25 is assigned for the degradation coefficient C_D. Only four tests are required for single speed compressors. Where there is a two speed compressor, tests at condition “A” and “B” are to be done for each speed.

For variable speed compressors, up to seven tests are required as follows:

- “A” and “B” wet coil tests at maximum compressor speed
- “B” wet coil is tested at minimum speed
- Low temperature wet coil test is conducted at minimum speed (indoor and outdoor 19.4/13.9°C dry/wet)
- Final wet coil test is conducted at an intermediate speed
- if a value for C_D of 0.25 is not used, dry coil tests “C” and “D” at minimum speed.

All single speed units are subject to four performance tests:

- high temperature test,
- cyclic test,

- frost accumulation test
- low temperature test.

Variable speed units are subject to: high temperature test (one maximum speed, two at minimum speed), cyclic test (minimum speed), frost accumulation test (maximum and intermediate speeds).

For single speed compressors, the Seasonal Energy Efficiency Ratio (SEER) is calculated via the following steps:

CLF = $Q_{\text{“D”}} / Q_{\text{“C”}}$

(Q = “average” capacity measured over a complete compressor on and off cycle)

C_D = $(1 - EER_D/EER_C) / (1 - CLF)$

C_D is the degradation coefficient (or 0.25 if not tested to conditions “C” and “D”)

PLF = $1 - (0.5 \times C_D)$

SEER = $PLF \times EER_B$

Where: EER_B is the EER to condition “B”.

For variable speed compressors, the calculations are much more complex. Essentially, the method involves the estimation of the performance of the system (cooling capacity and electrical energy) at 8 outdoor temperature points ranging 39°C down to 19.4°C based on test data for various conditions and averaging these as weighted by specified bin weightings for assumed hours of operation.

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.01 kW) expressed in W or Btu/h
- SEER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

Summary of test procedure for split-system central air conditioners and heat pumps

A split-system central air conditioner or heat pump is defined as a split-system unit (other than a packaged terminal air conditioner), which is powered by single phase electric current, air cooled, and has a rated capacity of below 19 kW.

Canada has based its standard, CAN/CSA C273.3-M91, on the US DOE test procedure for central air conditioners. The official US test procedure is contained in DOE regulations Code of Federal Regulations 430 Appendix M, the Energy Policy Act 1992 and standards ARI 210/240-89 & ASHRAE 37. All types of central air conditioners are rated using a seasonal energy efficiency ratio (SEER). The SEER units are in Btu per Wh. For determination of the SEER there 4 different temperature rating points. These are called DOE “A” to “D”. Point “A” is essentially the same as the ISO 5151 T1 condition and is used to rate the cooling capacity. Points “C” and “D” are used to determine a degradation coefficient C_D which is used to measure the efficiency loss as a result of cycling. These conditions apply to single speed compressors. If there is a 2 speed or variable speed compressor, there are additional rating points at part load. Note that many manufacturers now also publish EER information recorded under the “A” condition in addition to the mandatory SEER information, to assist in comparison of products.

Details

The test procedure consists of the following heating and cooling tests.

- cooling capacity tests (A, B, C, D)
- intermediate cooling test for units with variable speed compressors
- high temperature, cyclic, frost accumulation and low temperature heating tests,

Testing is to be done using the air enthalpy approach with the test chamber configured in one of the following arrangements: the tunnel air enthalpy method arrangement, the loop air enthalpy arrangement, the calorimeter air enthalpy method arrangement or the room air enthalpy method arrangement. In practice this test method constrains the cooling equipment to have a cooling capacity of less than 39 560W.

All types of central air conditioners are rated using a seasonal energy efficiency ratio (SEER). The SEER units are in Btu per Wh. For determination of the SEER there 4 different temperature rating points. These are called DOE “A” to “D”. Point “A” is essentially the same as the ISO 5151 T1 condition with minor differences and is used to rate the cooling capacity. Points “C” and “D” are used to determine a degradation co-efficient C_D which is used to measure the efficiency loss as a result of cycling. These conditions apply to single speed compressors. If there is a 2 speed or variable speed compressor, there are additional rating points at part load. Note that many manufacturers now also publish EER information recorded under the “A” condition in addition to the mandatory SEER information, to assist in comparison of products.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 66 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses.

Table 66: Test conditions for the determination of cooling capacity and SEER, Canada

Parameter	Standard test conditions				
	A	B	C	D	ISO T1
Temperature of air entering indoor side (°C)					
dry-bulb	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±1(0.5)
wet-bulb	19±0.34(0.17)	19±0.34(0.17)	14±0.34(0.17)	14±0.34(0.17)	19±0.3(0.2)
Temperature of air entering outdoor side (°C)					
dry-bulb	35±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	35±1(0.5)
wet-bulb					24±0.3(0.2)

Testing to conditions “C” and “D” are optional in that if the tests are not done, a value of 0.25 is assigned for the degradation co-efficient C_D. Only four tests are required for single speed compressors. Where there is a two speed compressor, tests at condition “A” and “B” are to be done for each speed.

For variable speed compressors, up to seven tests are required as follows:

- “A” and “B” wet coil tests at maximum compressor speed
- “B” wet coil is tested at minimum speed
- Low temperature wet coil test is conducted at minimum speed (indoor and outdoor 19.4/13.9^{o}C dry/wet)
- Final wet coil test is conducted at an intermediate speed
- if a value for C_D of 0.25 is not used, dry coil tests “C” and “D” at minimum speed.

All single speed units are subject to four performance tests:

- high temperature test,
- cyclic test,
- frost accumulation test
- low temperature test.

Variable speed units are subject to: high temperature test (one maximum speed, two at minimum speed), cyclic test (minimum speed), frost accumulation test (maximum and intermediate speeds).

For single speed compressors, the Seasonal Energy Efficiency Ratio (SEER) is calculated via the following steps:

$CLF = Q_{“D”} / Q_{“C”}$

(Q = “average” capacity measured over a complete compressor on and off cycle)

$C_D = (1 - EER_D/EER_C) / (1 - CLF)$

C_D is the degradation coefficient (or 0.25 if not tested to conditions “C” and “D”)

$PLF = 1 - (0.5 \times C_D)$

$SEER = PLF \times EER_B$

Where:EER_B is the EER to condition “B”.

For variable speed compressors, the calculations are much more complex. Essentially, the method involves the estimation of the performance of the system (cooling capacity and electrical energy) at 8 outdoor temperature points ranging 39^{o}C down to 19.4^{o}C based on test data for various conditions and averaging these as weighted by specified bin weightings for assumed hours of operation.

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.01 kW) expressed in W or Btu/h
- SEER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

S*plit-system central* air conditioners and heat pumps are not subject to labelling, even though they include split-package air conditioners and heat pumps of a small to medium sized cooling or heating capacity.

Summary of test procedure for large central air conditioners and heat pumps

Large central air conditioners and heat pumps are tested in a different way to that described for central air conditioners and heat pumps. Seasonal energy efficiency ratio and heating performance factors are not used, but rather the efficiency regulations are expressed in terms of a combination of EER, COP and IPLV requirements. The IPLV is the integrated part load performance, which is only used for units capable of operating with reduced capacities, such as variable speed drive units.

The test procedure and efficiency requirements for EER, COP and IPLV limits are set out in CAN/CSA-C746-93 *Performance standard for rating large air conditioners and heat pumps*, which references the US test procedures: ARI 210/240-89, ARI 340-86, ARI 360-86 and ARI 365-87 and ASHRAE 37-88 and ASHRAE 14-80.

Details

The test procedure consists of the following heating and cooling tests.

- rated cooling and heating capacity tests
- maximum operating conditions test
- low temperature operation test (cooling)
- insulation effectiveness test
- condensate disposal test (cooling)

Testing can always be done using the indoor air enthalpy approach, but 5 other methods are acceptable depending of the specifics of the equipment type under test.

For fixed (or single) capacity units the EER and COP are calculated in the usual manner; however, for variable capacity units the units are to be tested at each step in capacity reduction provided by the refrigeration system or condensing units as published by the manufacturer and the results are used to calculate the IPLV from:

where *PLF* is the part-load factor taken from an s-shaped curve of *PLF* vs. percentage of full load capacity at part load conditions, *n* is the number of capacity steps, *EER* is the energy efficiency ratio.

The temperature conditions for the heating and cooling tests are given in Table 67.

Table 67: Test conditions for the determination of capacity, EER, COP and IPLV, Canada

	Indoor unit		Outdoor unit					
			Air entering and surrounding					
	air entering		Air-cooled		Evaporative		Water	
	DB	WB	DB	WB	DB	WB	In	Out
Cooling standard rating cool part-load rating	 26.7 26.7	 19.4 19.4	 35.0 26.7	 23.9 19.4	 35.0 26.7	 23.9 19.4	 29.4 23.9	 35.0
Heating high-temp rating low-temp rating	 21.0 21.0	 15.0 15.0	 8.3 -8.3	 6.1 -9.4				

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling and heating capacities (sensible, latent and total, rounded to the nearest 0.01 kW) expressed in kW or Btu/h
- EER (Btu/Wh expressed in multiples of 0.05 up to 40 kW and 0.1 above)
- COP (Btu/Wh expressed in multiples of 0.02 up to 40 kW and 0.1 above)
- The above at standard and part-load ratings.

Summary of test procedure for large split-system central air conditioners and heat pumps

Large split-system central air conditioners and heat pumps are tested in the same way as described for large central air conditioners and heat pumps above.

B:3.2 Japan

Program: high impact voluntary efficiency targets for unitary (central) air conditioners – Top Runner program

Scope

In Japan a central air conditioner would be classified as a unitary air conditioner. Larger room air conditioners, of a packaged type, are classified as *unitary air conditioners* and are subject to energy efficiency targets. The existing targets differentiate depending on whether an appliance is integral (windows) or split-type and whether it is cooling-only or reversible. The targets for reversible units are a combination of EER and COP targets. Multi-split systems are currently excluded but are about to be included into new energy efficiency target regulations, due to come into effect between 2004 and 2007, which implies that either the draft international test procedure for multi-split units is to be adopted or that a new procedure will be created.

The applicability of Japan's *unitary air conditioner* regulations is indicated in Table 68.

Table 68: Product types included in the Japanese unitary air conditioner test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓[1]	✓[2]	✗	✓[1]	✗	✓[1]	✓[3]	✓[3]	✓	✓	5814W ≤ CC ≤ 26047W[4]	

1 Called 'integral type' units in the test procedure.
2 Called 'separate type' units in the test procedure.
3 The rated a.c. supply should have a voltage of 100V or 200V and a frequency of 50Hz or 60Hz
4 In addition, the rated cooling power consumption must exceed 3 kW.

Summary of test procedure (unitary air conditioners)

The Japanese unitary air conditioner test procedure, JIS B 8616-93 *Unitary air conditioners* replaces and unifies the previous two standards JIS B 8616-84 and JIS B 8615-83 dealing with unitary air conditioners. Unitary air conditioners can be ducted or non-ducted and hence the provisions in this standard are simultaneously comparable to both ISO 5151-94(E) (non-ducted air conditioners) and ISO 13253-93 (ducted air conditioners). Under the Japanese definition unitary air conditioners are packaged (in one assembly or are designed to be used in one assembly), can be single-packaged or split packaged, can be cooling-only or reversible, mono or three phase, and air or water cooled.

Variables required to be measured, determined or declared for regulatory purposes:

- Product classification according to its function
- Rated cooling capacity (W)
- Standard heating capacity (W)
- Classification according to the condenser cooling system
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption
- Energy Efficiency Ratio, EER, (W/W)

The heating and cooling capacities must be not less than 92% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER or COP of 23%.

B:3.3 Korea

Program: mandatory energy labelling, MEPS and high impact voluntary efficiency targets for unitary air conditioners

Scope

In Korea, in keeping with some other South East Asian economies, a central air conditioner would be classified as a unitary air conditioner. Larger room air conditioners, of a packaged type, are classified as *unitary air conditioners* and are subject to energy efficiency regulations. Cooling-only and reverse-cycle units are included, as are single-phase or three-phase units and air-cooled or water-cooled units. Ducted units are not excluded from the above definitions. In practice, this means that most types of air conditioning equipment are classified as unitary air conditioners provided they satisfy the capacity constraints (greater than 3 kW of power consumption) and are of a packaged-type. Multi-split systems are excluded.

Unlike any APEC economy Korea has devised efficiency standards and targets that treat constant speed air conditioners (those using a single-speed compressor) differently than those using a variable speed. Both the fixed and variable-speed air conditioners (either room or unitary) must satisfy MEPS and energy labelling and are subject to efficiency targets. The variable speed units are tested and rated using a seasonal energy efficiency ratio (SEER). Reversible units are not subject to COP requirements but are required to satisfy the cooling-mode performance requirements.

Applicability of Korean unitary air conditioners regulations is indicated in Table 69.

Table 69: Product types included in the Korean unitary air conditioner test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓ [1]	✓ [2]	✗	✓ [1]	✗	✓ [1]	✓	✓	✓	✓	[3]	

1 Called ‘integral type’ units in the test procedure.
2 Called ‘separate type’ units in the test procedure.
3 The rated cooling output must exceed 26.047 kW (22400 kCal/h)

Summary of test procedure (unitary air conditioners)

The Korean unitary air conditioner test procedure, KS B 6369-95

Testing methods for unitary air conditioners

references KS B 6368 and appears to be a corollary of the Japanese unitary air conditioner test procedures JIS B 8616-84 and JIS B 8615-83. Unitary air conditioners can be ducted or non-ducted and hence the provisions in this standard are simultaneously comparable to both ISO 5151-94(E) (non-ducted air conditioners) and ISO 13253-93 (ducted air conditioners). Under the Korean definition unitary air conditioners are packaged (in one assembly or are designed to be used in one assembly), can be single-packaged or split packaged, air or water cooled, single or three phase but must have a cooling capacity of greater than 26 kW.

The test procedure consists of the following cooling tests:

- cooling capacity,
- cooling power consumption,
- cooling overload performance
- enclosure sweat and condensate disposal tests
- freezing test

and the following heating tests:

- heating capacity,
- heating power consumption,
- power consumption of electric heater (for models with a separate resistance heater),
- heating overload performance,
- automatic defrosting test.

The test allows two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. Heating and cooling capacity measurements can also be made with the air-enthalpy method. The cooling and heating capacities can be calculated by either the direct (calorimeter) method or the in-direct (air-enthalpy) method. The cooling and heating capacities are calculated from the measurements in the same way as specified in ISO 5151-94(E).

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 70. The tolerances are indicated as the maximum permissible variation of individual readings from the specified value. The Korean *unitary air conditioner* rating conditions are almost harmonised with the ISO 5151 T1 condition except for a half degree difference in the indoor side wet-bulb temperature and wider tolerances for all measurements. The heating capacity test conditions are also similar to ISO 5151-94 although the indoor side dry-bulb temperature is 21°C (as opposed to 20°C) and there is no indoor wet-bulb requirement. The temperature conditions for the defrosting and overload tests are also slightly different.

The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected.

Table 70: Test conditions for the determination of cooling and heating capacity, Korea

Condition	Indoor inlet air condition		Outdoor side conditions					
			Air cooled		Water cooled		Water-cooled heat pump	
	dry-bulb	wet-bulb	dry-bulb	wet-bulb	dry-bulb	wet-bulb	dry-bulb	wet-bulb
Cooling capacity	27±1	19.5±0.5	35±1	24±0.5	30±0.5	35±0.5	18±0.5	29±0.5
Heating capacity	21±1	-	7±1	6±0.5	-	-	15.5±0.5	-

Variables required to be measured, determined or declared for regulatory purposes:

- Product classification according to its function
- Rated cooling capacity (W or kCal/h)
- Standard heating capacity (W or kCal/h)
- Classification according to the condenser cooling system
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption
- Energy Efficiency Ratio, EER, (W/W or kCal/W)

The heating and cooling capacities must be not less than 92% of their rated values while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER or COP of 23%.

B:3.4 Mexico

Program: mandatory energy labelling and MEPS for air-cooled central air conditioners

Scope

Mexico defines central air conditioners in keeping with other NAFTA economies to be large single-packaged (US definition) or split systems. In Mexico a central air conditioner must have a cooling capacity of between 10540 W and 17580 W. Under the international system of definitions it is possible a room air conditioner could be classified under either of the above categories, although in practice room air conditioners are seldom of a size above 10.5 kW.

The applicability of Mexican central air conditioners regulations is indicated in Table 71.

Table 71 Product types included in Mexican central air conditioner regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✗	✓	✓	✓	✓	✗	✗	✗		✗	✓	✗	✓	✗	≤10.548 kW	None

Summary of test procedure

The Mexican test procedure and standards regulation, NOM-011-ENER-96 *Energy efficiency of central conditioners. Limits, testing methods and labelling* uses ostensibly the same method to test the cooling capacity, power input and energy efficiency ratio(s) as specified in ANSI/ASHRAE-37-88 *Method of testing for rating unitary air-conditioning and heat pump equipment*.

The NOM-011-ENER-96 standard excludes heat pumps and water-cooled units. The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected.

Details

The test procedure consists of the following cooling tests.

- rated cooling capacity and cooling electrical power consumption

There are no heating tests.

The test allows one of two different types of test equipment to be used to measure the cooling and/or heating capacity, either the calibrated or balanced-ambient room-type calorimeter. The cooling capacities are calculated using the calorimeter method only (the air-enthalpy method is not permitted). For the calorimeter method two simultaneous determinations of the capacities are required, as in ISO 5151, one on the indoor-side and one on the outdoor side. If simultaneous determinations are used their values must be within 4% of each other. Stable test conditions have to be maintained for 1 hour before capacity data can begin to be recorded. The capacity tests last for not less than 1 hour with readings taken every 10 minutes for a total of 7 readings.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 72 the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses. The Mexican room air conditioner rating conditions are almost fully harmonised with the

ISO 5151 T1 test condition except for almost insignificant differences in the tolerances and very small differences in the main indoor and outdoor temperatures. These differences have their origin in the test conditions used in other NAFTA economies, although the Mexican values are not fully identical to those.

Table 72: Test conditions for the determination of cooling capacity, Mexico

Parameter	Standard test conditions	
	NOM-073-SCFI-94	**T1**
Temperature of air entering indoor side (°C)		
dry-bulb	26.6±0.55(0.28)	27±1(0.3)
wet-bulb	19.4±0.33(0.17)	19±0.5(0.2)
Temperature of air entering outdoor side (°C)		
dry-bulb	34.9±0.55(0.28)	35±1(0.3)
wet-bulb	23.8±0.33(0.17)	24±0.5(0.2)

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacity
- EER (W/W or Btu/Wh)
- Cooling-mode electrical power consumption

The cooling capacity must be not less than 95% of its rated value while the electrical power consumption in the cooling-mode shall be within 0.5% of its rated value. These tolerances imply a maximum permitted deviation in the EER of 5.5%.

B:3.5 Chinese Taipei

Program: mandatory MEPS for room air conditioners

Scope

In Chinese Taipei a central air conditioner would be classified as a unitary air conditioner. Larger room air conditioners, of a packaged type, are classified as *unitary air conditioners* and are subject to energy efficiency regulations. Cooling-only and reverse-cycle units are included, as are single-phase or three-phase units and air-cooled or water-cooled units. Ducted units are not excluded from the above definitions. In practice, this means that most types of air conditioning equipment are classified as unitary air conditioners provided they satisfy the capacity constraints (greater than 3 kW of power consumption and up to 22400 kcal/h cooling capacity) and are of a packaged-type. Multi-split systems are excluded. Unitary air conditioners must be 60 Hz and either 110/220 V for single phase or 220/440 V for three phase.

Unitary air conditioners (air-cooled and water-cooled) are subject to energy efficiency targets. Reversible units are not subject to COP requirements but are required to satisfy the cooling-mode performance requirements.

The applicability of Chinese Taipei’s unitary air conditioners regulations is indicated in Table 73.

Table 73: Product types included in Chinese Taipei unitary air conditioner test procedure

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✓	✓	✗	✓	✗	✓	✓[1]	✓[1]	✓	✓	≤ 22400 kcal/h[3]	

1 The rated a.c. supply should have a voltage of 110V or 220V and a frequency of 60Hz
2 The rated a.c. supply should have a voltage of 220V or 440V and a frequency of 60Hz
3 In addition, the rated cooling power consumption must exceed 3 kW.

Summary of test procedure (unitary air conditioners)

The Chinese Taipei test procedure for unitary air conditioner and heat pumps is, CNS 2725 (classified no. B4008) *Unitary air conditioner.* Unitary air conditioners can be ducted or non-ducted and hence the provisions in this standard are simultaneously comparable to both ISO 5151-94(E) (non-ducted air conditioners) and ISO 13253-93 (ducted air conditioners). Under the Chinese Taipei definition unitary air conditioners have a power input of more than 3 kW and rated cooling capacity of less than 22400 kcal/h. The compressor, condenser, evaporator, air blower and electric heater, etc. can be installed in one (single-packaged) or two (split-packaged) containers. Multi-split units are therefore excluded as are special air conditioning appliances such as spot conditioners.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 74. The tolerances are indicated as the maximum permissible variation of individual readings from the specified value. Chinese Taipei's *unitary air conditioner* rating conditions are almost harmonised with the ISO 5151 T1 condition except for a half degree difference in the indoor side wet-bulb temperature and wider tolerances for all measurements. The heating capacity test conditions are also similar to ISO 5151-94 although the indoor side dry-bulb temperature is 21°C (as opposed to 20°C) and there is no indoor wet-bulb requirement. The temperature conditions for the defrosting and overload tests are also slightly different.

The test conditions are always at full-load, at the rated frequency and voltage, and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected.

Table 74: Test conditions for the determination of cooling and heating capacity

Condition	Indoor inlet air condition		Outdoor side conditions					
			Air cooled		Water cooled		Water-cooled heat pump	
	dry-bulb	wet-bulb	dry-bulb	wet-bulb	dry-bulb	wet-bulb	dry-bulb	wet-bulb
Cooling capacity	27±1	19.5±0.5	35±1	24±0.5	30±0.5	30±0.5	18±0.5	29±0.5
Heating capacity	21±1	-	7±1	6±0.5	-	-	15.5±0.5	-

Variables required to be measured, determined or declared for regulatory purposes:

- Product classification according to its function
- Rated cooling capacity (kcal/h)
- Rated heating capacity (kcal/h)
- Rated voltage, phase and frequency
- Cooling power consumption (kW)
- Rated standard heating power consumption (kW)
- Energy Efficiency Ratio, EER, (kcal/Wh)

The cooling capacities must be not less than 95% of its rated value (92% for the heating capacity) while the electrical power consumption in the cooling or heating-mode shall be not more than 115% of the rated power consumption. These tolerances imply a maximum permitted deviation in the EER of 20% and in the COP of 23%.

B:3.6 United States of America

Program: mandatory energy labelling and MEPS for central air conditioners

Scope

The USA has an extensive MEPS program for air conditioners and heat pumps, that includes the following product types:

- central air conditioners and heat pumps
- small commercial package air conditioners and heat pumps
- large commercial package air-conditioners and heat pumps

Central air conditioners in the USA include both ducted systems and ductless split systems (i.e., mini-splits or split-packaged units). The predominant type of central air conditioner in the USA is the ducted system. Small ducted systems are either split systems or single package systems, but mostly the latter. The US efficiency regulations classify a central air conditioner depending on its cooling (or heating capacity). Units cooling or heating capacities above 135000 Btu/h (40 kW) are classed as large commercial systems and have different efficiency requirements from other types. All ‘commercial’ units with capacity below 135 000 Btu/h are classed as small. Small commercial units with capacities between 65000 Btu/h (19.05 kW) and 135000 Btu/h (40 kW) are tested in the same way as large systems but have different efficiency requirements. Unitary air conditioners or heat pumps of below 65000 Btu/h capacity and which are not single-packaged room air conditioners or heat pumps nor packaged terminal air conditioners or heat pumps are classed as ‘central’ systems and have a different test procedure and set of efficiency requirements. All central air conditioners, with capacities up to 65000 Btu/h, including split-packaged (mini-split) systems, are rated using a seasonal energy efficiency ratio, SEER, that is based on the amalgamated results of testing cooling capacity at 4 different test conditions. Similarly all central heat pumps with capacities up to 65000 Btu/h are rated using a similar approach to produce a heating seasonal performance factor, HSPF. The commercial (small and large) air conditioners and heat pumps can be air, water or evaporatively cooled.

For small-commercial air conditioners and heat pumps with capacities above 65000 Btu/h but below 135 000Btu/h, the cooling performance is regulated for the EER (static test conditions) and Integrated Part-Load Value (IPLV), which is a measure designed to reflect performance under part-load conditions. The heating performance is measured and regulated using a static COP test.

For large commercial air conditioners and heat pumps, defined as those with capacities above 135 000 Btu/h, a distinction is made depending on whether the capacity is above or below 760 000 Btu/h and whether the unit is an air cooled air conditioner, an air cooled heat pump or a water/evaporatively cooled air conditioner. Efficiency is measured and regulated in terms of the EER, COP and IPLV.

The applicability of US *central air conditioners* regulations is indicated in Table 75.

The applicability of US *small commercial air conditioners* regulations is indicated in Table 76.

The applicability of US *large commercial air conditioners* regulations is indicated in Table 77.

Table 75: Product types included in USA central air conditioner and heat pump regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✗	✓	✗	65000 Btu[1]	65000 Btu[1]

1 = 19.05 kW

Table 76: Product types included in USA small air conditioner and heat pumps regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✓	✓	✗	✗	✗	✓	✓	✓	✗	>65 kBtu to <135 kBtu[1]	>65 kBtu to <135 kBtu[1]

1 = 40 kW

Table 77: Product types included in USA large air conditioner and heat pump regulations

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✓	✓	✓	✗	✓	✗	✗	✗	✗	✓	✓	✓	✓	>135 kBtu to <700 kBtu[1]	>135 kBtu to <700 kBtu[1]

1 = 205 kW

Summary of test procedure for central air conditioners and heat pumps

A central air conditioner or heat pump is defined as a ‘product other than a packaged terminal air conditioner, which is powered by single phase electrical current, air cooled, rated below 65000 Btu/h (19.05 kW), not contained within the same cabinet as a furnace, the rated capacity of which is above 225000 Btu/hr and is a heat pump or cooling only unit’. This definition includes split-packaged room air conditions (mini splits).

The official US test procedure is contained in DOE regulations Code of Federal Regulations 430 Appendix M. Test method for measuring the energy consumption of central air conditioners is the Energy Policy Act of 1992 and the methodological standards and ARI 210/240-89. The cooling capacity, power input and energy efficiency ratio(s) be measured according to the method in ASHRAE-37-88 *Methods of testing for rating unitary air conditioning and heat pump equipment*.

Details

The test procedure consists of the following heating and cooling tests.

- cooling capacity tests (A, B, C, D)
- intermediate cooling test for units with variable speed compressors
- high temperature, cyclic, frost accumulation and low temperature heating tests,

Testing is to be done using the air enthalpy approach with the test chamber configured in one of the following arrangements: the tunnel air enthalpy method arrangement, the loop air enthalpy arrangement, the calorimeter air enthalpy method arrangement or the room air enthalpy method arrangement. In practice this test method constrains the cooling equipment to have a cooling capacity of less than 39 560W.

All types of central air conditioners are rated using a seasonal energy efficiency ratio (SEER). The SEER units are in Btu per Wh. For determination of the SEER there 4 different temperature rating points. These are called DOE “A” to “D”. Point “A” is essentially the same as the ISO 5151 T1 condition with minor differences and is used to rate the cooling capacity. Points “C” and “D” are used to determine a degradation co-efficient C_D which is used to measure the efficiency loss as a result of cycling. These conditions apply to single speed compressors. If there is a 2 speed or variable speed compressor, there are additional rating points at part load. Note that many manufacturers now also publish EER information recorded under the “A” condition in addition to the mandatory SEER information, to assist in comparison of products.

The test conditions for determining the cooling capacity and electrical power demand in the cooling-mode are indicated in Table 78 with the ISO 5151 T1 rating point for comparison. The tolerances are first indicated as the maximum permissible variation of individual readings from the specified value followed by the permitted variation of the arithmetical mean value from the specified value, indicated in parentheses.

Table 78: Test conditions for the determination of cooling capacity and SEER, USA

Parameter	Standard test conditions				
	A	B	C	D	ISO T1
Temperature of air entering indoor side (°C)					
dry-bulb	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±0.56(0.28)	27±1(0.5)
wet-bulb	19±0.34(0.17)	19±0.34(0.17)	14±0.34(0.17)	14±0.34(0.17)	19±0.3(0.2)
Temperature of air entering outdoor side (°C)					
dry-bulb	35±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	28±0.56(0.28)	35±1(0.5)
wet-bulb					24±0.3(0.2)

Testing to conditions “C” and “D” are optional in that if the tests are not done, a value of 0.25 is assigned for the degradation co-efficient C_D. Only four tests are required for single speed compressors. Where there is a two speed compressor, tests at condition "A" and "B" are to be done for each speed.

For variable speed compressors, up to seven tests are required as follows:

- "A" and "B" wet coil tests at maximum compressor speed
- "B" wet coil is tested at minimum speed
- Low temperature wet coil test is conducted at minimum speed (indoor and outdoor 19.4/13.9^{o}C dry/wet)
- Final wet coil test is conducted at an intermediate speed
- if a value for C_D of 0.25 is not used, dry coil tests "C" and "D" at minimum speed.

All single speed units are subject to four performance tests:

- high temperature test,
- cyclic test,
- frost accumulation test
- low temperature test.

Variable speed units are subject to: high temperature test (one maximum speed, two at minimum speed), cyclic test (minimum speed), frost accumulation test (maximum and intermediate speeds).

For single speed compressors, the Seasonal Energy Efficiency Ratio (SEER) is calculated via the following steps:

$CLF = Q_{\text{"D"}} / Q_{\text{"C"}}$

(Q = "average" capacity measured over a complete compressor on and off cycle)

$C_D = (1 - EER_D/EER_C) / (1 - CLF)$

C_D is the degradation coefficient (or 0.25 if not tested to conditions "C" and "D")

$PLF = 1 - (0.5 \times C_D)$

$SEER = PLF \times EER_B$

Where: EER_B is the EER to condition "B".

For variable speed compressors, the calculations are much more complex. Essentially, the method involves the estimation of the performance of the system (cooling capacity and electrical energy) at 8 outdoor temperature points ranging 39^{o}C down to 19.4^{o}C based on test data for various conditions and averaging these as weighted by specified bin weightings for assumed hours of operation.

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling capacities (sensible, latent and total) expressed in Btu/h or W
- SEER (Btu/Wh expressed in multiples of 0.1)
- Cooling-mode electrical power consumption

Summary of test procedure for small commercial air conditioners and heat pumps

A small commercial air conditioner or heat pump is defined as a 'air-cooled, water-cooled, evaporatively cooled, or water source (not including ground water source) electrically operated, unitary central air conditioners and central air conditioning heat pumps for commercial application which are rated at below 135000 Btu per hour (40 kW). In practice, the term 'for commercial application' implies they are above 65000 Btu/h in capacity.

The official US test procedure is contained in the Energy Policy Act of 1992, which cites ASHRAE 90.1 Energy efficient design of new buildings except low-rise residential building, which in turn cites the following: ARI 210/240-89 Unitary air-conditioning and air-source heat pump equipment.

All the standard ratings including the cooling capacity, power input and energy efficiency ratio(s) are measured according to the method in ASHRAE-37-88 *Methods of testing for rating unitary air conditioning and heat pump equipment*.

Small commercial air conditioners and heat pumps are tested in a different way to that described for central air conditioners and heat pumps. Seasonal energy efficiency ratio and heating performance factors are not used, but rather the efficiency regulations are expressed in terms of a combination of EER, COP and IPLV requirements. The IPLV is the integrated part load performance, which is only used for units capable of operating with reduced capacities, such as variable speed drive units.

Details

The test procedure consists of the following heating and cooling tests.

- rated cooling and heating capacity tests
- maximum operating conditions test
- low temperature operation test (cooling)
- insulation effectiveness test
- condensate disposal test (cooling)

Testing can always be done using the indoor air enthalpy approach, but 5 other methods are acceptable depending of the specifics of the equipment type under test.

For fixed (or single) capacity units the EER and COP are calculated in the usual manner; however, for variable capacity units the units are to be tested at each step in capacity reduction provided by the refrigeration system or condensing units as published by the manufacturer and the results are used to calculate the IPLV from:

where *PLF* is the part-load factor taken from an s-shaped curve of *PLF* vs. percentage of full load capacity at part load conditions, *n* is the number of capacity steps, *EER* is the energy efficiency ratio.

The temperature conditions for the heating and cooling tests are given in Table 79.

Table 79: Test conditions for the determination of capacity, EER, COP and IPLV, USA

	Indoor unit		Outdoor unit					
			Air entering and surrounding					
	Air entering		Air-cooled		Evaporative		Water	
	DB	WB	DB	WB	DB	WB	In	Out
Cooling								
standard rating cool	26.7	19.4	35.0	23.9	35.0	23.9	29.4	35.0
part-load rating	26.7	19.4	26.7	19.4	26.7	19.4	23.9	
Heating								
high-temp rating	21.0	15.0	8.3	6.1				
low-temp rating	21.0	15.0	-8.3	-9.4				

Variables required to be measured, determined or declared for regulatory purposes:

- Total cooling and heating capacities (sensible, latent and total, rounded to the nearest 0.01 kW) expressed in kW or Btu/h
- EER (Btu/Wh expressed in multiples of 0.05 up to 40 kW and 0.1 above)
- COP (Btu/Wh expressed in multiples of 0.02 up to 40 kW and 0.1 above)
- The above at standard and part-load ratings.

Summary of test procedure for large commercial air conditioners and heat pumps

A large commercial air conditioner or heat pump is defined as a ‘air-cooled, water-cooled, evaporatively cooled, or water source (not including ground water source) electrically operated, unitary central air conditioners and central air conditioning heat pumps for commercial application which are rated at above 135000 Btu per hour (40 kW) and below 240 000 Btu/h (73 kW).

The official US test procedure is contained in the Energy Policy Act of 1992, which cites ASHRAE 90.1 Energy efficient design of new buildings except low-rise residential building, which in turn cites the following: ARI 360-86 (for air-cooled and water/evaporatively cooled air conditioners) Commercial and industrial unitary air-conditioning equipment ARI 340-86 (for heat pumps) Commercial and industrial unitary heat pump equipment.

All the standard ratings including the cooling capacity, power input and energy efficiency ratio(s) are measured according to the method in ASHRAE-37-88 *Methods of testing for rating unitary air conditioning and heat pump equipment*.

- Large commercial air conditioners and heat pumps are tested in essentially the same way as described for small commercial air conditioners and heat pumps above.

B:3.7 ISO 13253-94 – Ducted air conditioners

Scope

The applicability of the ISO 13253 test procedure for ducted air conditioners is indicated in Table 80. The procedure applies to air conditioners of any capacity and type provided they are ducted including cooling-only and reversible, single-phase and three-phase, and air-cooled or water-cooled units. The test procedure excludes single-duct room air conditioners and multi-split systems. Water-cooled heat-pumps are not included. Part-load conditions are not tested and in practice it is not possible to use the test procedure to rate the performance of variable or multiple speed drive air conditioners.

Table 80: Product types included in or excluded from ISO 13253 test procedures

Ducted	Non-Ducted	Cooling only	Reversible	Single packaged (window/wall)	Split packaged (mini-split)	Multi-split systems	Single-duct	Spot	Packaged Terminal	Mono-phase	Three-phase	Air-cooled condenser	Water-cooled condenser	Cooling capacity requirement	Heating capacity requirement
✓	✗	✓	✓	✓	✓	✗	✗		✓	✓	✓	✓	✓ [1]	None	None

1 Heat pumps with water cooled condensers are excluded.

Summary of test procedure

The international test procedure consists of a series of cooling and heating (for reversible units only) tests as follows.

Cooling tests:

- rated cooling capacity,
- maximum cooling test,
- minimum cooling test,
- enclosure sweat and condensate disposal test,

Heating tests:

- rated heating capacity,
- maximum heating test,
- minimum heating test,
- automatic defrost test.

The test requires the indoor air-enthalpy method to be used to measure the cooling and/or heating capacity, but gives informative information on the following other methods:

- indoor air-enthalpy method
- compressor calibration method
- refrigerant enthalpy method
- air flow measurement
- outdoor air enthalpy method

Test conditions have to be maintained for a minimum of 1 hour before capacity data can begin to be recorded. The capacity tests last for 30 minutes with readings taken every 5 minutes.

The rated cooling performance of the air conditioner can be tested at one or more of three different sets of test conditions that are designed to represent performance under a moderate, cool or hot climate. The designated climate type must be indicated on the air conditioner. In practice the T1 test condition, indicating performance under a moderate climate, is the world standard condition for rating air conditioners. The standard test conditions for the cooling capacity test are shown in Table 81. The test conditions are always at full-load and with a single set of stable environmental conditions, thus the part-load performance of variable or multiple speed drive units is not reflected.

Table 81: Test conditions for the determination of cooling capacity, ISO

Parameter	Standard test conditions		
	T1	**T2**	**T3**
Temperature of air entering indoor side (°C)			
dry-bulb	27	21	29
wet-bulb	19	15	19
Temperature of air entering outdoor side (°C)			
dry-bulb	35	27	46
wet-bulb[1)]	24	19	24
Condenser water temperature[2)] (°C)			
inlet	30	22	30
outlet	35	27	35

T1 = Standard cooling capacity rating conditions for **moderate** climates

T2 = Standard cooling capacity rating conditions for **cool** climates

T3 = Standard cooling capacity rating conditions for **hot** climates

1) The wet-bulb temperature is not required when testing air-cooled condensers which do not evaporate the condensate.

2) Representative of equipment working with cooling towers. For equipment designed for other uses, the manufacturer shall designate the condenser water inlet and outlet temperatures or the water flow rates and the inlet temperature in the ratings

The standard test conditions for the heating capacity test are shown in Table 82. The heating capacity of reversible air conditioners must be tested at a minimum of the high and low heating conditions, while the extra-low test condition is optional.

Table 82: Test conditions for the determination of heating capacity, ISO

Parameter	Standard test conditions
Temperature of air entering indoor side (°C)	
dry-bulb	20±1(0.3)
wet-bulb (maximum)	15±0.5(0.2)
Temperature of air entering outdoor side (high) (°C)	
dry-bulb	7±1(0.3)
wet-bulb	6±0.5(0.2)
Temperature of air entering outdoor side (low) (°C)	
dry-bulb	2±1(0.3)
wet-bulb	1±0.5(0.2)
Temperature of air entering outdoor side (extra low) (°C)	
dry-bulb	-7±1(0.3)
wet-bulb	-8±0.5(0.2)

Variables required to be measured, determined or declared for regulatory purposes:

- Climate classification types
- Total cooling capacities (sensible, latent and total, rounded to the nearest 0.1 kW)
- EER (expressed in multiples of 0.05)
- Heating capacity (as appropriate, rounded to the nearest 0.1 kW)
- COP (only applicable to reversible units operating in the heating-mode and expressed in multiples of 0.05)
- Rated voltages and frequencies
- Cooling power consumption
- Refrigerant designation and refrigerant mass charge

There appears to be no constraint of the uncertainty of determination of the cooling capacity. The electrical power must be measured within a maximum uncertainty of ±0.5%.

B:4 Non-air-source heat pumps

B:4.1 Canada

Program: mandatory energy labelling and MEPS for non-air-source heat pumps

Scope

Canada has an extensive MEPS program for non-air-source heat pumps and dehumidifiers, that includes the following product types:

- internal water-loop heat pumps (CAN/CSA-C655-M91)
- ground-source heat pumps (CAN/CSA-C446-94) (including ground water-source heat pumps)

Heat Pumps

The internal water-loop heat pumps standard, CAN/CSA-C655-M91, applies to factory-assembled water source single-package and split-system heat pumps intended for water source applications that have a cooling capacity of less than 40 kW.

The ground-source heat pumps standard, CAN/CSA-C446-M94, applies to factory-assembled water or liquid-source, single-package and split-system heat pumps intended for ground source applications that have a cooling capacity (or heating only capacity) of less than 40 kW. This standard replaces CAN/CSA-C446-M90 and includes air or water (hydronic-type) as the energy sink on heating and energy source on cooling heat pumps.

Heat sources and sinks for these different heat pumps types is shown in Table 83.

Table 83: Heat sources and sinks for the basic heat pump types, Canada

	Heating	Cooling
Ground source heat pumps		
Source	water or liquid	air or water
Sink	air or water	water or liquid
internal water-loop heat pumps		
Source	water	Air
Sink	air	Water

Summary of test procedures – internal water loop heat pumps

The Canadian test procedure and standards regulation, CAN/CSA-C655-M91 *Performance standard for internal water-loop heat pumps* specifies that cooling capacity, power input and energy efficiency ratio(s) be measured according to the method in ASHRAE-37-78 *Methods of testing for rating unitary air conditioning and heat pump equipment*.

The test procedure consists of the following tests:

- cooling capacity,
- cooling power consumption,
- heating capacity,
- heating power consumption,
- maximum high temperature operation test
- insulation effectiveness test,

The conditions for the cooling test are:

- air temperature entering the indoor portion of the unit is 27°C dry-bulb and 19°C wet bulb and its surrounding air temperature is 27°C.
- water temperature entering the refrigerant-to-water heat exchanger is 30°C.
- water temperature leaving the refrigerant-to-water heat exchanger is 35°C

The conditions for the heating test are:

- air temperature entering the indoor portion of the unit is 21°C dry-bulb and 16°C wet bulb and its surrounding air temperature is 21°C.
- water temperature entering the refrigerant-to-water heat exchanger is 21°C.

For split-systems a minimum piping length of 7.62m is required during testing.

Both EER and COP must be evaluated and marked on the product.

Summary of test procedures – ground source heat pumps

The Canadian test procedure and standards regulation, CAN/CSA-C446-M94 *Performance standard for ground-source heat pumps* specifies that cooling capacity, power input and energy efficiency ratio(s) be measured according to the method in ASHRAE-37-78 *Methods of testing for rating unitary air conditioning and heat pump equipment*.

The test procedure consists of the following tests:

- cooling capacity,
- cooling power consumption,
- heating capacity,
- heating power consumption,
- maximum high temperature operation test (closed-loop units)
- low-temperature operation test,
- insulation effectiveness test,
- condensate disposal test

The conditions for the heating and cooling tests are shown in Table 84.

Table 84: Rating conditions for ground-source heat pumps, Canada

		Air	Water	LIQin[1]
Cooling	Closed-loop	26.7°C db	13°C	25°C
	Open system	19.4°C wb	13°C	10°C
Heating	Closed-loop	21.1°C db	40°C	0°C
	Open system	15.6°C wb	40°C	10°C

1 LIQin =temperature of the liquid or water entering the refrigerant-to-liquid heat exchanger.

The standard requires part-load ratings to be established for heat pumps that are capable of variable capacity control, such as two-speed or variable-speed compressor units. The test conditions under part load are the same as for standard ratings except for closed-loop systems in cooling-mode, LIQin is 21°C and is 5°C in heating-mode.

Both EER and COP must be evaluated and marked on the product.

B:5 Dehumidifiers

B:5.1 Canada

Program: MEPS for dehumidifiers

Scope & Summary

The dehumidifiers standard, CAN/CSA-C749-94, applies to factory-made, self-contained, electrically operated, mechanically refrigerated dehumidifiers with daily water-removal capacities of up to 30 L. Capacity testing has been harmonised with ANSI/AHAM Standard DH-1 and includes procedures for measuring the capacity and the minimum energy factor, which is a measure of the energy efficiency of a dehumidifier calculated by dividing the water removed from the air by the energy consumed in the process, measured in L/kWh. The standard rating conditions are for the air entering the dehumidifier to be at 26.7°C dry-bulb temperature and 20.9°C wet-bulb temperature. Energy efficiency requirements are specified for Canada and for some provinces. Canada is the only economy to regulate dehumidifiers and already uses a relevant regional test procedure.

B:6 Water Chillers

B:6.1 Canada

Program: mandatory MEPS for water chillers

Summary of Test Procedure

Energy efficiency requirements are required only at a Provincial level in Canada (Ontario, British Columbia, Nova Scottia, New Brunswick). Chillers covered are less than 5600 kW in capacity and are intended for application in the air conditioning of buildings. The test procedure is set out in CAN/CSA-C743-93 and is equivalent to ARI 550/590.

Energy efficiency is defined as COP and the Integrated Part Load Value (IPLV) for various size and technology combinations. Canada is the only economy to regulate water chillers and already uses a relevant regional test procedure.

B:7 Electric Space Heaters

B:7.1 Korea

Program: Mandatory energy labelling, MEPS and high impact voluntary targets for incandescent lamps.

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

B:7.2 USA

Program: mandatory labelling for electric space heaters (furnaces and boilers)

Summary of Test Procedure

USA Code of Federal Regulations 16CFR305 specifies that electric boilers and electric furnaces must carry an energy label. This regulation sets out the information to be displayed while CFR430 sets out how to determine the energy consumption. Under both regulations, the assumed average fuel utilisation efficiency (AFUI) is 100% for electric units. No testing is required under either regulation for electric units. The main purpose of the energy label for these electric products is to allow comparison of operating costs with boilers and furnaces using other fuels.

B:7.3 IEC 60675:1994 – Electric space heaters

IEC60675 household electric direct-acting room heaters- methods for measuring performance. Applies to electric direct-acting room heaters. They may be portable, stationary, fixed or built-in. It does not apply to: thermal-storage room heaters; heating appliances incorporated in the building structure; central heating systems; heaters connected to an air duct; and wall-paper, carpets or drapes incorporating flexible heating elements. The standard is mainly concerned with design and performance such as thermostat control and accuracy. Electric resistive heaters are nominally 100% efficient so testing for energy efficiency is generally not relevant.

ANNEX C: AC ELECTRIC MOTORS

C:1 Summary of Motor Test Procedure by Economy

Table 85: Summary of Electric Motor Energy Programs

	Australia	Brunei	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	USA	Vietnam
Energy Labelling																				O	
MEPS	U		M								M	U						M	U	M	

M = mandatory, V = voluntary, U = under consideration, O = US Motor Challenge program (voluntary)
Note: Mexico and Chinese Taipei include single and three phase motors, all others three phase only

C:1.1 Australia

Program: mandatory MEPS for three phase electric induction motors – under consideration

Summary of Test Procedure

The test procedure for three phase induction motors is currently set out in AS1359.102.1 and AS1359.102.2 which is based on IEC60034-2. A new draft standard AS/NZS1359.102.3 is in preparation and is based on the new draft IEC standard which will be equivalent to/ compatible with the IEEE test procedure for North America. Details of the test procedures are set out in the comparison section on IEC and IEEE below.

C:1.2 Canada

Program: mandatory MEPS for three phase electric induction motors

Summary of Test Procedure

The test procedure for three phase induction motors is set out in CAN/CSA-C390-93. The method of test is equivalent to the IEEE test procedure for North America, although the Canadian standard includes a number of modifications and improvements. The Canadian standard is currently under review. Details of the test procedures are set out in the comparison section on IEC and IEEE below.

C:1.3 Mexico

Program: mandatory MEPS for single phase and three phase electric induction motors

Summary of test procedure

The test procedure for single phase motors is set out in Mexican NOM-014-ENER-1998. The test method used to determine efficiency is equivalent to (EQV) both IEEE-114 and CAN/CSA-C747. The test procedure for three phase motors is set out in Mexican NOM-016-ENER-1998. The test method used to determine efficiency is equivalent to (EQV) both IEEE-112 and CAN/CSA-C390. Both Mexican NOMs are consistent with the methodology in the North American test procedures for induction motors. Details of the test procedures are set out in the comparison section on IEC and IEEE below.

C:1.4 New Zealand

Program: mandatory MEPS for three phase electric induction motors – under consideration

Summary of Test Procedure

A new draft standard AS/NZS1359.102.3 is in preparation which is based on the new draft IEC standard and which will be equivalent to/ compatible with the IEEE test procedure for North America. Details of the test procedures are set out in the comparison section on IEC and IEEE below.

C:1.5 Chinese Taipei

Program: mandatory MEPS for single phase and three phase electric induction motors

Summary of test procedure

The test procedure for single phase motors is set out in CNS4024 while efficiency levels are set out in [standard number not known, but levels are published by MOEA]. The test procedure for three phase motors is set out in CNS3192 while efficiency levels are set out in CNS2934. It has not been possible to obtain copies of the test procedures by the time of writing, but it is believed that the CNS methods are equivalent to (EQV) the IEEE method for North America.

C:1.6 Thailand

Program: mandatory MEPS for three phase electric induction motors – under consideration

Summary of test procedure

The test procedure for single phase motors is set out in TIS 866-2532 while the test procedure for three phase motors is set out in TIS 867-2532.. It has not been possible to obtain copies of the test procedures in English and it is unclear whether the these test methods are based on IEC or JIS methods. However, the new motor MEPS levels for Thailand, while still under consideration, appear likely to be based on US levels, so presumably the Thai test method will be revised to be compatible with IEEE.

C:1.7 USA

Program: mandatory MEPS for three phase electric induction motors, Motor Challenge program (voluntary)

Summary of Test Procedure

MEPS for motors is set out in the Energy Policy Act 1992. The referenced test procedure for three phase induction motors in this Act is NEMA MG-1. The method of test is equivalent to the IEEE test procedure Method B for North America. Details of the test procedures are set out in the comparison section on IEC and IEEE below.

C:2 Overview of International Standards for Motors

C:2.1 Comparison of IEC, JIS and IEEE

The four main test procedures for motors which are in use in the world are:

- IEC60034-2A Rotating electrical machines - Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests
- NEMA MG 1-1987, Motors and Generators, Revision No. 2
- ANSI/IEEE 112-1984, Test Procedure for Polyphase Induction Motors and Generators (Method B)
- JIS C4210 Low voltage three phase squirrel cage motors for general purpose

The IEEE and NEMA methods are equivalent and either is generally acceptable for use in North America, so there are in fact only three main methods of test.

While much of the content of these three main test methods is similar, there are some key differences which are outlined in the following section. The most important difference between the test methods is with respect to the treatment of additional or “stray” losses: under IEEE these are determined directly by measurement, under IEC they are assumed to be a constant 0.5% of input power for all motors while under JIS these losses are ignored (ie assumed to be 0.0%).

IEEE in fact has 5 main methods of test as follows:

- Method A – direct measurement (small machines only)
- Method B – direct method to determine stray losses (regression)
- Method C – back to back testing
- Method E – indirect method using reverse rotation test
- Method F – equivalent circuit of the machine is used to directly measure stray losses

Method B is the main one of concern in this report.

Two useful references can provide more technical details on the differences between these standards should these be required:

B. Renier, K. Hameyer & R Belmans, *Comparison of standards for determining efficiency of three phase induction motors*, report number PE-441-EC-0-07-1998, published by IEEE, USA.

RG Bartheld & JA Kline, Comparative efficiency measurement: IEC34-2 vs IEEE112, paper in de Almeida, Bertoldi, Leonhard (Eds), *Energy Efficiency in Electric Motors and Drives*, conference proceedings, October 1996, Portugal, papers published by Springer, Berlin, 1997.

C:2.2 Comparison Details

Overview

At first glance it appears possible to measure the efficiency of an electric motor by measuring its electrical input and its mechanical output. However, when the motor's efficiency is high, a small percentage error in the measurement of input or output becomes a large percentage error when applied to the motor losses. Therefore, it is more common to ascertain the efficiency of an electric motor by measuring its losses. This is the approach taken by all three standards reviewed in this section. The losses of an induction motor — the most common type — comprise: stator copper loss; rotor losses; iron losses; windage and friction loss; and additional load loss (also commonly called stray loss). The two main parts of an induction motor are the stator (static) and the rotor (turning).

The main losses in a motor are outlined below:

- Stator I^2R losses: stator copper losses are determined from the resistance of the stator at its temperature of operation. In IEC 60034-2 the losses are corrected to a nominal temperature.
- Rotor I^2R losses: rotor losses are obtained from the air gap power and the slip (which should be corrected to the specified stator temperature) and depend on the conductivity of the rotor material.
- Stator and rotor iron losses (also called core losses): are from eddy currents and hysteresis losses in laminations and depend on the flux density and frequency. Iron core losses are thought to be nearly constant in the stator for a given voltage, while rotor iron core losses are negligible at rated load. Iron losses for the stator are obtained from a no load test.
- Windage and friction losses: depend on the speed and sometimes the direction of the motor. They are also obtained from a no load test.
- Stray losses: these are not well understood, but in fact are those losses which are in addition to the losses determined above. They are believed to be made up of (1) flux pulsation losses in the rotor and stator teeth, (2) surface losses in the rotor and stator (negligible) due to space harmonics in the stator and rotor, (3) I^2R losses in rotor cage due to rotor currents induced by the harmonics of the flux density.

The differences in the IEC, JIS and IEEE test procedures are outlined below.

Instrumentation accuracy

Table 86: Summary of motor instrument accuracy

Parameter	IEC and JIS *	IEEE
Watts	±1.0%	±0.2%
Current	±0.5%	±0.2%
Voltage	±0.5%	±0.2%
Hz	±0.5%	±0.1%
Slip rpm	N/S **	±1
N-m	N/S	±0.2%
Ohms	±0.5%	±0.2%
^{o}C	±2	±1

Notes: * JIS to be confirmed, ** assumed accuracy is ±2.

Sequence of Testing

JIS and IEC do not specify a sequence of test. IEEE tests are to be undertaken in order of rated load temperature test, test under load and no-load test.

No-load Stabilisation

IEC and JIS contain no requirement for stabilisation prior to measurement. IEEE requires stabilisation of temperature and input power before readings are taken (less than 3% variation of input power for successive readings taken at half hour intervals). Stabilisation before measurement decreases windage and friction loss variability.

Reference temperature for stator I^2R losses

IEC and JIS correct the measured stator temperature to one of four insulation class ratings (Class A 75^{o}C, Class B 95^{o}C, Class F 115^{o}C, Class H 130^{o}C) for the determination of stator I^2R losses (rather than determine these at the actual stator operation temperature). The IEEE method uses the actual temperature in the stator during a load test for determination of stator I^2R losses, corrected to an ambient temperature of 25^{o}C. The IEC and JIS method means that if a motor is well designed and the stator runs "cool" it obtains no advantage under the test procedure as the stator losses are adjusted back up to the rated stator winding temperature for the insulation class of motor. Under the IEEE procedure, a lower stator temperature during actual use will be reflected in lower stator losses under the test procedure, which is more reflective of actual use.

Reference temperature for iron losses

IEC and JIS do not specify a reference temperature for measurement of iron losses. As the sum of the iron and stator losses are determined from the no load test, an increase on the stator losses from the increase in reference stator temperature will mean that the iron losses are underestimated during normal use. IEEE determines the no-load test losses at actual temperature of operation, which means that the balance between stator losses and iron losses will be more accurate.

Reference temperature for rotor I^2R losses

JIS and IEC do not specify a reference temperature for measurement of rotor I^2R losses. IEEE corrects the value of slip for each load point back to an ambient temperature of 25°C using the ambient corrected value for the stator I^2R losses. The impact of this difference is somewhat unclear, but the IEEE method is thought to be more accurate.

Additional or stray losses

As noted above this is the most significant difference between the test methods. JIS assume that additional losses are 0% for all motor types and sizes. IEC assume that additional losses are 0.5% of the rated input for all motor types and sizes. IEEE determine the additional losses through a series of measurements at various loads. A regression of the measurements is used to estimate the additional losses. The IEEE method is thought to be an accurate method of assessing additional losses for motors.

C:2.3 Technical issues associated with the use of motor standards

Although the IEC method has been through a range of amendments in recent years, the basic methodology has not changed markedly since its initial publication in the early 1970's. The JIS method was published in 1984 but may have also been amended recently, but the key aspects are thought to be the same. In all of the aspects discussed above, the IEEE test procedure is considered to be the superior of the three test methods.

In late 1997, CENELEC, then the IEC, initiated a new work item to review the IEC test procedure for motors with a view to considering the IEEE procedure and adopting the superior approaches as applicable. A new draft based on CAN/CSA-C390 was prepared during 1998 and circulated to a working group. The draft is very similar to the approach under IEEE with the exception that it allows "additional" losses to be either measured as per the IEEE Method B or estimated or "assigned" using an equation. The equation for estimating additional losses has been set at the high end of what is expected on the market, so a manufacturer with low additional losses has a strong incentive to measure these directly using the IEEE method. The estimation method was inserted essentially at the request of the Europeans who were concerned at the significant cost increase for tests under the proposed method, as torque has to be measured under the IEEE procedure (which requires more sophisticated and expensive instrumentation).

This new draft IEC standard was issued for voting in October 1998 and votes closed early 1999. It should be noted that the draft for voting was issued with a significant number of technical errors and this resulted in some negative responses. The voting, despite yes votes from UK, USA and Canada, did not pass as most of the major European economies voted no. The draft is again under review and it is hoped that most of the European concerns can be addressed during 1999 (some of which relate to a concern that there is no maximum size limit specified in the scope of the standard).

It is hoped that all of the technical issues can be resolved during 1999, which would allow publication in 2001/2002. This new IEC standard would provide a sound basis for future harmonisation of motor standards into the future within APEC economies.

ANNEX D: LIGHTING PRODUCTS

Lighting products are many and diverse and many APEC economies regulate these products for efficiency. For this report, lighting products are classified into the following groups:

- Incandescent lamps: including reflector lamps and general lighting service (GLS) lamps, typically ranging from 25W to 500W power.
- Fluorescent lamps: generally these are linear or circular and are characterised by double capped connection to a ballast, typically ranging from 15W to 110W power.
- Compact fluorescent lamps: small compact single ended fluorescent lamps – these can have an external ballast or can be self ballasted (ballast built in), typically 7W to 40W power (can also include D and double D shapes).
- Outdoor lighting systems

Other lighting types such as high intensity discharge lamps are not generally regulated, so standards for these have not been included.

D:1 Incandescent Lamps

Table 87: Summary of Incandescent Lamp Energy Programs

	Australia	Brunei	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	USA	Vietnam
Energy Labelling									M	U								U		M	
MEPS			M						M											M	

M = mandatory, V = voluntary, U = under consideration, T = Japanese Top Runner

D:1.1 Canada

Program: mandatory MEPS for incandescent reflector lamps

Summary of test procedure

The test procedure for incandescent reflector lamps is set out in CAN/CSA-C862-95. The light output and the power of the lamp is determined to determine its efficacy. The standard sets out a range of mandatory requirements for a lamp in addition to efficacy. The test procedures are broadly in line with the requirements for the USA.

Details

The standard is applicable to lamps rated from 40W to 205W with an E26 or E26 skirted medium screw-base and a diameter of greater then 70mm (PAR and R types).

It is not applicable to coloured lamps, heat lamps, lamps for special applications, ER or BR shaped lamps or bowl mirror lamps. Lamp types excluded include:

- coloured incandescent reflector lamps
- incandescent reflector lamps that are of the rough or vibration service type
- neodymium oxide type;
- has a coating or other containment system to retain glass fragments if the lamp is shattered and is specifically marked and marketed as an impact-resistant lamp;
- specifically marked and marketed for plant growth use
- specifically marked and marketed as either an infra-red heat lamp; a heat-sensitive use; for mine use; or for aquarium, terrarium or vivarium use.

The nominal temperature of test is 25^{o}C. Lamps are seasoned before tested (either 2 hours or 1% of rated life). The centre beam intensity is measured in accordance with IES publication LM-20 (goniometer method). This is used to determine the lamp efficacy in Lumens/Watt. The standard also specifies a number of other performance and design requirements for incandescent reflector lamps:

- The construction requirements specified in CAN/CSA C22.2 No 84 (safety).
- Space drawing limits specified in ANSI C78.21
- Rated beam angle as classified in ANSI C78.379
- Life must exceed 2000 hours when tested according to IES LM-49 or IEC 60064
- Centre beam intensity must exceed 80% or 85% of rated (depending on type) when tested to IES LM-20
- Wattage shall not exceed 106% of rated.
- Efficacy limits are set out in the standard and regulations

Requirements for the energy efficiency regulations:

• type of product (general service incandescent reflector lamp);

• lamp class as specified in ANSI C78.21, Table 1 of Part II;

• average lamp efficacy.

D:1.2 Korea

Program: Mandatory energy labelling, MEPS and high impact voluntary targets for incandescent lamps.

Summary of test procedure

The test procedure for incandescent lamps is set out in KS C7501. It is understood that an English version of this test procedure is not available, however, for this report we have analysed JIS C7501, which is supposed to be equivalent.

The standard covers the design and construction of A and PS type general lighting service (GLS) lamps. The standard also specifies initial performance characteristics, life, marking and related requirements. The general requirements appear to be broadly in accordance with IEC 60064.

Details

The scope of the standard A and PS type general lighting service lamps (GLS) with an Edison screw (ES) base of E25/E26 type. Performance requirements related to energy and energy service include:

- Initial luminous flux must be greater than 90% rated for coated and 93% for clear lamps.
- Average life >96% specified value.
- Dimensions are specified

A number of other requirements are also specified (eg temperature rise, strength, marking etc.), mostly related to construction and safety.

Ambient temperature is 20^{o}C ±15^{o}C for the test, with a humidity of 65% ±20%. The lamp is seasoned for 40 minutes with voltage of 120% and 20 minutes at a voltage of 130% before measurement. The lamp is held base up or base down for the luminance ratio test – the luminance is determined in a plane which is perpendicular to the lamp axis. The product has to be marked with the type and power.

D:1.3 Malaysia

Program: voluntary energy labelling for incandescent lamps – under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

D:1.4 Chinese Taipei

Program: mandatory energy labelling for incandescent lamps – under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

D:1.5 USA

Program: mandatory MEPS and energy labelling for incandescent reflector lamps and labelling for incandescent lamps

Summary of test procedure

The test procedure for incandescent GLS and reflector lamps is set out in 10CFR430 Sub Part B, Appendix R. All of the test conditions are externally referenced to IES standards. The test procedures are broadly in line with the requirements for Canada.

Details

Energy labelling applies to both GLS lamps and reflector lamps, while MEPS is only applicable to reflector lamps in the range 40W to 205W. All set up and test conditions are specified in standards prepared by the Illumination Engineering Society of North America (IESNA).

GLS lamps – Set up and lamp lumen output shall be determined in accordance with IES LM45 at the reference condition. Lamp electrical power input in watts shall be measured and recorded. Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition. The manufacturer is required to declare the Lumen output, the lamp power and the lamp life on the lamp package.

Reflector lamps – Set up and lamp lumen output shall be determined as total forward lumens, and may be measured in an integrating sphere at the reference condition in accordance IES LM20 or from an average intensity distribution curve measured at the reference condition specified in IES LM20. Lamp electrical power input in watts shall be measured and re-corded. Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition. The manufacturer is required to declare the Lumen output, the lamp power and the lamp life on the lamp package. The lamps must also meet the MEPS requirements set out in 10CFR430 Sub part C.

D:1.6 IEC60064 – GLS Lamps

Summary of test procedure

IEC60064 covers tungsten filament lamps (incandescents) for domestic and similar general lighting purposes (general lighting service or GLS lamps). It is relevant to A or PS (pear) shapes with either Edison screw (E26 or E27) or bayonet cap (B22d) bases with a rated power between 25W and 200W. It does not cover reflector lamps which are covered by IEC61341. IEC60064 specifies aspects such as marking, lamp dimensions, initial lumen readings, lumen maintenance, life test requirements and sampling procedures to verify compliance with the standard. The standard does not specifically cover efficacy, but data on lumen output and power measured under the standard can be used to determine this parameter if required.

Details

The standard is primarily aimed at ensuring that GLS lamps are built to specific dimensions and that they meet minimum performance requirements regarding lumen output and life. It also provides a method to allow third party certification to the standard using sampling plans. Main sections in the standard are:

- Lamp characteristics and specifications – dimensions, lumen output, lumen maintenance, rated life and data for luminaire design, including number data sheet for the various lamp types, powers and coatings.
- Minimum requirements including a reference to the safety standard IEC 60432-1.
- Verification of compliance (for certification purposes) and sampling plans.

Detailed statistical data is also provided.

The test procedure for determining luminous flux is as follows:

- Bulbs are seasoned at 110% rated voltage for between 0.04% and 0.1% of rated life. (in North America, lamp seasoning up to 1% rated life is permitted).
- Test voltage is to be within 0.2% of rated, voltage drop to the lamps shall be less than 0.1%.
- Lamps are operated base up, no ambient temperature is specified.
- For lamp life tests, voltage is between 100% and 110% of rated (in Japan, voltages up to 140% are permissible). Lamps are switched off twice daily for periods not exceeding 15 minutes. A lamp with a life longer than 125% of the rated value is considered to have a life of 125% of the rated value.

D:1.7 Technical Issues Associated with the use of IEC60064

IEC60064-93 appears to be adequate for general lighting service (GLS) lamps. The issue of efficacy is not addressed directly within the standard, although there appears to be sufficient data measured in the process of testing to determined all required outputs. IEC60064 does not cover reflector lamps – these are covered under IEC61341.

D:1.8 IEC61341 – Reflector Lamps

Summary of test procedure

IEC61341 describes the method of measuring and specifying the centre beam intensity and the associated beam angle(s) of reflector lamps. It applies to incandescent, tungsten halogen and gas-discharge reflector lamps for general lighting purposes. It does not apply to lamps for special purposes such as projection lamps. IEC61341 is relevant to all shapes and base types. It does not cover general lighting service or GLS lamps which are covered by IEC60064. IEC61341 does not specify any aspects such as marking, lamp dimensions, initial lumen readings, lumen maintenance, life test requirements or sampling procedures to verify compliance with the standard. The standard does not specifically cover efficacy, but data on beam intensity and angle and power measured under the standard can be used to determine this parameter if required.

Details

The standard is primarily aimed at the measurement of beam intensity and angle. It specifies parameters such as peak intensity, centre bean intensity, beam angle, symmetrical bean patterns, asymmetrical beam patterns and irregular bean patterns. Tungsten filament lamps are to be aged at its rated voltage for approximately 1 hour, while discharge lamps are aged for 100 hours. A photometer is used to measure the luminous flux over the projection area that is perpendicular to the main beam of the lamp. Where there is only one point of peak intensity, or where there are two within an angle of 10^{o}, the peak position is determined visually and the luminous flux measured at that point. The beam angle is then determined at the angle where the luminous flux is half of the centre bean intensity (two axes are measured).

The procedure for irregular beams is the same in principle, however the point of peak intensity is determined from a range of measurements, points of half intensity determined from a large number of measurements (at least 6 axes or a minimum of sixty measurement points across the illuminated area.

The standard provides for reporting of maximum beam intensity and beam angle (this can be on a number of axes for asymmetrical and irregular beams).

D:1.9 Technical Issues Associated with the use of IEC61341

IEC61341-94 appears to be adequate for the measurement of beam intensity and beam angle for reflector lamps. The issue of efficacy is not addressed directly within the standard, although there appears to be sufficient data measured in the process of testing to determined all required outputs.

D:2 Fluorescent Lamps

Table 88: Summary of Fluorescent Lamp Energy Programs

	Australia	Brunei	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	USA	Vietnam
Energy Labelling								M	M	U					U			U		M	
MEPS			M					T	M			U							U	M	

M = mandatory, V = voluntary, U = under consideration, T = Japanese Top Runner

D:2.1 Canada

Program: mandatory MEPS for linear fluorescent lamps

Summary of test procedure

The test procedure for fluorescent lamps is set out in various IES and ANSI standards. The procedure for Canada is essentially equivalent to that required for the USA. Canada is considering the adoption of CAN/CSA-C819-95 in the near future, so the requirements of this standard are summarised below. There is still extensive use of external references in this standard.

Details

The standard CAN/CSA-C819-95 is applicable to a limited range of fluorescent lamps as follows:

- 1200mm linear rapid start lamps
- 600mm U shaped rapid start lamps
- 2400mm linear rapid and instant start lamps

The standard excludes specialist lighting products such as:

- a fluorescent lamp that is specifically marked and marketed for plant-growth use;
- a cold-temperature fluorescent lamp;
- a coloured fluorescent lamp;
- a fluorescent lamp designed to be impact-resistant;
- a reflectorised or aperture fluorescent lamp;
- a fluorescent lamp designed for use in reprographic equipment;
- a fluorescent lamp primarily designed to produce ultraviolet radiation; or
- a fluorescent lamp with a colour-rendering index of 82 or greater.

The test temperature is specified as 25^{o}C. Luminous flux is determined under standardised conditions with a reference ballast as specified in IES LM9 and tested to IES LM9 or ANSI C82.3 and ANSI C78.375. Requirements of the standard include:

- dimensions to comply with ANSI C78.1 and ANSI C78.3
- rated life to be >12000 hours when determined in accordance with IES LM40
- luminous flux is determined in accordance with IES LM9 – a minimum allowable efficacy is specified.
- colour rendering index is to be determined in accordance with CIE 13.3, IES LM16 and IES LM58 – a minimum allowable CRI is specified (depending on the lamp type and size).

Requirements for the energy efficiency regulations:

- nominal power;
- shape of product for rapid start (straight or U-shape);
- nominal length & diameter;
- type of base for rapid start (medium bi-pin base or a recessed double-contact base)
- abbreviation under ANSI C78.1 or ANSI C78.3 as applicable
- correlated colour temperature and average colour-rendering index;
- average lamp efficacy.

D:2.2 Japan

Program: Top Runner efficiency target program for fluorescent lamps/ballast systems

Summary of test procedure

The test procedure for linear fluorescent lamps is set out in JIS C7601. This standard covers all aspect of fluorescent lamps including performance, design, construction, life, colour and safety. Therefore large parts of the standard are not relevant to this project. However JIS C7601 is based on a number of IEC standards and the requirements appear to be largely compatible with these requirements. The IEC standards used to develop JIS C7601 include:

- IEC60081 - Double-capped fluorescent lamps - Performance specifications
- IEC60901 - Single-capped fluorescent lamps - Performance requirements
- IEC61195 - Double-capped fluorescent lamps – Safety specifications
- IEC61199 - Single-capped fluorescent lamps - Safety requirements

The JIS standard notes that the lamp data sheets in IEC60081 and IEC60901 are not included. It appears that the basic performance requirements are therefore equivalent to IEC standards (if not identical). Efficacy can be determined from measurements within the standard.

Energy consumption efficiency (1m/W) is given by the following ratio:

$$\frac{\Sigma(\text{Lamp luminous flux (1m)} \times \text{Ballast factor} \times \text{Temperature correction factor of lamp})}{\text{Power consumption (W)}}$$

Ballast factor is given by the following ratio from a single reference lamp:

$$\frac{\text{Light output of the ballast}}{\text{Light output of reference ballast}}$$

Examples of temperature correction factors for various types of lamps and conditions of operation in the luminaire are provided in the section on Japan in the main report. Lamp luminous flux is the rated lamp output in Lumens.

D:2.3 Korea

Program: Mandatory energy labelling, MEPS and high impact voluntary targets for linear and circular fluorescent lamps.

Summary of test procedure

The test procedure for linear fluorescent lamps is set out in KS C7601. It is understood that an English version of this test procedure is not available, however, JIS C7601 is supposed to be equivalent, so the details can be obtained from the section on Japan.

D:2.4 Malaysia

Program: voluntary energy labelling for fluorescent lamps – under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

D:2.5 New Zealand

Program: Mandatory MEPS is under consideration

Summary of test procedure

There is currently no published test procedure for linear fluorescent lamps in New Zealand, however a joint Australian/New Zealand standard for the measurement of efficacy of both ballasts and lamps (based on EN50294) is currently under development.

D:2.6 Philippines

Program: MEPS and energy labelling is under consideration

Summary of test procedure

The test procedure for linear fluorescent lamps in the Philippines is PNS 02:1994. We understand that this standard is supposed to be equivalent to IEC60081.

D:2.7 Chinese Taipei

Program: Mandatory energy labelling for fluorescent lamps – under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

D:2.8 USA

Program: mandatory MEPS and energy labelling for general service (linear) fluorescent lamps

Summary of test procedure

The test procedure for general service (linear) fluorescent lamps is set out in 10CFR430 Sub Part B, Appendix R. All of the test conditions are externally referenced to IES and ANSI standards. The test procedures are broadly in line with the requirements for Canada.

Details

Energy labelling and MEPS applies to 1200mm and 2400mm general service (linear) fluorescent lamps. All set up and test conditions are specified in standards prepared by the Illumination Engineering Society of North America (IESNA) and in ANSI standards.

Set up and lamp lumen output shall be determined in accordance with IES LM9 at the reference condition, except that the voltage and current conditions are as set out in ANSI C78.1, ANSI C78.2, ANSI C78.3 and ANSI C78.375. The reference ballast is specified in ANSI C82.3. Lamp electrical power input in watts shall be measured and recorded. Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition. There is also a requirement to measure the colour rendering index (CRI) in accordance with CIE 13.3, IES LM16 and IES LM58. A minimum allowable CRI is specified (depending on the lamp type and size). The manufacturer is required to declare the Lumen output, the lamp power and the lamp life on the lamp package.

D:2.9 IEC60081 - Double-capped fluorescent lamps

Summary of test procedure

IEC60081 specifies the performance requirements for double-capped fluorescent lamps for general light service (generally linear tubular fluorescent lamps). These requirements include dimensions, starting characteristics, electrical and cathode characteristics, photometric characteristics, lumen maintenance, marking, information for ballast and starter design and information for luminaire design. Data sheets are provided for a wide range of lamp types and sizes. The requirements of this standard relate only to type testing. Conditions of compliance, including methods of statistical assessment, are under consideration. The standard covers determination of data on lumen output and total circuit power measured and hence determination of efficacy.

Details

The standard is primarily aimed at ensuring that fluorescent lamps are built to specific dimensions and that they meet minimum performance requirements regarding electrical characteristics and light output. The scope of the standard includes the following lamps:

- preheated cathodes at mains frequency with starter or on high frequency;
- preheated high resistance cathodes at mains frequency without starter or on high frequency;
- preheated low resistance cathodes at mains frequency without starter or on high frequency;
- preheated cathodes designed for high frequency operation;
- non-preheated cathodes designed for mains frequency operation;
- non-preheated cathodes designed for high frequency operation;

Lamps are expected to start properly at a rated voltage of between 92% and 106% of rated voltage in an ambient temperature of between 10°C and 50°C. The standard references IEC60921 and IEC60929 for ferromagnetic and electronic ballasts and IEC60155 and IEC60927 for starters.

The standard defines the requirements for a reference ballast which is to be used to test lamps. The initial luminous flux shall not be less than 92% of the rated value. The standard also specifies requirements for chromaticity and colour rendering index in comparison with rated values. The lumen maintenance shall not be less than 92% of its rated value at any time during the lamp's life.

The standard provides a detailed method of test for determining starting characteristics for all lamp configurations. Before the starting test, lamps are left in an atmosphere of between 20°C and 27°C and <65% humidity for not less than 24 hours. It also provides a detailed method of test to determine lumen output, which are in line with CIE recommendations. The supply is at rated voltage and frequency and the harmonic content shall be less than 3%. Lamps are to be aged for at least 100 hours before test. Measurements shall be made after a stabilisation period of not less than 15 minutes with a reference ballast specified for the lamp type under test. Lamps are operated in the horizontal position at temperature 25°C ±1°C. Test circuits are provided for lamps without cathode heating (with starter), with cathode heating (with starter) and for starter-less circuits.

D:2.10 Technical Issues Associated with the use of IEC60081

IEC60081-97 appears to adequately cover light output and general performance of double capped fluorescent lamps. The issue of efficacy is adequately addressed within the standard.

D:2.11 IEC60901 – Single capped fluorescent lamps

Summary of test procedure

IEC60901 specifies the performance requirements for single-capped fluorescent lamps for general lighting service (typically pin based compact fluorescent lamps requiring an external ballast). These requirements include dimensions, starting characteristics, electrical and cathode characteristics, photometric characteristics, lumen maintenance, marking, information for ballast and starter design and information for luminaire design. Data sheets are provided for a wide range of lamp types and sizes. The requirements of this standard relate only to type testing. Conditions of compliance, including methods of statistical assessment, are under consideration. The requirements and test conditions are generally identical to IEC60081 for double capped fluorescent lamps, except that an additional lamp category (with an internal means of starting) is included. The initial luminous flux and lumen maintenance requirements are both set at 90% (cf 92% for IEC60081). The standard covers determination of data on lumen output and total circuit power measured and hence determination of efficacy.

D:2.12 Technical Issues Associated with the use of IEC60901

IEC60901-96 appears to adequately cover light output and general performance of single capped fluorescent lamps. The issue of efficacy is adequately addressed within the standard.

D:3 Fluorescent Lamp Ballasts

Table 89: Summary of Fluorescent Lamp Ballast Energy Programs

	Australia	Brunei	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	USA	Vietnam
Energy Labelling	U								M	U					M			U	V		U
MEPS	U		M						M	M		U			M		S	M	U	M	U

M = mandatory, V = voluntary, U = under consideration, S = Singapore Accelerated Depreciation

D:3.1 Australia

Program: Mandatory MEPS and voluntary energy labelling for fluorescent lamp ballasts – both under consideration.

Summary of test procedure

The existing test procedures for fluorescent lamp ballasts are AS2643 and AS3963 which are equivalent to IEC60921 and IEC60929 respectively. A new draft standard based on EN50294 is in preparation for the measurement of ballast energy efficiency.

D:3.2 Canada

Program: mandatory MEPS for ballasts for fluorescent lamp ballasts

Summary of test procedure

The test procedure for fluorescent lamp ballasts is set out in CAN/CSA-C654-M91. Reference lamps and ballasts systems are defined in the standard. The lumen output of a test ballast with an appropriate reference lamp is determined under stabilised conditions. The ballast efficacy factor (BEF) is determined as the ratio of the relative light output of the test ballast/reference lamp combination (in comparison with the reference lamp/ballast system) divided by the total system power. Minimum BEF values as well as a number of other performance requirements are specified in the standard. No minimum ballast lumen factor is specified in the standard. The procedure for Canada is essentially equivalent to that required for the USA.

Details

The standard CAN/CSA-C654-M91 (as amended September 1992) is applicable to four types of fluorescent lamp ballasts; 40T12 rapid start, 96T12 rapid start, 96T12 instant start and F32T8 rapid start, all intended to operate at 60 Hz and either 120V, 277V or 347V. It does not apply to ballast designed for operation of a temperature of lower than –17.8^{o}C. Mandatory reference is made to the safety standard for ballasts. The test is undertaken at 25^{o}C and the supply system voltage, stability and impedance is also specified. Lamps are mounted in a horizontal position and light output and power input is to be stable before lumen and power measurements are undertaken (generally a minimum of 15 minutes). Reference lamps and ballasts are specified in the standard for each of the main lamp types and ballast combinations.

The lumen output (or lamp input power in the case of low frequency instant lamp ballasts) and total circuit power with a test ballast and reference lamp is measured. The lumen output (or lamp input power in the case of low frequency instant lamp ballasts) and total circuit power with a reference ballast and lamp is also measured. The relative light output is defined as the ratio of the light output of the test system to the light output of the reference system (expressed as 100 when they are equal). In the case of low frequency instant lamp ballasts, the relative lamp power is defined as the ratio of the lamp power of the test system to the lamp power of the reference system (expressed as 100 when they are equal). The Ballast Efficacy Factor (BEF) is determined as the ratio of the relative light output to the total power input in Watts (except for low frequency instant lamp ballasts, where the BEF is defined as the ratio of the relative lamp power to the total input power in Watts). For example, a single F40T12 lamp with a relative light output of 100 (ie equal to the reference ballast) and a total input power of say 50 Watts will have a BEF of 2.0. No minimum relative light output (or power output) is required under the standard.

The standard also mandates that ballasts must have a power factor of greater than 90%.

For regulatory purposes, the ballast type, BEF, the number and type of lamps the ballast is designed to operate and the design voltage has to be supplied.

D:3.3 Japan

Program: Top Runner efficiency target program for fluorescent lamps/ballast systems - this is covered in the section in fluorescent lamps above.

D:3.4 Korea

Program: Mandatory energy labelling, MEPS and high impact voluntary targets for fluorescent lamp ballasts.

Summary of test procedure

The test procedure for ferromagnetic fluorescent lamp ballasts is set out in KS C8102 while electronic ballasts are covered by KS C8100. It is understood that English versions of these test procedures ares not available, however, KS C8102 is supposed to be equivalent to JIS C8108 and has been summarised below. KS C8100 is supposed to be equivalent to IEC60929, so the details can be obtained from the section on IEC.

Details

The scope of the JIS C8108 covers the design and construction of ballasts for fluorescent lamps. It is a combined safety and performance standard is based largely on IEC60920 (safety) and IEC60921 (performance) and appears to be equivalent to these standards in most respects. The scope of the standard covers ballasts used with a starter, rapid and instant start ballasts and electronic ballasts. The standard defines the characteristics of reference ballasts and lamps for use in testing.

The standard covers aspects such as construction and marking, secondary voltage, starting voltage, cathode pre-heating, secondary short circuit, lamp current and wattage, lamp current waveform, lamp input current and power, power factor, noise, moisture resistance, temperature rise, insulation resistance, dielectric withstand voltage, abnormal temperature rise and thermal endurance of windings. Interestingly, the standard sets performance requirements for electronic ballasts and rapid start ballasts in terms of the ratio of luminous output in lieu of the measurement of the lamp wattage. As mentioned elsewhere, the determination of lamp power for these ballasts types is difficult under normal circumstances.

As with the IEC standards, the standard does not specifically cover efficacy, but data on lumen output and total circuit power measured under the standard can be used to determine this parameter if required.

D:3.5 Malaysia

Program: Mandatory MEPS for fluorescent lamp ballasts

Summary of test procedure

The test procedure for ferromagnetic fluorescent lamp ballasts is set out in MS 141. This standard is identical to IEC60921-1988, and only covers ferromagnetic ballasts. Reference is made to IEC60929 for the performance of electronic ballasts. The only difference is the addition of a brief Appendix to determine the ballast loss test (Appendix E) which is required for local Malaysian regulations. This requires the measurement and reporting of the lamp power, lamp voltage, current and total power using both the test ballast and the reference ballast on the reference lamp. The ballast loss is calculated from the total circuit power less the lamp power. The reference ballast power is used to check that the lamp is within specification, rather than to adjust to the results on the test ballast. This can only be used for ballasts that use an external starter. Malaysia is considering new test procedures that can deal adequately with rapid start and electronic ballast types.

D:3.6 Philippines

Program: Mandatory MEPS for fluorescent lamp ballasts

Summary of test procedure

The test procedure for fluorescent lamp ballasts in the Philippines is PNS 12-2:1996. We understand that this standard is supposed to be equivalent to IEC60921 and is therefore covered by the following section on the IEC standard.

D:3.7 Chinese Taipei

Program: Mandatory MEPS for fluorescent lamp ballasts (energy labelling is under consideration)

Summary of test procedure

The test procedures and requirements for fluorescent lamp ballasts are set out in CNS927-96 (performance requirements) and CNS3888-85 (method of test). Most of the tests relate to operation and safety of the ballast.

CNS3888 sets out the method of test including start voltage test, secondary voltage test, cathode pre-heat current, output current and power, lamp current waveform, power factor, moisture withstand, temperature rise, insulation resistance and insulation voltage. Most of these tests are specified in CNS3888 are similar in type and method specified in IEC60920 and IEC60921.

CNS927 sets out acceptance limits for tests conducted under CSN3888. These include construction and performance requirements. The performance requirements are almost identical to those set out in IEC60920 and IEC60921 although there are some very minor deviations for specialised product types and all product classifications are not identical. It is not clear how a ballast power consumption value for rapid start ballasts is determined for the energy efficiency regulations.

D:3.8 Thailand

Program: Voluntary energy labelling for fluorescent lamp ballasts (mandatory MEPS is under consideration)

Summary of test procedure

The test procedures and requirements for fluorescent lamp ballasts are set out in TIS23-2521. This is supposedly based on IEC 82 for ballasts which was withdrawn many years ago. It is assumed that the more recent standard IEC60921 is broadly equivalent to the TIS standard, but this is not available in English so confirmation has not been possible for this report. A new standard for electronic ballasts TIS 1506-2541 has recently been released. This is broadly based on IEC60929. For verification of efficacy, the Thai system uses the nominal ballast watt loss and the rated lamp power to determine an allowable system Lumens per watt.

D:3.9 USA

Program: mandatory MEPS fluorescent lamp ballasts

Summary of test procedure

The test procedure for fluorescent lamp ballasts is set out in 10CFR430 Sub Part B, Appendix Q. All of the test conditions are externally referenced to ANSI C82.2. The test procedures are broadly in line with the requirements for Canada.

Details

MEPS applies to the following fluorescent lamp ballasts types: 40T12 rapid start, 96T12 rapid start or 96T12HO instant start for either 120V or 277V only (this scope is slightly more restrictive compared with Canada). All set up and test conditions are specified in ANSI C82.2.

The lumen output and total circuit power with a test ballast and reference lamp is measured. The lumen output and total circuit power with a reference ballast and lamp is also measured. The relative light output is defined as the ratio of the light output of the test system to the light output of the reference system (expressed as 100 when they are equal). The Ballast Efficacy Factor (BEF) is determined as the ratio of the relative light output to the total power input in Watts. Where more one lamp is measured at the same time, the average light output and total power are used. No minimum light output requirement is specified.

D:3.10 IEC60921 – Ferromagnetic Ballasts

Summary of test procedure

IEC60921 specifies performance requirements for ballasts, excluding resistance types, for use on a.c. supplies up to 1000 V at 50 Hz or 60 Hz, associated with tubular fluorescent lamps with pre-heated cathodes operated with or without a starter or starting device and having rated wattages, dimensions and characteristics as specified in IEC publications 60081 and 60901. It applies to complete ballasts and their component parts such as resistors, transformers and capacitors. It only applies to ferromagnetic ballasts – electronic ballasts are covered under IEC60929.

IEC60921 specifies aspects such as marking, open circuit voltage, pre-heating conditions, lamp power and current, circuit power factor, supply current, maximum current to cathode, current waveform (harmonics), magnetic screening and impedance at audio frequencies. The standard does not specifically cover efficacy, but data on lumen output and total circuit power measured under the standard can be used to determine this parameter if required, although the standard in its current form is not really adequate.

Details

The standard is primarily aimed at ensuring that ballasts are designed to provide correct electrical inputs for starting and operating fluorescent lamps. Extensive references are made to lamp data sheets in IEC60081 and IEC60901 in terms of specification of ballast requirements. Although there are some requirements regarding the light output of lamps (ballast lumen factor or BLF), the energy efficiency or energy consumption of a ballast is not a primary consideration in the standard.

The standard mandates the following performance requirements:

- various marking requirements (power factor, audio frequency impedance, low distortion);
- specification for open circuit lamp voltages for the relevant lamp;

- meet specified preheating conditions for the relevant lamp;
- maintain lamp power and current for the relevant lamp type – for lamps with a starter, the reference lamp power and current from the test ballast must be between 92.5% and 115% when compared to the reference lamp and ballast; for lamps without a starter, the arc current shall be limited to 115% and the luminous flux >90% when compared to the reference lamp and ballast;
- limits on the difference between claimed and marked power factor
- various other electrical requirements such as supply current markings, maximum current to cathode, current waveform (limits on harmonics), magnetic screen and impedance at audio-frequencies.

The standard specifies details of reference lamps, reference ballasts, power quality and calibration of test equipment. The method used is to operate a reference lamp with a ballast under test, with a reference ballast which can be quickly switched in place of the test ballast. Once operating conditions are stable with the reference ballast, the reference ballast is switched into operation. The relevant lamp characteristics can then be determined for each ballast (eg current, voltage, power, lumen output).

D:3.11 Technical Issues Associated with the use of IEC60921

IEC60921-88 appears to adequately cover general performance of ferromagnetic fluorescent lamp ballasts. It is important to note that this standard specifies a minimum light output (or lamp power input) requirement, which does not appear to present in the North American standards. The issue of efficacy is not addressed directly within the standard although all of the required information on test ballasts and reference ballasts is contained in the standard. The technical difficulty is that for some ballast/lamp circuit types (mainly those without a starter and those used with high frequency ballasts) it is not possible to accurately determine that lamp power or ballast power directly. The approach that is taken in North America and now Europe is that the light output and total power circuit power for a test lamp or ballast is compared to a reference system. This seems to be the most reliable method of measuring lamp and ballast efficacy. This approach is discussed in more detail below in EN50294.

D:3.12 IEC60929 – Electronic ballasts

Summary of test procedure

IEC60929 specifies performance requirements for electronic ballasts for use on a.c. supplies up to 1 000 V at 50 Hz or 60 Hz with operating frequencies deviating from the supply frequency, associated with tubular fluorescent lamps as specified in IEC60081 and IEC60901 and with other tubular fluorescent lamps for high frequency operation. It only applies to electronic ballasts – ferromagnetic ballasts are covered under IEC60921.

IEC60929 specifies aspects such as marking, operating conditions, circuit power factor, supply current, maximum current to cathode, current waveform (harmonics), magnetic screening, impedance at audio frequencies, mains transient overvoltages and operational tests for abnormal conditions. The standard essentially covers the same material as IEC60921 but is considerably more complex due to the high frequency aspect of electronic ballasts. The standard also addresses the operation of lamps designed for high frequency ballasts. The standard does not specifically cover efficacy, but data on lumen output and total circuit power measured under the standard can be used to determine this parameter if required, although the standard in its current form is not really adequate.

Details

The standard is primarily aimed at ensuring that ballasts are designed to provide correct electrical inputs for starting and operating fluorescent lamps. The tests and requirements are similar to IEC60921 except where noted below:

- preheat time shall not be less than 0.4 seconds unless allowed on the relevant data sheet;
- various specification for starting voltage rises and substitution resistor currents;
- crest factor for open circuit shall not exceed 1.8;
- Ballast lumen factor (BLF - ratio of the light output of the test ballast to the reference ballast using the same reference lamp) shall not be less than 95% of the value declared. If the declared BLF is lower than 0.9, evidence is to be given that the performance of the lamp is not impaired;
- Total circuit power shall not be more than 110% of the value declared;
- Various requirements regarding current waveform (harmonic limitations);
- An endurance test is specified with temperature cycling (5 cycles) and open-circuit switching (1000 cycles).

The standard specifies details of reference lamps, reference ballasts, power quality and calibration of test equipment. The method used is to operate a reference lamp with a ballast under test, with a reference ballast which can be quickly switched in place of the test ballast. Once operating conditions are stable with the reference ballast, the reference ballast is switched into operation. The relevant lamp characteristics can then be determined for each ballast (eg current, voltage, power, lumen output).

D:3.13 Technical Issues Associated with the use of IEC60929

IEC60929-88 appears to adequately cover general performance of electronic fluorescent lamp ballasts. It is important to note that this standard specifies a minimum light output (or lamp power input) requirement, which does not appear to present in the North American standards. The issue of efficacy is not addressed directly within the standard although all of the required information on test ballasts and reference ballasts is contained in the standard. For efficiency it is subject to the same problems as IEC60921.

D:3.14 EN50294-1998 – Ballast input power method

Summary of test procedure

The standard is primarily aimed at measuring the efficacy of both fluorescent lamps and/or ballast combinations. It uses the total input power method for ballast-lamp circuits together with light output (or lamp power input). Test ballasts are operated with an appropriate reference lamp and the total circuit light output and input power are compared to a reference ballast and reference lamp circuit operated in parallel. The power and lamp output (or lamp power) is normalised back to standardised levels for comparison purposes.

Details

EN50294 titled "Measurement method of total input power of ballast-lamp circuits" was specifically developed by CELMA (European Lighting Manufacturer's Association) and subsequently adopted by CENELEC for use as the test method to determine the ballast energy efficiency under CELMA's voluntary energy labelling program. It is also going to be used as the basis for European ballast MEPS which is due to be finalised in the near future.

The scope of the standard covers double and single capped fluorescent lamps and their ballasts. The EN standard states a number of exclusions in the scope which are unclear in their intention. The requirements for safety and performance of IEC60920, IEC60921, IEC60928 and IEC60929 are referenced. The standard mandates that a ballast lumen factor be declared by the manufacturer – this has to be in the range 0.925 to 1.0 for ferromagnetic ballasts and between 0.925 and 1.075 for electronic ballasts. The test method for ferromagnetic and electronic ballasts is quite different and each is described below.

For ferromagnetic ballasts, the test ballast is operated with a reference lamp. In addition, a reference lamp and a reference ballast are operated in parallel. The total input power and the lamp power are measured for each circuit. The total input power for the test ballast/lamp circuit is corrected by the ratio of the measured lamp power for the reference circuit to the measured lamp power for the test circuit, times a factor of 0.95. It is unclear why the normalised ballast lumen factor of 0.95 has been chosen for ferromagnetic ballasts (this suggests that manufacturers tend to under-run lamps on average). There is also a small adjustment made for the difference between the measured reference lamp power and nominal reference lamp power (as stated on the data sheet).

For electronic ballasts, the test ballast is operated with a reference lamp. In addition, a reference lamp and a reference ballast are operated in parallel. The total light output and the total input power are measured for each circuit. The total input power for the test ballast/lamp circuit is corrected by the ratio of the light output for the reference circuit to the light output of the test circuit (ie to a BLF of 1.0). The total power is also corrected by the ratio of the nominal lamp power (lamp data sheet) for the reference circuit to the measured lamp power for the reference (the reference ballast is always a ferromagnetic ballast).

D:3.15 Technical Issues Associated with the use of EN50294

EN50294 has been specifically drafted to address issues of efficacy of fluorescent lamp ballasts. The general approach is good with respect to determination of energy consumption and allows comparison of a wide range of ballast and lamps types. Importantly, the test method is broadly similar in approach to that used in the North American standards.

There are a number of clauses in the CENELEC which are unclear or ambiguous and there is extensive reference made to European directive and other CENELEC standards which makes it unsuitable for use as an international standard. A number of the formulae are also questionable – in particular the adjustment to a BLF of 0.95 for ferromagnetic ballasts and 1.0 for electronic ballasts. However, despite these shortcomings, the general approach is good.

At this stage, EN50294 is only a CENELEC standard and a move has not yet been made to introduce this as an IEC standard. Australia and New Zealand are currently developing a local version of the EN50294 or use in their local ballast efficiency programs. This should provide some insight into the position adopted by the Europeans in their initial version and iron out some of the current problems. There is an opportunity to develop a new IEC standard which addresses the requirements of North America and other APEC member economies, as well as Europe. The basic method is now documented and with some multi-lateral input (especially from APEC member economies) it should be possible to develop a robust and useful international standard. This standard could be developed in a manner that would make it suitable for the measurement of efficacy of both lamps and ballasts.

D:4 Compact Fluorescent Lamps

Table 90: Summary of Compact Fluorescent Lamp Energy Programs

	Australia	Brunei	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	USA	Vietnam
Energy Labelling						V			M						U					M	
MEPS			M						M		M										

M = mandatory, V = voluntary, U = under consideration, T = Japanese Top Runner

D:4.1 Canada

Program: mandatory MEPS for compact fluorescent lamps (provincial)

Summary of test procedure

The test procedure for compact fluorescent lamps is set out in CAN/CSA-C861-95 and this standard references various IES and ANSI standards. The standard specifies a range of performance related requirements such as power input (declared versus actual), starting time, run-up time, crest factor and system efficacy (lumens per watt). The system of measuring total power input and light output is used, although a minimum light output requirement is not specified.

Details

The standard CAN/CSA-C861-95 is applicable to E26 medium screw-base compact fluorescent lamps and ballasted adaptors for use on 120V and 60Hz. The test temperature is specified as 25^{o}C. Lamps are seasoned for a minimum of 100 hours before testing. Lamp power and light output is to be stable before measurements are undertaken (minimum of 15 minutes, but could be 4 hours or more). Where a CFL ballast does not have an integrated lamp, a reference lamp is used. Instrumentation and testing is undertaken in accordance with IES LM66. The harmonic content of the supply shall not exceed 3% of the RMS voltage and voltage shall be regulated to within ±0.5% and the supply impedance shall be such that the voltage at the test unit does not vary by more than 2% when in and out of operation. Requirements of the standard include:

- reference to relevant safety standards.
- measured input power < 115% of the rated value.
- starting time < 6 seconds.
- run-up time less than 3 minutes.
- crest factor less than 1.7.
- system efficacy is specified for total input powers up to 35 watts

It should be noted that at the time of writing, only the provinces of Ontario and British Columbia regulated CFLs for energy efficiency (and is under consideration in New Brunswick).

D:4.2 Hong Kong, China

Program: Voluntary energy labelling for compact fluorescent lamps

Summary of test procedure

The test procedure for compact fluorescent lamps is set out in IEC60901, IEC90969 and CIE84. Analysis of IEC60901 is included in the section on fluorescent lamps while IEC60969 is included below.

D:4.3 Korea

Program: Mandatory energy labelling and MEPS and high impact voluntary targets for compact fluorescent lamps

Summary of test procedure

The test procedure for compact fluorescent lamps is set out in KS C7621. It is understood an English version of this test procedures is not available, however, we believe that it is based on KS C8100 and KS C7601, as well as parts of IEC60969. These KS standards are equivalent to JIS C8108 and JIS C7601 which have been analysed in the sections on ballasts and fluorescent lamps respectively above. An analysis of IEC60969 is included in a following section.

D:4.4 Mexico

Program: Mandatory MEPS for compact fluorescent lamps

Summary of test procedure

The test procedure for compact fluorescent lamps is set out in Mexican NOM 017. The test method is equivalent to IEC60901 (see the section on fluorescent lamps) but the NOM contains energy efficiency requirements as well (see Chapter on requirements by Economy).

D:4.5 Philippines

Program: Mandatory energy labelling for compact fluorescent lamps – under consideration

Summary of test procedure

The test procedure for compact fluorescent lamps is set out in PNS 603-2:1993, which is supposed to be based on IEC60969. This program is under consideration and it has not been possible to obtain a copy of the test procedure for analysis in this report.

D:4.6 USA

Program: mandatory energy labelling for compact fluorescent lamps

Summary of test procedure

The test procedure for compact fluorescent lamps is set out in 10CFR430 Sub Part B, Appendix R. All of the test conditions are externally referenced to an IES standard. The test procedures are broadly in line with the requirements for Canada, which reference the same IES standard, which involves determining the total input power and light output for the CFL. Note that no minimum light output is required..

Details

Energy labelling applies to compact fluorescent lamps. All set up and test conditions are specified in the standard prepared by the Illumination Engineering Society of North America IES LM66. Lamp electrical power input in watts and light output shall be measured and recorded. Lamp efficacy shall be determined by computing the ratio of the measured lamp lumen output and lamp electrical power input at equilibrium for the reference condition.

D:4.7 IEC60969 – Self ballasted lamps

Summary of test procedure

IEC60969 specifies the performance requirements together with the test methods and conditions required to show compliance of tubular fluorescent and other gas-discharge lamps with integrated means for controlling starting and stable operation (self-ballasted lamps), intended for domestic and similar general lighting purposes.

IEC60969 specifies aspects such as test conditions, start up, lamp wattage, measurement of luminous flux, colour, lumen maintenance and life. The standard does not specifically cover efficacy, but data on lumen output and total circuit power measured under the standard can be used directly to determine this parameter.

Details

The standard is primarily aimed at ensuring that compact fluorescent lamps with integrated ballasts operate satisfactorily. It applies to self ballasted lamps with a rated total power of up to 60W and a rated voltage of 100V to 250V with either Edison screw or bayonet cap base.

Test conditions are an ambient temperature of 25^{o}C and a humidity of less than 65%. Voltage supply shall be within ±0.5% during stabilisation and ±0.2% during measurements. The harmonic content of the supply shall not exceed 3% of the RMS voltage. Lamps shall be aged for a period of 100 hours before lumen test. The standard mandates the following performance requirements:

- starting and run up time shall comply with manufacturer claims;
- measured total lamp wattage shall be less than 115% of the rated value;
- initial luminous flux shall be greater than 90% of the claimed value;
- colour coordinates to be within the tolerance area of the claimed value;
- lumen maintenance after 2000 hours shall be not less than value declared by the manufacturer;
- life to 50% of failures shall be not less than value declared by the manufacturer.

It would seem reasonable to mandate some maximum startup time in the case where a manufacturer does not declare a value (or declares an excessive value). Although there are some requirements regarding the light output of CFLs, the energy efficiency or energy consumption is not a primary consideration in the standard.

D:4.8 Technical Issues Associated with the use of IEC60969

IEC60969-88 appears to adequately cover most aspects of general performance of compact fluorescent lamp. It is important to note that this standard specifies a minimum light output requirement, which does not appear to present in the North American standards. The issue of total lumen output and power input is address in the standard so efficacy is adequately addressed. The use of reference lamps and ballasts is not relevant to integral lamps covered under IEC60969.

D:5 Indoor Lighting Systems

D:5.1 Mexico

Program: mandatory MEPS for indoor lighting systems

Summary of test procedure

The test procedure for indoor lighting systems is set out in Mexican NOM 007. This is a building code for non residential buildings and sets lighting efficiency levels for a range of building types. It is broadly equivalent to ASHRAE 90.1 but uses a simplified structure that corresponds to interior lighting. The NOM sets a general value for each of the six building types (offices, hotels, hospitals, schools, restaurants, shopping centres) rather than dividing into sub-areas as required by ASHRAE 90.1. As this NOM does not relate to specific electrical products, it is not within the scope of this report.

D:6 External Lighting Systems

D:6.1 Canada

Program: mandatory MEPS for external lighting systems (provincial)

Summary of test procedure

There are two relevant Canadian standards for outdoor lighting systems: CAN/CSA-C239-94 (Performance standard for dusk to dawn luminaires) and CAN/CSA-C653-94 (Performance standard for roadway lighting luminaires).

CAN/CSA-C239-94 (dusk to dawn luminaires) covers the following aspects:

- mandates a high efficiency lighting source (high pressure sodium, mercury or low pressure sodium)
- various ballast performance requirements (including low temperature start and high power factor)
- photo controllers to be surge protected and comply with performance requirements of ANSI C136.10 with a switch on at 15 lux.

CAN/CSA-C653-94 (roadway lighting) states that characteristics of roadway luminaires are to be determined in accordance with IES LM31. Grid points for lighting calculations are to be in accordance with IES RP8. CAN/CSA-C653-94 specifies maximum allowable values of watt per square meter (power density) and minimum values of luminance (candelas per square meter) for both high pressure sodium and metal halide street luminaires.

It should be noted that at the time of writing, only some provinces[4] regulated outdoor lighting systems for energy efficiency.

D:6.2 Mexico

Program: mandatory MEPS for outdoor lighting systems

Summary of test procedure

The test procedure for outdoor lighting systems is set out in Mexican NOM 013. This standard is used to set illuminance levels and set efficacy levels (lumens per watt) for outdoor lighting on roadways and buildings. It is based on IES LEM6 but also sets values for car parks and areas illuminated by tower lights. Details of the test method are not available in English.

4 CAN/CSA-C653 – Ontario, British Columbia, Nova Scottia, New Brunswick – various efficiency levels by state.
CAN/CSA-C239 – Ontario, British Columbia (New Brunswick under consideration)

ANNEX E: ELECTRIC WATER HEATERS AND WASHING PRODUCTS

This Annex covers "Wet" products which are regulated for efficiency in APEC economies. Although these products are only regulated in a limited number of economies, the increasing interest in these products means that there is likely to be an increase in energy related regulation. For this report, products are grouped into the following categories:

- Electric water heaters: includes storage and non storage systems. Generally covers those for household use, but some economies regulated commercial systems as well. Note that water heaters heated with fuels other than electricity have not been included, even though these are very common.
- Clothes washers: generally for household use. Drum and non-drum technologies are covered.
- Dishwashers: only for household use.
- Clothes dryers: only for household use.

E:1 Electric Water Heaters

E:1.1 Australia

Program: mandatory MEPS for electric storage water heaters

Summary of test procedure

AS1056.1-1991 is a standard which covers the design, construction and energy efficiency of electric storage water heaters. Under AS 1056.1-1991, the hot water delivery capacity (for a 12^{o}C temperature drop) is determined. Pre-defined delivery capacities are specified in the standard. The standing heat loss is determined under static conditions for an air-hot water temperature differential of 55^{o}C. Maximum allowable heat loss levels are specified in the standard for the standardised hot water delivery capacities. Mandatory requirements that came into force on 1 October 1999 are included in Amendment 3 to the standard issued in 1996. Static storage capacity is not determined.

Details

Hot water delivery capacity is the only capacity defined under AS1056.1 (static storage volume is not measured). Hot water is discharged at a pre-defined rate until a temperature drop of 12^{o}C is measured at the water heater outlet. Pre-determined values for rated hot water delivery capacity are specified in the standard. The measure hot water delivery capacity shall not be less than the rated hot water delivery capacity.

The static heat loss over a 24 hour period is also measured for a temperature rise of 55°C. Power is supplied to the heater and energy over a whole number of thermostat cycles is determined. In cases where the manufacturer's maximum rated temperature exceeds 75°C, the heat loss is determined at a temperature of the maximum thermostat setting less 20°C. Maximum allowable heat loss levels are specified in the standard. New levels for unvented displacement water heaters (mains pressure) which are mandatory in legislation from October 1999 are specified in Amendment 3 dated 5 August 1999.

Variables required to be measured, determined or declared for regulatory purposes:

- Rated hot water delivery capacity (declared by manufacturer)
- Standing heat loss kWh/24 hours

E:1.2 Canada

Program: mandatory MEPS for electric storage water heaters

Summary of test procedure

The current test procedure is CAN/CSA-C191-M90 and covers the design, construction and energy efficiency of electric storage water heaters. Under CAN/CSA-C191-M90, the static volume of the tank is determined. Hot water delivery capacity is determined under the "diffusion test" for a temperature drop of 17°C. The standing heat loss is determined under static conditions for an air-hot water temperature differential of 44°C. Maximum allowable heat loss levels are specified in the standard as a function of static capacity.

Canada is currently considering the adoption of CAN/CSA-C745-95 in the near future. Although a hot water delivery capacity test is specified (called first hour rating test), this is not essential except for heat pump systems, where the recovery efficiency has to be determined from this test. A energy delivery test is conducted consisting of 6 drawoffs totalling 243.4 litres at 1 hour intervals. Standing heat losses are then determined over the remained of the 24 hour test period. For this test the air-hot water temperature differential is 37.5°C while the hot-cold water temperature differential is 42.8°C. The energy factor is determined from the energy delivery test energy consumption.

Details

The scope of CAN/CSA-C390.0-M90 is electric storage water heaters (resistive element type) of 175L and 270L. CAN/CSA-C390.1-M90, which is cited in regulations, includes tanks from 50L to 450L. Static capacity of the water heater under CAN/CSA-C191-M90 is measured from the mass a water in the tank. A hot water delivery test (called the diffusion test) is conducted with an initial temperature of 56°C - water is discharged at 18L/min until a temperature drop of 17°C occurs. Static heat loss test is determined for an air-hot water temperature differential of 44°C. Maximum allowable heat loss levels are defined in CAN/CSA-C390.1-M90. A delivery test to check the delivery temperature for a range of drawoff profiles is also specified for 175L and 270L tanks, but this appears not to be mandatory. Energy is not measured for this test.

Table 91: Summary of Water Heater Test Procedures

Water Heaters	Australia	Canada (1)	Canada (2)	Korea	Malaysia	New Zealand	Chinese Taipei	USA (1)	USA (2)	International
Labels				U	U	V	U	M		
MEPS	M	M	M	U		U	M	M	M	
Test Procedure	AS1056.1	CAN/CSA-C191.0-M90, CAN/CSA-C191.1-M90	CAN/CSA-C745-95	not determined	not determined	NZS4606.1	CNS11010, CNS3263	10CRF430.27 App E (Res)	ASHRAE 90.1 (Comm)	IEC60379
Related Procedure	IEC60379		10CRF430.27 App E (Res)			IEC60379		CAN/CSA-C745-95	ANSI Z21.10.3-93	IEC60379
Relation	NEQ		IDT			NEQ		IDT		IDT
Ambient air temp C	20	24	19.7				25	19.7		20
Cold water C		10	14.4				20	14.4		15
Hot water C	75	68	57.2				max rated	57.2		65
Hot-cold difference C		58	42.8					42.8		50
Hot-air difference C	55	44	37.5			55.6		37.5		45
Static capacity		yes	yes			yes	yes	yes		Yes
Hot water capacity	yes	yes *	yes **					yes **		Yes
Flow rate L/min	12 *	18	11.4				15 *	11.4		10 *
Pressure	280 kPa		>275 kPa *				<100 kPa **	>275 kPa *		
Temperature drop C	12	17	13.9					13.9		measured **
Static heat loss	max levels **	max levels	***			max levels *	modified ***	***		Yes
Energy delivery test		yes **	yes ***				yes *	yes		
24 hour delivery Litres			243.4				****	243.4		
Number of drawoffs			6				13 ****	6		
Interval			1 hour				1 hour	1 hour		
Other			Recovery efficiency ****				Efficiency test	Recovery efficiency ****		Reheating time, Mixing factor

Local voltage and frequency, Empty cell means not specified or not relevant, M = mandatory, V = voluntary, U = under consideration
Technical information regarding the test procedures as contained in this table is not necessarily reproduced in the section on each economy

Interpretation Notes for Table 91: Summary of Water Heater Test Procedures

Australia:
* for >160L, 9 L/min for < 160L ** based on hot water deliver, not capacity

Canada (1):
- called a Diffusion test
- ** energy not measured - delivery test used to confirm that water heater can deliver (within 12C drop) and recover when subject to specified drawoff schedules

Canada (2):
This standard (CAN/CSA-C745) due to come into force in the near future
* minimum pressure, max is manufacturer rated ** First hour rating test, only really required for heat pump type
*** Static heat loss test under CAN/CSA-C191-M90 allowed as an alternative *** Static heat loss also determined during period of no drawoff under energy delivery test
**** Determined from First hour rating test for heat pump units, assumed to be 98% for electric resistive

New Zealand:
Only hot water - air temperature difference is specified * heat loss limits are not yet mandatory

Chinese Taipei:
* for >100 litres, 5 L/min for tanks < 100 litres ** tank pressure to be less than 300 kPa
*** modified test measures temperature drop over 16 hours with no power, called Heat preservation test *** Limits are set in CNS11010
**** Test of use performance test, 11 drawoffs at 1/13th capacity, then 50% drawoff
**** energy not measured, max allowable temperature drop on final discharge is set in CNS11010
Efficiency test is 67% discharge and recovery, limits are set in CNS11010

USA (1):
US procedure includes instantaneous electric, gas and oil * minimum pressure, max is manufacturer rated
** First hour rating test, only really required for heat pump type *** Static heat loss also determined during period of no drawoff under energy delivery test
**** determined from First hour rating test for heat pump units, assumed to be 98% for electric resistive

IEC:
Humidity < 85% * for 50-200L units, 2 L/min < 10L, 5 L/min 10-50L, 5% capacity/min >200L
** Hot water output test measures average temperature of water at a discharge of rated capacity

Canada are considering the introduction of CAN/CSA-C745-95 in the near future. This standard is equivalent to the current USA test procedure in CFR430 and also includes heat pump systems. The key elements to this test procedure are:

- Static capacity determination is equivalent to CAN/CSA-C390-M91
- Air temperature corrected to 19.7°C
- Hot water temperature corrected to 57.2°C (temperature difference of 37.5°C)
- Cold water temperature corrected to 14.4°C (energy base)
- Drawoff test consisting of 6×40.6 litre drawoffs at 1 hour intervals (total 243.4 litres) (24 hour simulated use test)
- Determination of static heat loss during remainder of 24 hour test period when there is no drawoff. (standby losses)

Actual temperature variations in air and water temperatures are corrected to nominal values in the determination of the Modified Daily Energy Consumption (Q_{dm}). The test procedure also has a method to determine the recovery efficiency of heat pump water heaters through an actual drawoff test (water is drawn until the thermostat activates - first hour rating test).

The annual energy consumption of a water heater is given as $365 \times Q_{dm}$. The energy factor (EF) is the ratio of the energy in the hot water delivered to Q_{dm}. (ie an overall efficiency for the delivery of the specified hot water profile over 24 hours). Heat pumps may have an EF which is greater than 1.0, while resistive units must have an EF of less than 1.0.

As an alternative, CAN/CSA-C745-95 provides a static heat loss value to CAN/CSA-C390-M90 which is equivalent to the Energy Factor requirements set out in the standard.

Variables required to be measured, determined or declared for regulatory purposes under CAN/CSA-C390-M90:

- Static capacity
- Standing heat loss kWh/24 hours (standby loss)

Variables required to be measured, determined or declared for regulatory purposes under CAN/CSA-C745-95:

- Static capacity
- Standing heat loss kWh/24 hours (standby loss)
- Modified Daily Energy Consumption
- Energy Factor
- Annual energy consumption

E:1.3 Korea

Program: mandatory MEPS and labelling for electric storage water heaters under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

E:1.4 Malaysia

Program: voluntary energy labelling for electric water heaters – under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

E:1.5 Mexico

Program: MEPS for storage water heaters

Summary of test procedure

Water heater MEPS in Mexico are defined in NOM-003. However, it is understood that efficiency requirements for electric water heaters are not included in the scope of this standard (it covers other fuel types) and it is understood that electric water heaters are extremely unusual in Mexico.

E:1.6 New Zealand

Program: mandatory MEPS for electric storage water heaters under consideration

Summary of test procedure

NZS 4606.1-89 is a standard which covers the design, construction and energy efficiency of electric storage water heaters. Under NZS 4606.1-89 the standing heat loss is determined under static conditions for an air-hot water temperature differential of 55.6^{o}C. The tank is kept at the required temperature by adjusting to the input power to the heater element (ie normal thermostat is bypassed). Maximum allowable heat loss levels are specified in the standard for a range of tank capacities. Mandatory requirements are under consideration.

E:1.7 Chinese Taipei

Program: mandatory MEPS for electric storage water heaters (energy labelling is under consideration)

Summary of test procedure

CNS3263 is a standard which covers the design, construction, safety and energy consumption of electric storage water heaters. It is not related to any other water heater test procedure. The tank capacity is determined for the volume of water held. Three main energy related tests are conducted under CNS3263. First is Test of

Heating Performance - the overall efficiency of recovery from a 75% discharge is determined. The second is the Test of Heat Preservation where the power is disconnected and the temperature fall over 16 hours is determined. The final test is the Test of Use Performance where the tank delivers a specified hot water profile and the temperature at the end of the last discharge is determined. Performance requirements for these three test, including those for energy efficiency, are specified in CNS11010.

Details

Under CNS3263 the thermostat is set at the highest nominal temperature for all of the following tests and two thermostat cycles are allowed to occur before testing is commenced.

For the heating performance test, hot water equal to two thirds of the tank capacity is discharged and the unit is allowed to recover. The overall efficiency is determined from the ratio of the energy contained in the water to the total energy used by the water heater. [test period is unclear from the English text, but is assumed to terminate at the completion of the first cut out of the thermostat after drawoff is completed.]

Test of heat preservation performance disconnects the power and the hot water temperature is determined after a 16 hour period.

Test of use performance appears to only apply to low pressure units (non-pressure resistant type). Twelve discharges of one thirteenth (7.7%) of the tank capacity are conducted at 1 hourly intervals. The following hour 50% of the tank's volume is discharged and the temperature of the hot water is measured.

Performance requirements are specified in CNS11010 for all three tests.

Variables required to be measured, determined or declared for regulatory purposes:

- Static tank capacity
- Heating performance efficiency (%)
- Heat preservation performance (^oC)
- Use performance (^oC)

E:1.8 USA

Program: mandatory MEPS and labelling for electric storage water heaters

Summary of test procedure

The test procedure is set out in CFR430 Subpart B Appendix E for consumer products (mainly residential sector) and ASHRAE 90.1 for non-residential products (commercial and industrial).

The requirements in CFR430 Appendix E are the same as those set out in CAN/CSA-C745-95, other than US CFR430 also covers instantaneous electric water heaters as well as gas and oil systems. Although a hot water delivery capacity test is specified (called first hour rating test), this is not essential except for heat pump systems, where the recovery efficiency has to be determined from this test. A energy delivery test is conducted consisting of 6 drawoffs totalling 243.4 litres at 1 hour intervals. Standing heat losses are then determined over the remained of the 24 hour test period. For this test the air-hot water temperature differential is 37.5°C while the hot-cold water temperature differential is 42.8°C. The energy factor (used to define the MEPS level) is determined from the energy delivery test energy consumption.

For non-residential products covered under the Energy Policy Act 1992, the test procedures are specified in ASHRAE 90.1. This cites ANSI Z21.10.3 for gas water heaters for the determination of standby loss. Details on the requirements of this standard are yet to be determined.

Details

CFR430 Appendix E is equivalent to CAN/CSA-C745-95 except the scope of CFR430 also includes instantaneous electric water heaters and gas and oil systems. Heat pump systems are also included. The key elements to this test procedure are:

- Static tank capacity is determined by water volume
- Air temperature corrected to 19.7°C
- Hot water temperature corrected to 57.2°C (temperature difference of 37.5°C)
- Cold water temperature corrected to 14.4°C (energy base)
- Drawoff test consisting of 6×40.6 litre drawoffs at 1 hour intervals (total 243.4 litres) (24 hour simulated use test)
- Determination of static heat loss during remainder of 24 hour test period when there is no drawoff. (standby losses)

Actual temperature variations in air and water temperatures are corrected to nominal values in the determination of the Modified Daily Energy Consumption (Q_{dm}). The test procedure also has a method to determine the recovery efficiency of heat pump water heaters through an actual drawoff test (water is drawn until the thermostat activates - first hour rating test).

The annual energy consumption of a water heater is given as $365 \times Q_{dm}$. The energy factor (EF) is the ratio of the energy in the hot water delivered to Q_{dm}. (ie an overall efficiency for the delivery of the specified hot water profile over 24 hours). Heat pumps may have an EF which is greater than 1.0, while resistive units must have an EF of less than 1.0.

The Energy Policy Act specifies static heat loss limits for commercial water heaters. The test conditions are set out in ASHRAE 90.1 which in references ANSI Z21.10.3 for gas water heaters. The requirements of this ANSI standard (ambient conditions, ΔT etc.) are yet to be determined.

Variables required to be measured, determined or declared for regulatory purposes:

- Static capacity
- Standing heat loss kWh/24 hours (standby loss) (two different methods)
- Modified Daily Energy Consumption
- Energy Factor
- Annual energy consumption

E:1.9 IEC 60379 – Electric storage water heaters

Summary of test procedure

IEC 60379-87 is essentially a method for measuring the performance of electric storage water heaters. It is not applicable to heat pump or solar units or those with more than one heated volume. The main performance measures determined under the test procedure are:

- Static capacity based on volume of water;
- Standing heat loss per 24 hours (no drawoff) at an air hot water temperature differential of 45°C (ambient air of 20°C and hot water at 65°C);
- Hot water output, defined as a capacity of X litres at Y °C, is determined from a measurement of water temperatures for a drawoff equal to the rated capacity;
- Reheating time is determined from cold to first thermostat cutout and corrected back to a temperature rise of 50°C (cold water at 15°C and hot water at 65°C);
- Mixing factor is determined by comparing the hot water temperature without cold replenishment to the hot water temperature with cold replenishment.

Details

The main variables determined in this test procedure are standard heat loss test and the hot water output. Heat loss is determined at the tank thermostat temperature for a whole number of thermostat cycles over a period of not less than 48 hours. The heat loss value is then corrected back to a temperature rise above ambient of 45°C (ambient air of 20°C and hot water at 65°C).

Hot water output test: the flow rate is determined from the tank size as follows:

- 2 L/min for tanks less than 10 L
- 5 L/min for tanks from 10 L to 50 L
- 10 L/min for tanks from 50 L to 200 L
- 5% of the rated capacity per minute for tanks > 200 L

The thermostat temperature is selected and the tank allowed to heat up to temperature. Once the thermostat has cut out, the power is disconnected and a hot water volume equal to the rated capacity of the tank is drawn off. The temperature is measured continuously during the drawoff and the average temperature is determined.

E:1.10 Technical issues associated with the use of IEC60379

IEC60379-87 is really only suitable for use in determining the characteristics of electric storage water heaters. It cannot be used for other types of electric water heaters (eg instantaneous electric, heat pump, solar) nor is it suitable for use with other fuel types. The standard also has limitations in that it is unable to directly determine the energy consumption of a water for a specified hot water delivery profile (task efficiency), which is required for some economies (eg USA). Task efficiency is particularly important for non-electric water heater types and solar and heat pump water heaters.

To the extent that energy efficiency is specified as a function of the standing heat loss for electric storage water heaters (eg current or proposed requirements for Australia, Canada, New Zealand), IEC60379 provides a suitable basis as an APEC regional test procedure. However, to accommodate the requirements of other economies, a more sophisticated approach is required.

E:1.11 AS 4234 – Water heater computer model

Summary of Test Procedure

AS4234-94 provides outlines a method of estimating the task efficiency of solar water heaters. Firstly, the solar water heater performance characteristics are determined for an outdoor test running over a period of approximately 6 weeks. During this period the water heater is subject to actual hot water drawoff profiles and the behaviour of the water heater together with the ambient conditioners are accurately monitored. Once the key parameters are accurately determined, the simulation model can be used to accurately estimate the task total energy consumption for any climate and any drawoff pattern. The scope of the standard includes the following system types:

- single tank solar water heaters with electric or gas in-tank boosting
- solar pre-heaters in series with an instantaneous gas or electric booster
- solar pre-heaters in series with a conventional storage water heater
- heat pump water heaters with a flat plate evaporator exposed to ambient air, solar radiation or both

The following types of solar collectors are included:

- solar water heaters with flat plate, concentrating or evacuated tube solar collectors
- thermosiphon or pumped fluid circulation through the solar collectors
- annular tank in heat exchanger in a thermosiphon loop
- horizontal or vertical water storage tanks
- storage tanks with dual electric elements
- solar collectors acting as the evaporator in a heat pump circuit
- heat exchangers acting as the condenser in a heat pump circuit

A computer model called "Rating" is supplied with the standard and can be used to model the above systems as well as the performance of conventional systems such as electric storage systems (single or dual element, continuous or load controlled energisation profiles), gas storage or gas instantaneous systems. The model is based on the TRNSYS model with a user friendly interface to deal with water heaters.

As data input, the model requires specified water heater characteristics, climate data for the place where the simulation is required (hourly data for a minimum of 1 year - see below) and the drawoff profile (either daily, seasonal on unique profile for a year). Weather data requirements are:

- Latitude and Longitude
- Month
- Day
- Hour
- Horizontal global irradiation, MJ*100/HOUR
- Sun Tracking Beam Irradiation, MJ*100/HOUR
- Ambient Temperature, DEG.C*10
- Wind Speed, M/S*10
- Wet Bulb Temperature, DEG.C*10
- Wind Direction, Compass Points
- Cloud Cover, Octas

E:1.12 Technical Issues Associated with the use of AS4234

Actual tests on solar and conventional systems has shown that the model provides a very accurate estimate of the task energy consumption (for any weather or climate pattern, any drawoff pattern and any energisation profile). This model could be used as a basis for APEC economies for the measurement of energy consumption and energy efficiency of water heaters. It is likely that test under IEC60379-87 could provide the necessary input data for electric storage water heater for such a model. The data requirements for conventional systems are minimum and can be determined for simple standard tests. Heat pump and solar systems require more effort to determine the required input variables.

Although this model could possibly form the basis for a suitable generic water heater test procedure, it is yet to be published as a formal Australian or international standard. The computer model currently is provided as a tool associated with AS4234. While some additional documentation and software development may be necessary before it is ready to be publish as a standard, the basic modelling engine appears to be sound and robust and suitable for widespread application. It is recommended that this model be investigated further.

E:2 Clothes Washers

E:2.1 Australia

Program: mandatory energy labelling for clothes washers

Summary of test procedure

Under AS/NZS2040.1-98, for regulatory purposes, a mixed cotton load of the claimed rated capacity is washed on the program recommended for a normally soiled cotton load with a warm wash and cold rinse. The energy, water, washing, spinning and severity of washing performance is measured during the test. The standard sets mandatory limits for these variables. The standard is partly derived from IEC 60456, but has significant technical deviations such as the inclusion of soft water, top loading detergent and different soil swatches.

Details

Energy consumption of clothes washers under AS/NZS 2040.2-98 is as follows:

CEC = $E_t \times 365$

Where:

- 365 is uses per year
- Et is tested energy consumption at rated capacity, normal program, warm wash (minimum 35^{o}C) to AS/NZS 2040.1

The Australian standard is derived from IEC 60456 but has been modified to include a detergent and a method for non-drum type machines and a more typical load (NEQ). The standard mandates minimum performance levels to be attained for soil removal, spin performance and severity of washing. Only a single test on a machine is required under the standard (all required variables are measured during the test), but three separate units are required to be tested for energy labelling registration purposes.

Hot water energy (nominally at 60^{o}C) is determined from a base temperature of 20^{o}C (equal to cold water supply temperature). Cold water energy adjustment (where cold water deviates from 20^{o}C) is applicable to operations that use hot water or where water is heated internally.

The washer component of combination washer-dryers are tested under this procedure.

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption
- Electrical energy consumption
- External hot water energy
- Program time
- Cold water energy correction

- Rated capacity (declared by manufacturer)
- Wash performance (limits are set)
- Spin performance (limits are set)
- Severity of washing performance (limits are set)
- Vibration test (limits are set)

Notes:

1. All masses in the standard are based on bone dry mass, except rated capacity which has a nominal moisture content of 108% of bone dry.
2. Detergent for drum type machines is specified as IEC type B with 5% perborate.
3. Detergent for non drum machines is defined in Table A1 of AS/NZS 2040.
4. Soil swatches are type AS9 from the Centre for Testmaterials, Netherlands.
5. Soil removal determined using Kubelka-Munk equations.
6. Reflectometer measurements Y tristimulus, Illuminant D65.
7. Severity of washing swatches are Cosmo embroidery fabric article No. 1100-33, Japan.
8. Although a reference machine is required, a brand and model is not specified, only performance specifications are provided.
9. Mixed cotton load - sheets, pillow cases, tablecloths, shorts, T shirts, pillow cases, under shorts, wash cloths, handkerchiefs.
10. Vibration test is with unbalanced load.

E:2.2 Canada

Program: mandatory energy labelling and MEPS for clothes washers

Summary of test procedure

CAN/CSA-C360-98 is mainly concerned with the determination of energy and water consumption for a wide range of temperature selection options on the normal program. Vertical axis machines without adaptive fill control do not need a load for testing, but all other types use either a 3.18 or 1.36 kg load of energy clothes and stuffer cloths, depending on the size (standard or compact) and the fill level being tested. Performance of the clothes washer is not measured in the test. A method for the measurement of water removal (spin performance) is specified, but this is not currently required.

Details

Energy consumption of clothes washers under CAN/CSA-C360-98 is as follows:

$E = E_{TE} \times 392$

Where:

- 392 is uses per year (Canada used 416 cycles per year for clothes washers but this has recently been amended)
- E_{TE} is the total per cycle energy consumption for a normal cycle, made up of hot water energy and mechanical energy, weighted for the various program and temperature options.

For MEPS, the Energy Factor (EF) is defined as:

$EF = V_c / E_{TE}$

Where V_c is the volume of the clothes washer.

It is also a requirement that the normal program shall include an unheated rinse option. It is anticipated that a new MEPS level based on the Modified Energy Factor (MEF) will come into force in the future. This will require the measurement of remaining moisture content (spin performance).

A large number of temperature options need to be tested for the normal program under CAN/CSA-C360-98 to determine E_{TE}. The temperature combinations for wash/rinse options are set out in detail in Table 2 in the standard. The standard also deals with options for auto fill, adaptive controls and variable temperature adjustment facilities. The description below is intended to provide a qualitative overview of the general test requirements:

1. Test all Normal wash/rinse temperature combinations on full load/water level (suds saver on if available).
2. Test all Normal wash/rinse temperature combinations on minimum load/water level (suds saver on if available).
3. Test 1. And 2. above with suds return option on for warm/cold option (if suds saver available).
4. Test non-normal programs for any temperature options which are locked out of use for the Normal program (only where applicable).

The wash rinse combinations are weighted depending on the combinations available; an example for 5 temperature combinations is shown in Table 93.

Table 92: Summary of Clothes Washer Test Procedures

Clothes Washers	Australia	Canada	China	Hong Kong,China 1	Hong Kong,China 2	Mexico	New Zealand	Singapore	USA	International
Labels	M	M		V	V	M	V	V	M+V	
MEPS		M	M			M			M	
Other								Accel Dep.		
Test Procedure	AS/NZS 2040-98	CAN/CSA-C360-98	GB12021.4-89, GB4288, GB2829	IEC60456-94	JIS C9606-87	NOM-005	AS/NZS 2040-98	IEC60456	10CRF430.27 App J & J1	IEC60456-98
Related Procedure	IEC60456	USA	None	IEC60456-98	JIS C9606-93		IEC60456	IEC60456	CSA-C360	IEC60456-98
Relation	NEQ	EQV		EQV	IDT	none	NEQ	IDT	EQV	IDT
Ambient temp	20C		20C	20C	20C ***	20C	20C			20C
Humidity			60%-70%		65% ***					
Cold water	20C	15C		15C		20C	20C		15.6C	15C
Hot water	60C	60C		60C			60C		60C	60C
Hardness	45 ppm			250 ppm	< 80 ppm		45 ppm			250 ppm *
Pressure	320 kPa	240 kPa	100 kPa?			249 kPa	320 kPa		240 kPa	240 kPa
Reference machine	N/S			Wascator	N/S		N/S			Wascator
Program	Normal	Normal		various		prescribed	Normal		Normal	various
Wash temperature	> 35C	all possible **		various	> 30C		> 35C		all possible **	
Detergent	IEC C / IEC B			IEC A/IEC B **	JIS		IEC C / IEC B			IEC A/IEC C **
Load type	mixed	none		IEC cotton or easy care	mixed **	square cloths	mixed		none	mixed ****
Material	cotton	none		cotton or poly/cotton	Cotton	cotton	cotton		none	cotton ****
Capacity	rated	3.18 kg *	5 kg?	rated	Rated	75% rated	rated		3.18 kg *	Rated
Load measurements	bone dry	bone dry		normalised	Normalised		bone dry		bone dry	Normalised + bone dry
Volume drum/bowl		measured							measured	measured
Soil swatch	CFT AS9			IEC x 4 ***	JIS oil/carbon		CFT AS9			IEC x 4 ***
Wash performance	SR > 80%			measured	Measured		SR > 80%			measured
Rinse performance				measured	> 1.0 ****					measured
Spin performance	WEI < 1.1	measured ***		measured	> 45% *		WEI < 1.1		measured ***	measured
Severity of washing	Z < 0.3						Z < 0.3			
Other	vibration						vibration			

Local voltage and frequency, Empty cell means not specified or not relevant, M = mandatory, V = voluntary, U = under consideration
Technical information regarding the test procedures as contained in this table is not necessarily reproduced in the section on each economy

Interpretation Notes for Table 92: Summary of Clothes Washer Test Procedures

Australia:
IEC type C detergent non drum IEC type B detergent drum NS = Brand not specified, performance specification provided
Mixed load - sheets, pillow cases, tablecloths, shorts, T shirts, pillow cases, under shorts, wash cloths, handkerchiefs

Canada:
Compact < 45L Non thermostat control 38C H&C * 1.36 kg compact * 1.36 kg minimum fill
* Energy determined with no load for most * load used for adaptive systems - poly/cotton energy & stuffer cloths
** Various temperature combinations specified for energy *** not currently required but anticipated for MEF in future MEPS

Hong Kong, China (1): Performance not measured, only energy and water consumption for a range of programs ** Either detergent may be used

Hong Kong, China (2): NS = Brand not specified, performance specification provided * limits for vertical type, horizontal and other >40%
** mixed load includes sheets, shirts, towels and handkerchiefs *** ambient conditions are specified for normalising clothes load, not for testing
**** Rinse performance conduction in NaCl solution

Korea: Labelling and MEPS under consideration, test procedure not determined (EQV JIS C9606?)
Malaysia: Voluntary labelling under consideration, test procedure not determined.
Mexico: Programs defined for semi-automatic and manual washers

New Zealand:
IEC type C detergent non drum IEC type B detergent drum NS = Brand not specified, performance specification provided
Mixed load - sheets, pillow cases, tablecloths, shorts, T shirts, pillow cases, under shorts, wash cloths, handkerchiefs

Philippines & Chinese Taipei: Labelling under consideration, test procedure not determined.

USA:
Compact < 45L Non thermostat control 38C H&C * 1.36 kg compact * 1.36 kg minimum fill * Energy determined with no load for most
* load used for adaptive systems - poly/cotton energy & stuffer cloths ** Various temperature combinations specified for energy
*** not currently required but anticipated for MEF in future MEPS

IEC:
* 50 ppm an alternative for soft water ** Type C is for drum, Type C is for non-drum
*** 4 soils are carbon black, blood, chocolate/milk, red wine **** this is mixed cotton load of sheets, pillowcases, handtowels – other loads for easy care and wool

Table 93: Sample Temperature Use Factors - Canada

Wash/rinse	TUF
Hot/warm	0.18
Hot/cold	0.12
Warm/warm	0.30
Warm/cold	0.25
Cold/cold	0.15

Source: CAN/CSA-C360-98, Table 2

Where a suds saver option is available, it is assumed that the use of this is 0.14 with the suds-saver switch set to suds return (on the Warm/cold temperature option) and use without suds save is 0.86 (this is applied to the TUF factors in Table 93) (otherwise non suds save is 1.0). The energy consumption at maximum and minimum water levels is determined for the weighted temperature setting options for a water temperature rise of 50^{o}C. The total energy consumption E_{TE} is calculated as a weighted average of 0.72 for maximum load and 0.28 for minimum load for hot water and electrical energy. Typically around 20 to 30 tests would be required to satisfy the various temperature combination requirements (noting that many machines will not require a test load).

The washer component of combination washer-dryers are tested under this procedure.

Appendix J1, which will come into force in parallel with the USA sometime in the next few years, will include a requirement for Energy Factor and Modified Energy Factor, in which case a test load will be required in all cases. The load will also vary with the size of the machine. At the moment the CSA standard is not very clear on how to test a horizontal axis machine with adaptive fill control.

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption (hot and cold separately)
- Electrical energy consumption
- External hot water energy
- Volume of clothes container
- Temperature selections available
- Type and nature of adaptive controls
- Suds saver controls
- Spin performance (for MEF and MELF in future)

Notes:

1. Load sizes are defined in terms of bone dry mass.
2. Compact machines are defined as those with a volume of less than 45 litres.
3. Vertical axis machines without adaptive fill control do not need a load for testing - in these cases hot water consumption is adjusted by 0.94.
4. Compact machines are tested with a load of 1.36 kg for all cases.

5. Standard sized machines (drum or with adaptive fill control) have a load of 3.18 kg for maximum and 1.36 kg for minimum water levels.
6. Energy test cloths are poly cotton nominally 0.6m × 0.9m, while stuffer clothes are 0.25m × 0.25m, both hemmed.
7. Machines without a thermostatic inlet control and without an internal heater have a hot and cold water supply at $38^oC \pm 5.5^oC$.
8. Cold water supply temperature is specified as $15^oC \pm 3^oC$ but no energy adjustment is required for temperature deviations.

E:2.3 China

Program: MEPS for clothes washers

Energy consumption of clothes washers is specified in GB12021.4-89, GB2829 and GB4288. Unfortunately an English version of these test procedures is not available for analysis. It is unclear how the energy consumption is determined under this test procedure.

E:2.4 Hong Kong, China

Program: voluntary energy labelling for clothes washers

Summary of test procedure

Hong Kong, China references IEC 60456-94 for drum machines and specifies two standard load types (cotton and easy care) at the claimed rated capacity. A range of available programs are to be tested. The wash/rinse temperature is not specified. Energy, water consumption, washing, spinning and rinse performance are measured during the test. Other details are as per IEC 60456.

For top loading machines JIS C9606-1987 is referenced.

Details

Energy consumption of clothes washers for the voluntary clothes washer label is as follows:

$$E = E_t \times 260$$

Where:

- 260 is uses per year
- E_t is the total per cycle energy consumption as determined in IEC60456-94 or JIS C9606-97 as applicable to drum and non-drum machines respectively.

Rated capacity of the machine is as declared by the manufacturer. If rated capacity is not declared, it is determined from the drum/bowl volume.

For drum machines, the requirements are as per IEC 60456-94. For other machines (non-drum = agitator and impeller) the requirements are as per JIS C9606-87.

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption

- Energy consumption
- Rated capacity (declared by manufacturer)
- Wash performance
- Spin performance (limits are set for non-drum in JIS)
- Rinsing performance (limits are set for non-drum in JIS)

E:2.5 Korea

Program: energy labelling and MEPS for clothes washers – under consideration

Summary of test procedure

This program is under consideration, but the test procedure is set out in MOCIE Rule 24 of 1999 (this is EQV to JIS C9606).

E:2.6 Malaysia

Program: voluntary energy labelling for clothes washers – under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

E:2.7 Mexico

Program: mandatory energy labelling and MEPS for clothes washers

Summary of test procedure

NOM-005 is mainly concerned with the determination of energy consumption for a cold wash cycle. Performance of the clothes washer is not measured in the test.

Details

Energy consumption of clothes washers under NOM-005 is as follows:

$$E = E_t \times 416$$

Where:

- 416 is uses per year
- E_t is the total per cycle energy consumption for the specified program on a cold wash.

For MEPS, a maximum allowable energy consumption per year is defined for a range of washer types and sizes.

The program to be used for energy labelling and MEPS is the most unfavourable in terms of energy consumption. The water level is at the maximum level specified by the manufacturer. Programs for semi-automatic and manual washers are defined in NOM-005. The load is at 75% of the manufacturer's stated rated capacity. The load consists of a hemmed cotton sheets 0.45m × 0.45m, with make up weights of 0.1m × 0.1m. Cloths are conditioned over various cycles until their weight variation between dry cycles is less than 1%. Water level must be at the maximum level possible. Specific wash cycles and times are given for the test. No detergent is used and wash performance is not assessed.

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption (cold)
- Electrical energy consumption (mechanical only)

E:2.8 New Zealand

Program: voluntary energy labelling for clothes washers

Summary of test procedure

The New Zealand voluntary energy labelling program uses AS/NZS 2040 and is identical to the Australian program, other than it is voluntary in nature.

E:2.9 Philippines

Program: mandatory energy labelling for clothes washers (under consideration)

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

E:2.10 Singapore

Program: Singapore Green Labelling Scheme (endorsement) and Scheme for 1 year Accelerated Depreciation Tax Incentive (businesses only)

Summary of test procedure

Singapore requires products to be tested to IEC 60456 to verify the required limits of energy consumption and water efficiency to be eligible for the scheme. No deviations from the standard are specified other than the test is for a Normal program on a cold wash. For the 1 year accelerated depreciation program, no testing is required (replacement system is the be analysed by a certified engineer).

E:2.11 Chinese Taipei

Program: energy labelling for clothes washers (under consideration)

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

E:2.12 USA

Program: mandatory energy labelling and MEPS, Energy Star (voluntary) for clothes washers

Summary of test procedure

The test procedure for clothes washers in the USA is set out in the US Code of Federal Regulations CFR430 Appendix J. As for Canada (USA and Canada have largely equivalent requirements for most washer types), CFR430 is mainly concerned with the determination of energy and water consumption for a wide range of temperature selection options on the normal program. Vertical axis machines without adaptive fill control do not need a load for testing, but all other types use either a 3.18 or 1.36 kg load of stuffer cloths for determining energy and water consumption, depending on the size (standard or compact) and fill level being tested. Performance of the clothes washer is not measured in the test.

Details

The energy label is based on 392 uses per year of the weighted average clothes washer energy (E_W below) (this is defined in a separate regulation for energy labelling - CFR305) (uses per year until recently were 416).

For MEPS, the Energy Factor (EF) is defined as:

$$EF = C / E_W$$

Where

- C is the volume of the clothes washer.
- E_W is the total per cycle energy consumption for a normal cycle, made up of hot water energy and mechanical energy, weighted for the various program and temperature options.

It is anticipated that a new MEPS level based on the Modified Energy Factor (MEF) will come into force in the future (final rule anticipated in 2000 – new procedure is shown in current CFR430 as Appendix J1). This will require the measurement of remaining moisture content (spin performance).

USA test procedure is largely the same as that for Canada, so the details will not be repeated. However, some differences include:

- The USA now (as of February 1998) has a variable sized load for the determination of remaining moisture content (spin performance). The load size is determined from the drum/bowl volume. This variable is not currently required for MEPS or labelling but will be used in the Modified Energy Factor which is likely to form the basis of the new MEPS levels to come into force in the future.

- The CFR430 and CFR305 also require energy costs to be calculated and shown on the label (for electric energy consumed by the clothes washer plus external electric and gas hot water systems).
- There are some differences in the waivers available for non-conventional clothes washers.
- The USA is developing more elaborate ways of dealing with machines that have adaptive water fill control systems.
- The USA are proposing to use variable test loads (minimum, average and maximum loads based on drum/bowl volume) for all machine types in the future in the determination of energy and water consumption - this will come into effect when the new MEPS levels are announced.
- Both Canada and the USA have recently moved to 396 cycles per year.

Energy Star requirements for clothes washers are specified in terms of total water use per cycle and/or the use of drum technology, so specific test methods are not required

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption (hot and cold separately)
- Electrical energy consumption
- External hot water energy
- Volume of clothes container
- Temperature selections available
- Type and nature of adaptive controls
- Suds saver controls

E:2.13 JIS C9606 – Clothes washers

Summary of test procedure

JIS C9606-93 specifies the performance, construction and safety requirements for clothes washers. The scope covers all clothes washers for domestic use with a capacity of less than 10kg, including impeller (jet or vortex), agitator and drum machines. A mixed cotton load is washed with soil swatches attached in order to determine wash performance. Spin performance and rinsing performance are also determined - mandatory minimum requirements are specified for these variables. All masses are determined under normalised conditions (20°C and 65% humidity), but conditions for the test are not specified. At least four tests on each machine are required.

Details

The washing performance of the clothes washer is determined using a carbon black/oil impregnated swatch cloth (initial reflectance ~40%). This cloth is available from the Laundry Research Association in Japan. The washing performance is calculated as follows:

$D = (R_w - R_i) / (R_0 - R_i)$

Where D is the washing performance and

R_w = reflectance of the soiled swatch after washing

R_i = reflectance of the soiled swatch before washing

R_0 = reflectance of the unsoiled swatch

The washing performance for the test machine is then normalised against the performance of the reference machine. There is no mandatory performance level for the test machine but the reference result must lie in the range 0.35 - 0.5. Detergent is a phosphate based detergent as specified as defined in Clause 8.14 (called JIS). The standard specifies the wash period for various machine types (including drum machines). A wash temperature of 30^oC is specified in the standard.

The rated capacity of the machine for each performance measure (washing, spinning and rinsing) must be declared by the manufacturer (each can be a different capacity). All clothes masses are determined are standardised conditions of 20^oC and 65% humidity as per IEC60456. The load consists of flat cotton hemmed sheets of various sizes to simulated sheets, towels and handkerchiefs. An artificial shirt is also included as a load item.

A minimum water extraction and rinse performance requirement is specified in the standard for various types of machines. The rinse performance test uses a solution of NaCl as the wash liquor and the conductivity is measured at the start and the end of the test to determine the rinse performance.

The following performance measures are required or determined during the test:

- Washing performance (soil removal - this does not have to be declared and no minimum value is set)
- Rinsing performance (using salt solution)
- Spin extraction (water removal)
- Rated capacity for washing, spinning and rinsing
- Water consumption and washing capacity for each water level

Note that energy is not specified although this could be measured during the wash performance test.

E:2.14 IEC 60456 – Clothes washers

Summary of test procedure

IEC 60456-98 specifies three standard load types (cotton, easy care and wool) of the claimed rated capacity. Neither the program to be used nor the wash/rinse temperature is specified. The energy, water, washing, spinning and rinse performance is measured during the test. The standard does not set any mandatory limits for these variables. At least five tests on each machine are required.

Details

Rated capacity of the machine is as declared by the manufacturer. If rated capacity is not declared, it is determined from the volume of volume of the washing drum/bowl. A front loading commercial reference machine (Wascator by Electrolux, Sweden) is run in parallel with all tests and used to normalise the results. Water hardness of 250 ppm or 50 ppm $CaCO_3$ equivalent can be selected, depending on the local requirements. Cotton, easy care (ply-cotton) and wool loads are specified from 2 to 10 kg. Different capacities are normal for cotton and easy care. All masses are determined as either normalised mass (equilibrium moisture content after 24 hours at ISO139 conditions: 20^oC and 65% humidity) or in terms of bone dry mass. A total of 4 soil swatches are specified as carbon black, blood, chocolate/milk, red wine (these are available as EMPA 101 to 104). IEC Type A detergent (phosphate free with enzymes) is specified for drum machines. IEC Type C detergent (phosphate without enzymes) is specified for non-drum machines. IEC Type B detergent (phosphate without enzymes) is listed but not specified for use in the standard.

The following performance measures are determined during the test:

- Washing performance (soil removal)
- Rinsing performance
- Spin extraction (water removal)
- Water and energy consumption
- Shrinkage during a wool wash test
- Program time

The third edition of IEC 60456 first appeared in February 1998 (English only) and in English and French in June 1998. The second edition was published in January 1994. The first edition was published in 1974 (with several amendments through 1970's and 1980's).

The main changes to IEC 60456-98 compared with IEC 60456-94 are as follows:

- Agitator and impeller machines are included for the first time (together with a specification for Detergent C), but some parts of the test procedure are still under consideration.
- Changes to instrumentation and reflectometer specifications.
- Test load was harmonised with clothes dryer test procedure IEC 61121.
- Specification to the reference machine were refined
- Default hot water temperature was raised from 55^oC to 60^oC.
- Energy consumption determination was refined (cold and hot water energy calculations).
- Soft water option was included (but some limits are still under consideration).

During 1999 the IEC sub-committee IEC SC59D set up a maintenance team to oversee the ongoing work required to keep the standard current.

E:2.15 Technical Issues Associated with the use of IEC60456

IEC 60456-98 has been under active development in recent years. The current edition, while a large improvement over the previous editions, still has some outstanding issues to be resolved before it could be recommended for use as an international standard for assessing clothes washer performance. These include:

- Detergent compositions are still being modified - non-drum non-phosphate detergent with enzymes has not been developed while phosphate based detergents with enzymes and oxygen bleaches are under development for both drum and non-drum machines.
- Detergent dosing issues for hard and soft water are still to be resolved.
- Severity of washing performance and creasing are still under consideration.
- There are some questions regarding the reproducibility of the rinse performance test.
- Local conditions and requirements of test will mean that the performance test will not be very portable with respect to different economies (eg water hardness, load type, wash temperatures). However, this would be a problem for any test procedure for clothes washers.

IEC 60456 could eventually provide a suitable international test procedure for clothes washers (once some of the above issues are resolved), but some retesting because of local requirements for water hardness and wash temperatures will be inevitable. IEC 60456 should only be used where a performance based test is required for clothes washers. It would not be suitable for North America, for example, where it is currently not necessary to determine wash performance or other performance variables, although the requirements there are becoming increasingly more elaborate and prescriptive to deal with adaptive controls of various types.

E:3 Dishwashers

E:3.1 Australia

Program: mandatory energy labelling for dishwashers

Summary of test procedure

Under AS/NZS2007-98, for regulatory purposes, a soiled load of the claimed rated capacity is washed on the program recommended by the manufacturer for energy labelling. The energy, water, washing and drying performance is measured during the test. The standard sets mandatory limits for washing and drying performance. The standard is closely related to IEC 60436, but has minor technical deviations such as local soiling ingredients. In the most recent edition, a Miele G590 reference machine is used to normalise the wash performance results and the scoring system has been modified to resemble EN50242. The scoring system is now the same as Europe (0-5).

Details

Energy consumption of dishwashers under AS/NZS 2007-98 is as follows:

$$CEC = E_t \times 365$$

Where:

- 365 is uses per year
- Et is tested energy consumption at rated capacity, soiled load

The Australian standard closely resembles IEC 60436-81 but recently it has been necessary to modify the standard to keep it relevant (prior to 1998 it was EQV, but now is NEQ). The latest edition of AS/NZS 2007 has been modified to include a reference machine (Miele G590 reference) to normalise wash performance results and the scoring system has been modified to be similar to that in the European standard used for energy labelling EN50242 (from 0 = dirty to 5 = clean), whereas previously the scoring system was as per IEC (0-2). The wash index (WI) is expressed as the ratio of the test machine to the reference machine on the Economy half 55^{o}C program (this reference program is under consideration). The standard mandates minimum performance levels to be attained for wash performance and drying performance. Two separate tests required under the standard (one with a soiled load for assessing wash performance, energy and water consumption and one with a clean load to assess drying performance), but three separate units are required to be tested for energy labelling registration purposes.

Hot water energy (nominally at 60^{o}C) is determined from a base temperature of 20^{o}C (equal to cold water supply temperature). Cold water energy adjustment (where cold water deviates from 20^{o}C) is applicable to operations that use hot water or where water is heated internally.

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption

- Electrical energy consumption
- External hot water energy
- Cold water energy correction
- Rated capacity (declared by manufacturer)
- Wash performance (limits are set)
- Drying performance (limits are set)
- Program time

Notes:

1. Detergent specified is IEC type A (IEC 60436-81) with phosphate and chlorine bleach.
2. Soils include infant cereal, tea, tomato juice, eggs, margarine, spinach.
3. Wash performance is assessed visually by technicians in a special viewing cabinet (1000 lux), with a scoring system of 0 for dirty and 5 for clean.
4. IEC 60436-81 does not specify limits for water hardness.
5. Since 1996 a new version of IEC 60436 has been under active development and Australia has been a contributor to this work. The recent changes to AS/NZS 2007 are likely to be included in the new IEC standard, if published.

E:3.2 Canada

Program: mandatory energy labelling and MEPS for dishwashers

Summary of test procedure

CAN/CSA-C373-92 is used to determine energy and water consumption for a dishwasher on the normal and truncated normal programs. Machines that are recommended for use with 60^{o}C water are tested without a load, but water heating dishwashers use an AHAM load. Performance of the dishwasher is not measured in the test (no soil is used).

Details

Energy consumption of clothes washers under CAN/CSA-C373-92 is as follows:

$$E = E_A \times 322$$

Where:

- 322 is uses per year
- E_A is the average total per program energy consumption, averaged for a normal program and a truncated normal program (where available), made up of hot water energy and mechanical energy, for the recommended water connection mode.

For MEPS, the Energy Factor (EF) is defined as:

$$EF = 1 / E_A$$

Dishwashers that are recommended for use with a water supply of 60°C are tested on the normal and truncated normal program *without a test load*. Dishwashers that heat water internally are also tested on the normal and truncated normal program but *with a test load as defined in AHAM DW-1*. The load used in this case is 8 place settings plus six serving pieces, or at the capacity stated by the manufacturer if this is less than 8 place settings.

The total energy for the normal and truncated normal program are averaged to give average total energy consumption. The testing of certain water connection configurations eg dual or hot connect with water heating, hot or cold connect, is not clear in the standard.

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption (hot and cold separately)
- Electrical energy consumption
- External hot water energy

E:3.3 New Zealand

Program: voluntary energy labelling for dishwashers

Summary of test procedure

The New Zealand voluntary energy labelling program uses AS/NZS 2007 and is identical to the Australian program, other than it is voluntary in nature.

E:3.4 USA

Program: mandatory energy labelling and MEPS, Energy Star (voluntary) for dishwashers

Summary of test procedure

The test procedure for dishwashers in the USA is set out in the US Code of Federal Regulations CFR430 Appendix C. As for Canada (USA and Canada have identical requirements for dishwashers), CFR430 is mainly concerned with the determination of energy and water consumption for normal and normal truncated programs. Machines that are recommended for use with 60°C water are tested without a load, but water heating dishwashers use an AHAM load. Performance of the dishwasher is not measured in the test (no soil is used).

Details

The energy label is based on 322 uses per year of the average total per program energy consumption, averaged for a normal program and a truncated normal program (where available), made up of hot water energy and mechanical energy, for the recommended water connection mode (usage per year is defined in a separate regulation for energy labelling - CFR305).

Table 94: Summary of Dishwasher Test Procedures

Dishwashers	Australia	Canada	New Zealand	USA	International
Labels	M	M	V	M+V	
MEPS		M		M	
Other					
Test Procedure	AS/NZS2007	CAN/CSA-C373-92	AS/NZS2007	10CRF430.27 App C, AHAM DW-1	IEC60436-81
Related Procedure	IEC60436	USA	IEC60436	CAN/CSA-C373-92	IEC60436-81
Relation	NEQ	IDT	NEQ	IDT	IDT
Ambient temp	20C	21-29C	20C	21-29C	20C
Humidity	60%		60%		55%
Cold water	20C	10C	20C	10C	15C
Hot water	60C	49C/60C *	60C	49C/60C *	60C
Hardness	45 ppm		45 ppm		300 ppm
Pressure	320 kPa	240 kPa	320 kPa	240 kPa	240 kPa
Reference machine	Miele G590 *		Miele G590 *		
Program	not specified **	normal & normal truncated	not specified **	normal & normal truncated	
Wash temperature	not specified		not specified		
Detergent	IEC A		IEC A		IEC B *
Rinse aid	IEC neutral		IEC neutral		Type I or II **
Load type	IEC ***	AHAM/none **	IEC ***	AHAM/none **	IEC
Capacity	rated	8 ***	rated	8 ***	rated
Soil	IEC		IEC		IEC
Wash performance	WI > 1.0		WI > 1.0		Measured
Drying performance	DI > 50%		DI > 50%		Measured

Local voltage and frequency, Empty cell means not specified or not relevant, M = mandatory, V = voluntary, U = under consideration
Technical information regarding the test procedures as contained in this table is not necessarily reproduced in the section on each economy

Interpretation Notes for Table 94: Summary of Dishwasher Test Procedures

Australia:
* This is a specially prepared reference machine, same as required for EN50242
** From 2000, the program will be for a normally soiled load
*** excludes serving bowls and platter

Canada:
* 49C for water heating dishwashers
* 60C where recommended by the manufacturer
** none for 60C DW, AHAM for water heating DW
*** 8 place settings + serving pieces as per AHAM, except where capacity is stated as less than 8

New Zealand:
* This is a specially prepared reference machine, same as required for EN50242
** From 2000, the program will be for a normally soiled load
*** excludes serving bowls and platter

USA:
* 49C for water heating dishwashers
* 60C where recommended by the manufacturer
** none for 60C DW, AHAM for water heating DW
*** 8 place settings + serving pieces as per AHAM, except where capacity is stated as less than 8

IEC:
* IEC A detergent is phosphate with chlorine bleach, now deleted
* IEC B detergent is non-phosphate with oxygen bleach and enzymes
* IEC C detergent is phosphate with oxygen bleach and enzymes, under development
** Type 1 rinse aid is neutral
** Type 2 rinse aid is acid for hard water
** Type 3 & 4 rinse aids for acid for hard water without alcohol have recently been released

For MEPS, the Energy Factor (EF) is defined as:

$EF = 1 / E_A$

Where

- E_A is the average total per program energy consumption, averaged for a normal program and a truncated normal program (where available), made up of hot water energy and mechanical energy, for the recommended water connection mode.

USA test procedure is identical to Canada, so the details will not be repeated. In addition, CFR430 and CFR305 also require energy costs to be calculated and shown on the energy label (for electric energy consumed by the dishwasher plus external electric and gas hot water systems).

Energy Star requirements are defined in terms of the Federal Standard MEPS levels.

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption (hot and cold separately)
- Electrical energy consumption
- External hot water energy
- Place settings (for testing, not declared on the label)

E:3.5 IEC 60436-81 - Dishwashers

Summary of test procedure

IEC 60436-81 specifies a standard load type consisting of dinner plates, bread and butter plates, desert bowls, soup bowls, cups, saucers, glasses, cutlery and serving items of the claimed rated capacity. Neither the program to be used nor the wash temperature is specified. The energy, water, washing and drying performance is measured during the test. The standard does not set any mandatory limits for these variables. At least five tests on each machine are required.

Details

Rated capacity of the machine is as declared by the manufacturer. Water hardness is defined as 300 ppm $CaCO_3$ equivalent for machines with a water softener, or at 50, 150 or 300 ppm for those without. Load compositions are defined in terms of place settings (which much be an integer).

Soil is applied to the load and includes:

- Tomato juice
- Tea
- Eggs
- Baby cereal
- Spinach margarine

The soil is applied and allowed to dry for two hours under ambient conditions before being loaded and washed. Washing performance is visually assessed by a technician in a viewing box. Each piece is scored as dirty (0), with a small particle of soil (1) or clean (2).

Drying performance can be measured during the wash performance test (but this is difficult in practical terms).

The following performance measures are determined during the test:

- Wash performance
- Drying performance
- Water and energy consumption
- Program time

The second edition of IEC 60436 first appeared in 1981. Amendments 1 & 2 were issued in 1992 while Amendment 3 (the most recent and incorporating 1 & 2) was issued in August 1994.

The main changes to IEC 60436-81 in the amendments is as follows:

- Phosphate free reference detergent B is specified.
- Changes to the detergent dosing levels
- A number of minor technical and editorial changes

Since 1996 IEC SC59A working group 1 has been actively revising IEC 60436 in an attempt to get an international test procedure into place that can meet the need of Europe, Australasia and North America. The has required significant development work and has drawn on local experience in all regions. The new test procedure has also drawn on EN50242 for Europe.

E:3.6 Technical Issues Associated with the use of IEC60436

Due to the lack of active work since its publication, IEC 60436-81 has fallen behind in its ability to adequately assess the performance of dishwashers now on the market. Increasingly, dishwashers are being equipped with adaptive controls that adjust performance in proportion to soil loads, so it is becoming necessary to test units for energy consumption with a soiled load to get an indicative result. The increasing requirements for accurate performance assessment (in terms of repeatability and reproducibility) for various program now also means that IEC 60436-81 is inadequate.

IEC SC59A working group 1 has been undertaking a complete revision of the IEC standard since late 1996 with a view to making it more repeatable and reproducible. The new draft standard was issued as a committee draft in 1998. Currently a series of round robins is being undertaken to assess the repeatability and reproducibility of the draft. It is hoped that this can progress to DIS by 2000. The main changes proposed in the CD include:

- Inclusion of a reference machine to normalise washing and drying performance results (Miele G590 reference), although the exact use of the reference machine is still being debated.

- Some adjustment to the soils used (inclusion of meat, milk, deletion of tomato juice).
- Sourcing soiling materials and their handling, storage and use have been reviewed.
- Some test conditions have been harmonised (hardness, water temperatures).
- Inclusion of hot and dual connection dishwashers.
- Method for calculating energy and energy corrections for water temperature variations.
- Changes in the rinse aid (new formulations without alcohol).
- New detergent C is under development (with phosphate base and oxygen bleach and enzymes).
- Drying method of load before washing is still under consideration - two methods are air drying in controlled conditions and oven drying (latter more likely).

Given the active involvement of Australasia, Europe and North America in the development of the revised IEC 60436, it is hoped that this could eventually provide a suitable international test procedure for dishwasher. IEC 60436 should only be used where a performance based test is required for dishwasher. It would not be suitable for North America, for example, where it is currently not necessary to determine wash performance or other performance variables. However, it appears that a performance task test (with a soiled load) is becoming increasingly necessary to adequately deal with adaptive controls of various types.

E:4 Clothes Dryers

E:4.1 Australia

Program: mandatory energy labelling for clothes dryers

Summary of test procedure

Under AS/NZS 2442-96, for regulatory purposes, a mixed cotton load of the claimed rated capacity is dried on the hottest program for timer dryers and on the selected program for automatic moisture sensing dryers. Condenser dryers are connected to a cold water supply if necessary. The energy, initial and final content and program time (before cooldown) are measured during the test. The standard sets mandatory limits for energy efficiency, but these are weak. Maximum temperature limits on the clothes are set to prevent scorching and timer dryers must be able to dry the clothes in a single setting. The standard was originally related to AHAM HLD-1, but now has significant technical deviations.

Details

Energy consumption of clothes washers under AS/NZS 2442-98 is as follows:

$$CEC = E_t \times 150 \times F$$

Where:

- 150 is uses per year (actual use in Australia has been recently estimated at about 50 times per year)
- E_t is tested energy consumption at rated capacity
- Field use factor = 1.0 for automatic moisture sensing dryers and 1.1 for manual and timer dryers.

The Australian standard closely resembles AHAM HLD-1 but with several additions and alterations. The rated capacity (as specified by the manufacturer) is equal to the bone dry mass plus an 8% allowance for moisture content. A mixed cotton load (with polyester/cotton shirts) is dampened to an initial moisture content of 90% of the bone dry mass of the load. The program selected is the hottest for timer dryers and the program to be tested for automatic moisture sensing dryers. Timer dryers are operated until a moisture content of 6% of bone dry mass remains (measurements are taken either side of this point with a correction via interpolation). Auto-sensing dryers are allowed to operate through their selected program, but this must have a final moisture content of <6% of bone dry mass. The test is stopped at the start of the cool-down period for both dryer types. Other performance requirements are a maximum allowable temperature on the load and/or drum of 130^{o}C (to prevent scorching) and all dryers must be capable of reaching the 6% moisture content target in a single setting. The dryer component of combination washer-dryers are tested under this procedure.

Table 95: Summary of Clothes Dryer Test Procedures

Clothes Dryers	Australia	Canada	New Zealand	USA	International
Labels	M	M	V		
MEPS	(M)	M		M	
Other					
Test Procedure	AS/NZS2442	CAN/CSA-C373-92	AS/NZS2442	10CRF430.27 App D, AHAM HLD-1	IEC61121-97
Related Procedure	AHAM HLD-1	USA	AHAM HLD-1	CAN/CSA-C373-92	IEC61121-97
Relation	NEQ	IDT	NEQ	IDT #	IDT
Ambient temp	23C *	24C	23C *	24C	20C
Humidity	60%	50%	60%	50%	65%
Cold water	20C		20C		15C
Pressure	320 kPa		320 kPa		240 kPa
Hardness		< 17 ppm		< 17 ppm	250 ppm *
Program	max temp **	max temp	max temp **	max temp	dry-cotton **
Load type	mixed ***	poly/cotton energy & stuffer cloths	mixed ***	poly/cotton energy & stuffer cloths	IEC ***
Drum volume		measured		measured	measured ****
Capacity	rated	3.18 kg *	rated	3.18 kg *	rated
Initial moisture	90% ****	70%	90% ****	70%	70%
Final moisture	6% *****	2.5%-5%	6% *****	2.5%-5%	0%
Cooldown included	no	no	no	no	yes
Field use factors	yes	yes	yes	yes	no
Energy correction	interpolation	linear	interpolation	linear	linear
Max temperature	< 130C		< 130C		
Other	single operation		single operation		

Local voltage and frequency, Empty cell means not specified or not relevant, M = mandatory, V = voluntary, U = under consideration
Technical information regarding the test procedures as contained in this table is not necessarily reproduced in the section on each economy

Interpretation Notes for Table 95: Summary of Clothes Dryer Test Procedures

Australia:
All masses are bone dry
Rated capacity includes 8% moisture allowance
* Ambient temperature is changing to 20C with an amendment in 1999
** hot program for timer dryers
** autosensing dryers must reach 6% bone dry mass
*** mixed load harmonised with AS/NZS clothes washer load
*** Mixed load - sheets, pillow cases, tablecloths, shorts, T shirts, pillow cases, under shorts, wash cloths, handkerchiefs
**** moisture content in regulations is 100%, currently in transition
***** for timer dryers, auto sensing terminate under program control
Exhaust duct simulator used for ducted systems
Water pressure and temp is for condenser dryers

Canada:
All masses are bone dry   * compact less than 125 L * compact load is 1.36 kg
Small loads are disconnected for the test   Exhaust duct simulator used for ducted systems

New Zealand: same notes as for Australia

USA:
All masses are bone dry
* compact less than 125 L
* compact load is 1.36 kg
Small loads are disconnected for the test
Exhaust duct simulator used for ducted systems defined in AHAM HLD-1
Includes test procedure for gas dryers

IEC:
All moisture content is normalised moisture content to ISO139
* water hardness may be removed and replaced with conductivity in future
** three programs are dry cotton, iron-dry cotton and easy care
*** IEC cotton load is sheets, towels and pillowcases
**** drum volume only measured if rated capacity not stated

Variables required to be measured, determined or declared for regulatory purposes:

- Water consumption (if applicable)
- Electrical energy consumption
- Program time
- Automatic moisture sensing or timer type
- Program, timer and or temperature setting tested
- Rated capacity (declared by manufacturer)
- Maximum clothes temperature (limits are set)
- Energy efficiency (kWh per kg moisture removed - limits are set)

Notes:

1. Ambient temperature is currently 23^{o}C but will change to 20^{o}C in 1999 via an amendment.
2. Current initial moisture content is 100% of bone dry mass in regulations - this is in transition to 90% through the standard.
3. Dryer load is same as for clothes washers.
4. Exhaust duct simulator used for ducted exhaust systems.

E:4.2 Canada

Program: mandatory energy labelling and MEPS for clothes dryers

Summary of test procedure

CAN/CSA-C373-92 determines the energy consumption to dry a specified load. The requirements are identical with Canada. Standard sized machines have a 3.18 kg bone dry load while compact machines have a 1.36 kg bone dry load. The load consists of poly/cotton energy clothes and stuffer cloths. The program to be tested is the maximum temperature. The initial moisture content of the load is 70% of bone dry mass and this is dried to a level of 2.5% to 5% of bone dry mass. The test is terminated at the start of the cool-down period.

Details

The annual energy consumption of clothes dryers under CAN/CSA-C373-92 is as follows:

$E_A = E_T \times 416$

Where:

- 416 is uses per year
- E_T is the energy consumption in kWh per cycle.
- E_T includes field use factors (FU) as follows: FU = 1.04 for automatic moisture sensing dryers and FU = 1.18 for timer dryers

For MEPS, the Energy Factor (EF) is defined as:

$EF = 1 / E_T$

The volume of the dryer drum is measured and compact machines are defined as those with a volume of less than 125 L. Standard sized dryers use a load of 3.18 kg bone dry load while compact machines have a 1.36 kg bone dry load. The load consists of poly/cotton hemmed sheet with a dimension of 0.60m × 0.90m (same as for clothes washers). Smaller stuffer cloths of the same material 0.25m × 0.25m are used to fine tune the load. The load is pre-conditioned and water added to give an initial moisture content of approximately 70% of the bone dry mass. Water added to the load has a hardness limit of < 17ppm $CaCO_3$ equivalent (very soft). The dryer is set at the maximum time on the hottest program and operated until a final moisture content of 2.5% to 5% of bone dry mass is attained. The dryer is not allowed to operate into a cool down mode. The energy consumption is corrected back to a moisture removal of 66% using a linear correction factor. Field use factors above are included in the annual energy consumption. The dryer component of combination washer-dryers are tested under this procedure.

Variables required to be measured, determined or declared for regulatory purposes:

- Electrical energy consumption
- Volume of clothes drum
- Automatic moisture sensing or timer type
- Program, timer and or temperature setting tested

Notes:

1. Load sizes are defined in terms of bone dry mass.

E:4.3 New Zealand

Program: voluntary energy labelling for clothes dryers

Summary of test procedure

The New Zealand voluntary energy labelling program uses AS/NZS 2442 and is identical to the Australian program, other than it is voluntary in nature.

E:4.4 USA

Program: mandatory MEPS for clothes dryers

Summary of test procedure

CFR430 Appendix D determines the energy consumption to dry a specified load. The requirements are identical with Canada other than the scope also includes gas dryers. Standard sized machines have a 3.18 kg bone dry load while compact machines have a 1.36 kg bone dry load. The load consists of poly/cotton energy clothes and stuffer cloths. The program to be tested is the maximum temperature. The initial moisture content of the load is 70% (± 3.5%) of the bone dry mass and this is dried to a level of 2.5% to 5% of bone dry mass. The test is terminated at the start of the cool-down period.

Details

For MEPS, the Energy Factor of clothes dryers under CFR430 Appendix D is as follows:

$EF = 1 / E_T$

- E_T is the energy consumption in kWh per cycle.
- E_T includes field use factors (FU) as follows: FU = 1.04 for automatic moisture sensing dryers and FU = 1.18 for timer dryers

The technical details for Canada and the USA are identical for electric clothes dryers so the details are not repeated here. The scope of CFR430 Appendix D also covers gas fired dryers. Note that the USA does not have energy labelling for dryers.

An external reference to AHAM HLD-1 is made for the specification of a dryer exhaust duct simulator.

Variables required to be measured, determined or declared for regulatory purposes:

- Electrical energy consumption
- Volume of clothes drum
- Automatic moisture sensing or timer type
- Program, timer and or temperature setting tested

Notes:

1. Load sizes are defined in terms of bone dry mass.

E:4.5 IEC 61121 – Clothes dryers

Summary of test procedure

IEC 61121-97 specifies two standard load types (cotton and easy care) of the claimed rated capacity. If the rated capacity is not stated, this is determined from the drum volume. Different capacities are normal for cotton and easy care. Three programs are specified in the standard - dry cotton and iron-dry cotton for the cotton load and easy care. The initial moisture content is 70% of normalised mass while the final moisture content depends on the program selected. The energy and drying performance is measured during the test. A linear energy correction is made depending on the actual initial and final moisture content. The standard does not set any mandatory limits for these variables. Provision for water consumption is made for some condenser dryers. At least five tests on each machine are required.

Details

Rated capacity of the machine is as declared by the manufacturer. If rated capacity is not declared, it is determined from the volume of volume of the washing drum/bowl. Water hardness of 250 ppm $CaCO_3$ equivalent is specified for wetting the load and for the water supply, although the issue of conductivity is under consideration (a level of 90 ± 10 mS/metre is proposed to replace the water hardness for autosensing dryers are that sensitive to conductivity). Cotton and easy care (poly-cotton) loads are specified from 2 to 10 kg. All masses are determined as either normalised mass (equilibrium moisture content after 24 hours at ISO139 conditions: 20^{o}C and 65% humidity) or in terms of bone dry mass. The dryer is to be at ambient temperature before the test commences. The initial moisture content is specified as 70% of normalised mass load for cotton loads (roughly equivalent to 75% moisture content under bone dry) and 50% of normalised mass load for easy care loads. The final target moisture content depends on the program under test: 0% for dry cotton (nominally 6% to 8% bone dry), +12% iron dry and +2% for easy care. The condensation efficiency and the drying evenness can also be calculated if required. A standardised dryer exhaust duct is fitted to dryers which are intended to be operated with a duct and where a duct is not supplied.

Under IEC61121-97, the program time, energy (and where applicable water consumption) are corrected via a linear equation which takes the ratio of the actual moisture removed during the test (initial - less final) in proportion to the target moisture removal (for dry cotton this is 70% - 0% = 70%).

The following performance measures are determined during the test:

- Water and energy consumption
- Condensation efficiency (condenser dryers only)
- Drying evenness (optional)
- Program time

The second edition of IEC 61121 appeared in October 1997. The first edition was published in August 1991.

The main changes to IEC 61121-97 compared with IEC 61121-91 are as follows:

- Improved tolerance on instrumentation, base loads and initial moisture content.
- Introduction of condensing efficiency test.
- Introduction of optional drying evenness test.
- Elimination of previous standard Load I so that only standard Load II is now specified for dryers - this is also harmonised with clothes washer IEC60456.
- Final moisture content for iron dry has been changed.
- Correction of energy, water and time has been altered (but this is still under consideration).
- Conductivity is under consideration.

During 1999 the IEC sub-committee IEC SC59D set up a maintenance team to oversee the ongoing work required to keep the standard current.

E:4.6 Technical Issues Associated with the use of IEC61121

IEC 61121-97 has been under active development in recent years. The current edition is reasonably competent, although there are a few technical issues which are outstanding:

- The method of correction for the water, energy and program time has a technical problem (although it is similar in nature to the North American test procedures). For a typical dryer, the moisture removal rate is non linear (the rate of moisture removal decreases with increasing dryness), so estimating time, energy or water consumption requires information about the slope of the curves near the target moisture content to be accurate (current correction method assumes linearity).
- Initial moisture content of 70% normalised does not necessarily suit many economies and tends to be set locally to reflect the typical spin performance of clothes washers on the market. IEC SC59D is considering a proposal to make the standard more generic whereby the energy and time for any initial moisture content could be estimated from the dryer characteristics (shape of the moisture removal curve). Thus the standard could be used to estimate performance over a range of typical initial moisture contents (varying the final moisture content is more problematic). However, the proposal still requires considerable refinement.
- The issue of conductivity and how it affects certain auto-sensing dryers needs to be resolved.
- The load composition for this standard is sheets, towels and pillowcases and this is not seen as terribly representative of typical household loads, although North American test procedures use only plain pieces of hemmed material.

IEC 61121 could eventually provide a suitable international test procedure for clothes dryers (once some of the above issues are resolved). Substantial retesting because of local variations in initial moisture content could be avoided if the generic approach can be refined and accepted. It is recommended that this area of development receive some significant effort over the next few years.

ANNEX F: OFFICE EQUIPMENT AND CONSUMER ELECTRONICS

This Annex covers a range of electronic equipment which broadly fall into two main categories. These are:

- Office equipment: a range of electronic equipment used in business and commercial applications, but also increasingly in the residential sector. Items such as computers and associated equipment (printers, hard disk drives, scanners, multi-function devices), fax machines and photocopiers are included.
- Consumer electronics: electronic equipment generally used in the residential sector (with some commercial applications) for home entertainment and similar purposes. Items such as televisions, video cassette recorders (VCRs), stereo amplifiers and associated equipment such as tape recorders, radio receivers and compact disc players are included.

Generally speaking, the specifications and technology for these equipment types are changing rapidly (except perhaps for photocopiers), so traditional “standards” (which are often slow to develop) are not widely used for testing (at least for performance – there are however numerous relevant safety standards). By and large, most of the program coverage for these product types are flexible voluntary programs (eg various endorsement programs) which are able to keep up with technology changes by setting their own test requirements. The few “traditional” energy programs that require MEPS or similar requirements to published standards are generally thought to be out of date with respect to products that are now available on the market.

For Energy Star office equipment, the criteria to qualify for the use of the logo as well as the conditions of test are presented together, as these requirements are highly integrated and not always easy to separate. For consumer electronics, Energy Star and other requirements are listed by APEC Economy. The last section includes miscellaneous electronic equipment. This includes a range of MEPS requirements for computers and associated equipment for Russia from the late 1980’s, for which few details have been obtained.

F:1 Office equipment

F:1.1 Background

Energy Star and other national programs

All APEC economies which have energy efficiency programs covering office equipment make use, explicitly or implicitly, of the United States Environmental Protection Agency’s (EPA) *Energy Star* program. The Energy Star logo is a registered mark which the EPA makes available for use by the manufacturers and retailers of office equipment which meets specified criteria. This Annex describes the criteria and the test procedures to establish whether a product meets the criteria. Participation in the program is not mandatory, but US participants must agree with the EPA to abide by the product criteria and other conditions of logo use.

Energy Star is not the only office equipment energy efficiency program in the world. The Swiss *E2000* labelling program, now used in a number of European countries, also covers office equipment as well as televisions and VCRs. Unlike *Energy Star*, the E2000 program takes into account the efficiency range of products on the market. Each year, a new energy performance level for endorsement eligibility is declared. The performance level is selected so that about 20% to 30% of products on the market are eligible. Manufacturers are invited to nominate and register eligible equipment for endorsement. Complying equipment is entitled to carry the E2000 label for the year of compliance, which is indicated on the label. More information can be obtained from the Swiss Federal Office of Energy web site: www.energielabel.ch

APEC economies only use the Energy Star program. In some cases (eg Japan, New Zealand) there is a formal agreement between government agencies or industry groups and the US EPA regarding use of the Energy Star logo in that country, and confirming common technical criteria and conditions of logo use. In other cases the Energy Star technical criteria are incorporated into local "green" labelling programs (eg the "Greenmark" label in Chinese Taipei and the "Energy Boy" logo on Korea). In some other cases, the Energy Star logo (and by implication the criteria, although this is not always spelt out) are used informally. The new Japanese "Top Runner" program which covers photocopiers, computers and magnetic disks (computer hard drives) is thought to be considering the Energy Star test procedures outlined below.

Relevant Documents

The US EPA publishes two classes of documents that, between them, cover the energy performance criteria and the test procedures for each class of office equipment included in the Energy Star program:

- "Testing conditions" for the product; and
- "Memorandum of Understanding" (MOU) for use in agreements between the EPA and participating suppliers, which includes, among other things, the energy performance criteria and in some cases also includes a copy of the "Testing conditions".

The classes of office equipment covered and the documents relevant to each are summarised in Table 96.

Table 96. Energy Star Program documents relevant to office equipment

Product	Testing Conditions Document and application date of latest version	MOU Document and application date of latest version of criteria
Computers and integrated computer/monitors	Testing conditions for Energy Star Measurement: Personal Computers and Monitors; May 1996	Computer MOU Version 3.0, 1 July 1999 (incorporates copy of Testing Conditions)
Monitors	Testing conditions for Energy Star Measurement: Personal Computers and Monitors; May 1996	Monitor MOU Version 3.0, 1 July 1999 (incorporates copy of Testing Conditions)
Printers and Fax machines	Testing conditions for Energy Star Measurement: Printers and Fax Machines; June 1995	Printer/Fax MOU Version 2.0, 1 October 1995
Photocopiers	Testing conditions for Energy Star Measurement: Copiers; June 1995	Copier MOU (dated 1 July 1995) Current criteria effective 1 July 1997)
Scanners	Testing conditions for Energy Star Measurement: Scanners; March 1997	Scanner MOU 1 April 1999
Multi-function devices (MFD) and upgradeable digital copiers (UDCs)	Testing conditions for Energy Star Measurement: Multifunction devices; April 1997	MFD MOU including Amendment 1.0 (dated 23 October 1998). Current criteria effective 1 April 1999
Controlling devices	No separate document	Controlling device MOU Version 1.1 (undated)

Source: US EPA Website, www.epa.gov July 1999

General Test Criteria

The main values to be measured in testing are:

- The time that elapses between an operator input (eg a keystroke or print command) and the automatic shift to a lower power mode of operation. This can be measured with a stopwatch; and
- The power consumption in the lower power mode of operation.

The *Testing Conditions* specify the characteristics of the power supply, the ambient conditions and the capabilities of the instruments to be used. Tests take place with a line impedance of <0.25 ohm and Total Harmonic Distortion (voltage THD) of <5%, and at a ambient temperature of 25°C ± 3°C.[5]

The watt-hour meters must be of the "true power" type, and must be able to read the current drawn by devices with switching (non-sinusoidal) power requirements, to a resolution of 0.1W.[6]

Products carrying the Energy Star logo are required to meet the specified power management criteria in all markets where they are sold, so tests must be performed

5 The exception is copiers, which are tested with a power supply THD of <3% and an ambient temperature of 21°C ± 3°C. A 2 ft minimum distance from the wall is also specified for copiers.

6 The Testing Conditions define True Power as (volts) x (amps) x (power factor), reported in Watts, as distinct from Apparent Power, defined as (volts) x (amps), reported as VA or volt-amps. .

not only at US voltage and frequency conditions but also at the conditions of other markets in which the product is to be supplied with the Energy Star logo, as shown in Table 97.

Table 97. Voltage and frequency test conditions

Market	Voltage	Frequency
Unites States	115 V RMS ± 5 V	60 Hz ± 3 Hz
Europe, New Zealand	230 V RMS ± 10 V	50 Hz ± 3 Hz
Japan	100 V RMS ± 5 V 200 V RMS ± 10 V	60 Hz ± 3 Hz

Source: Testing Conditions for Energy Star Measurement: Copiers. Assumed to apply to all other Energy Star products.

For paper-handling products (printers, faxes, copiers, MFDs), it is also necessary to determine the output capacity in terms of copies or pages per minute, since different criteria apply to products of different output capacities. Capacity is to be determined using the paper size used in that market, ie 8.5"x11" for the US and A4 for other markets.

F:1.2 Product Criteria and Specific Conditions

Computers

The definition of "computers" is intended to cover those sold for business and home use: desktop, tower, mini-tower, portable units, high-end desktop computers, workstations, network computer desktops, X terminal controllers and computer-based point-of-sale retail terminals. To qualify, units must be capable of being powered from an alternating current power outlet, although they may also be capable of battery operation. Computers sold or otherwise marketed as "servers" or "file servers" are not included.

The Energy Star requirements specify that computers should enter the low power states summarised in Table 98, "after a period of inactivity", ie after a user input such as a keyboard input or a mouse movement. Additional guidelines are:

- Power management features must be user-adjustable, but activated before shipping with initial preset default times of 30 minutes or less;
- Computers must include one or more user-adjustable mechanisms to power down an Energy Star compliant monitor;
- The monitor control function must be activated before shipping with initial preset times so that the computer powers down the monitor to the first low-power or "sleep mode" in not more than 30 minutes of inactivity, and to the second low-power, or "deep sleep" mode in not more than 60 minutes of inactivity; and
- Computers must be able to "sleep" in any operating system pre-installed before shipping, unless clearly stated in the product literature.

Table 98. Energy Star power management requirements for computers

Model ship date	Requirements		
I July 1999 to 30 June 2000 (Tier I)	• Shall enter a sleep mode • If shipped with network capability, shall sleep on networks and respond to wake events	Power supply(a)	Maximum Watts in sleep mode
		≤200W	≤30W
		>200W	≤15% of power supply
On and after 1 July 2000 (Tier II)	• Shall enter a sleep mode • If shipped with network capability, shall sleep on networks and respond to wake events	Guideline A	
		≤200W	≤15W
		>200≤300W	≤20W
		>300≤350W	≤25W
		>350≤400W	≤30W
		>400W	10% of maximum continuous output rating
		Guideline B: ≤15% of power supply	

(a) Maximum continuous output power rating is the value defined by the power supply manufacturer in the operating instructions provided with the product.

For Tier II, the requirements differ according to whether the computer is:

- Not intended to be networked (Guideline A applies);
- Shipped with the capability to remain in low-power-sleep mode while the network interface adaptor retains the ability to respond to network queries (Guideline A applies); or
- Shipped with the capability to be on networks that currently require the computer's processor and/or memory to be involved in maintaining the network connection (Guideline B applies).

EPA expects computers sold or otherwise marketed as personal computers to be qualified under Guideline A only. Computers that always maintain a power consumption of 15 W or less comply with Tier II whether or not they incorporate a sleep mode.

Integrated Computer Systems

Integrated computer systems are those where the computer and the visual display monitor are integrated into the one unit such that:

- the system is connected to the power outlet through a single power cable; and
- it is not possible to measure the power consumption of the two components separately.

Energy Star compliant integrated computer systems are required to:

- enter a sleep mode after a period of inactivity;
- if shipped with network capability, shall sleep on networks and respond to wake events;
- be shipped with a preset sleep mode default time of no more than 30 minutes.

During the Tier I period (see Table 98), integrated computer systems must consume no more than 45W in sleep mode, and in the Tier II period no more than 35W. Integrated computers systems that never exceed these power consumption levels comply whether or not they incorporate a sleep mode.

Monitors

Energy Star is mainly intended to cover monitors or visual display units intended for use with computers, but mainframe terminals and other cases where the monitor is physically separated from the computer are also covered. The monitor may be a cathode-ray tube (CRT), a flat panel display or other display device and its associated electronics.

For products shipped from 1 July 1999, monitors are Energy Star compliant of they have the capability to automatically enter two successive low-power modes. In the first low-power "sleep" mode the monitor must consume no more than 15W after receiving instructions from the computer or via other functions. If the monitor continues to be idle, it must enter a second low-power "deep sleep" mode upon instructions from the computer or via other functions. In this mode it must consume no more than 8W.

The monitor should automatically return to full operational capability upon resumption of user activity, but for activity not initiated by the user (eg network "wake" events) it should remain in its low-power mode.

If the monitor includes a USB hub or port/s, it must be tested without any devices or upstream cords connected to the hub or port/s.

Printers and Fax Machines

Printers include standard desktop printers such as ink jet, laser, light-emitting-diode (LED), dot matrix and high-end colour printers such as thermal wax transfer and colour laser.

Fax machines are those whose primary function is sending and receiving faxes and which print received faxes on to plain paper using means such as ink jet, bubble jet, laser, LED or thermal wax transfer.

Products that are marketed and sold as fully functional printers which also have the ability to send and receive faxes are called "Printer/fax Combo" units and are also covered by the same criteria. (Products whose primary function is copying but which are also able to print, fax or both are defined as "Multi-function devices", and other criteria apply).

To qualify for Energy Star, printers, fax machines or printer/fax combos must be shipped so that they meet the criteria in Table 99.

Table 99. Energy Star power management requirements for printers and fax machines

Market segment (pages per minute)	Average Watts in low-power mode	Printer default time to low-power mode(a)	Fax machine default time to low-power mode
0 <ppm≤ 7	15 W	15 minutes	5 minutes
7 <ppm ≤14	30 W	30 minutes	5 minutes
> 14 ppm and high-end colour	45 W	60 minutes	15 minutes

(a) Also applies to printer/fax combos

Products whose consumption never exceeds the low-power values comply whether or not they incorporate a low-power mode.

The average power consumption in low-power mode is measured as an average, ie by measuring power consumption over a long enough time period to allow for typical variations in power, such as cycling of the fuser (1 hr is recommended). Where low-power mode consumption does not vary (eg dot matrix and inkjet type machines) it is acceptable to take several measurements of instantaneous power using a high-quality watt-meter.

Copiers

A copier is a commercial reprographic imaging unit whose sole function is the production of duplicates from a graphic hardcopy original. A copier must include a marking system, an imaging system and a paper handling module. Energy Star covers all black and white plain paper copying technologies, although the main focus is on the widely-used light lens type.

There are different criteria for copiers depending on their speed (in copies per minute) and format: either standard format (ie 8.5"x11" for the US and A4 for other markets) or large format (ie 17"x22" for the US and A2 for other markets).

The criteria for standard format copiers are indicated in Table 100 and those for large format copiers in Table 101. Copiers may have some or all of the following modes:

- Off mode: the condition that exists when the copier is connected to an appropriate electricity supply source, and the unit has been recently shut off via the auto-off feature;
- Stand-by mode: the condition that exists when the machine is not making copies, has reached operating conditions and is ready to male a copy, but has not yet entered energy-saver mode. When the copier is in this mode, there will be virtually no delay before it is capable of making the next copy;
- Low-power mode: the lowest power state the copier can automatically enter within a specified period after the last copy was made, without actually turning off. For purposes of determining the power consumption in this low-power mode, the manufacturer may choose to measure the lowest of either the energy-saver mode or the standby mode;
- Energy-saver mode: the condition that exists when the machine is not making copies, has previously reached operating conditions but is consuming less power

than when it is in standby mode. When the copier is in this mode, there may be some delay before it is capable of making the next copy. This delay is known as the "recovery time". As Table 100 indicates, one of the criteria which a medium speed standard format copier must meet to comply with Energy Star is a recovery time of less than 30 seconds..

Table 100. Energy Star power management requirements for standard format copiers

Copier speed (copies per minute)	Low-power mode (W)	Low-power default time	Recovery time 30 secs	Off mode (W)	Off default time	Automatic duplex mode
0<cpm≤20	None	None	NA	≤5	≤ 30 min	No
20<cpm≤44	3.85x cpm+5	15 min	Yes	≤15	≤ 60 min	No
cpm>44	3.85x cpm+5	15 min	Recommended	≤20	≤ 90 min	Optional (a)

Source: Summary of Energy Star Copier Specification, Revised 14 December 1998. Criteria are slightly different from those in latest version of MOU (Version 1.0 5/96), especially with regard to duplex mode, where requirements have been relaxed. (a) Required to be offered as an option.

Table 101. Energy Star power management requirements for large format copiers

Copier speed (copies per minute)	Low-power mode (W)	Low-power default time	Recovery time 30 secs	Off mode (W)	Off default time	Automatic duplex mode
20<cpm≤44	NA	NA	NA	≤20	≤30 min	No
cpm>44	NA	NA	NA	≤40	≤90 min	No

The Testing conditions contain procedures for measuring the average power consumption of copiers in the off and the other modes. In all cases the unit must be pre-conditioned for a minimum of 24 hrs at ambient room temperature, and plugged in to a live power line but turned off for at least 12 hours.

Scanners

A scanner is an electro-optical device for converting colour or black-and-white graphical information into electronic images that can be stored, edited converted or transmitted, primarily in a computing environment. The Energy Star program focuses mainly on the most common designs (eg flatbed, sheet-fed and film scanners), but other types that meet the criteria may also qualify for the label.

The criteria are simply that the scanner should enter a low-power mode of not more than 12 watts, after not more than 15 minutes of inactivity, and that this should be set be the supplier before shipping the product.

The average power consumption in low-power mode is measured as an average, ie by measuring power consumption over a long enough time period to allow for typical variations or surges in power, such as cycling of the lamps (1 hour is recommended). Where low-power mode consumption does not vary it is acceptable to take several measurements of instantaneous power using a high-quality watt-meter.

Multi-Function Devices (MFDs)

A MFD is a physically integrated device of a combination of fully integrated components whose primary function is copying, but is also able to carry out one or both of the additional core functions of printing or faxing. The MFD may be connected to a network, and may produce copies in black-and-white, grey scale or colour.

The Energy Star criteria for MFDs using standard paper formats and large paper formats are summarised in Table 102 and Table 103. These are similar to the requirements for copiers, except that there is no default time specified to low-power mode, and there is reference to a sleep mode rather than an off mode. For MFDs:

- low-power mode is the condition that exists when the machine is not producing hard-copy output, and is consuming less power than when it is in standby mode; and
- sleep mode is the lowest power state the unit can automatically attain without actually turning off.

Table 102. Energy Star power management requirements for standard format MFDs

MFD speed (images per minute)	Low-power mode (W)	Recovery time 30 secs	Sleep mode (W)	Sleep mode default time	Automatic duplex mode
0<ipm≤10	NA	NA	≤25	≤ 15 min	No
10<ipm≤20	NA	NA	≤70	≤ 30 min	No
20<ipm≤44	3.85x cpm+50	Yes	≤80	≤ 60 min	Optional
44<ipm≤100	3.85x cpm+50	Recommended	≤85	≤ 90 min	Optional
ipm>100	3.85x cpm+50	Recommended	≤105	≤ 120min	Optional

Table 103. Energy Star power management requirements for large format MFDs

MFD speed (images per minute)	Low-power mode (W)	Recovery time 30 secs	Sleep mode (W)	Sleep mode default time	Automatic duplex mode
0<ipm≤40	NA	NA	≤70	≤ 30 min	No
Ipm>40	4.85×cpm+50	Recommended	≤105	≤ 90min	No

Some digital copiers can be upgraded into an MFD in the field with the installation of add-on devices that allow printing or faxing. These are termed upgradeable digital copiers (UDCs). Suppliers may consider such a system of components to be an MFD and seek Energy Star endorsement if it meets the criteria Table 104 or Table 105.

Table 104. Energy Star power management requirements for standard format UDCs

MFD speed (images per minute)	Low-power mode (W)	Recovery time 30 secs	Sleep mode (W)	Sleep mode default time
0<ipm≤10	NA	NA	≤5	≤ 15 min
10<ipm≤20	NA	NA	≤5	≤ 30 min
20<ipm≤44	3.85× cpm+5	Yes	≤15	≤ 60 min
44<ipm≤100	3.85× cpm+5	Recommended	≤20	≤ 90 min
ipm>100	3.85× cpm+5	Recommended	≤20	≤ 120min

Table 105. Energy Star power management requirements for large format UDCs

MFD speed (images per minute)	Low-power mode (W)	Recovery time 30 secs	Sleep mode (W)	Sleep mode default time
0<ipm≤40	NA	NA	≤65	≤ 30 min
ipm>40	4.85× cpm+45	Recommended	≤100	≤ 90min

In order to be classified as a UDC under the MFD rules, the upgrade options must be available on the market or intended for availability within one year of the base unit being launched. Digital copiers that are not designed for functional upgrades must qualify for energy Star under the copier criteria.

MFDs and UDCs must be shipped with the default time to low-power mode set at 15 minutes.

Duplexing (automatically printing images on both sides of the paper) is not required to be the default setting for any MFD. However, it is required to be offered as an option for all standard format models rated faster than 20 images per minute. Further, it is recommended that duplexing be set as the default mode for copying and any other feasible functions and its use described to customers upon installation.

Controlling Devices

A controlling device is a device easily installed by the end user and designed to reduce the energy consumption of existing personal computers, monitors or printers by turning them off when not in use. The device may consist of external hardware units connected via cables to the personal computer, monitor or printer, and may also include a software-based user interface. If both hardware and software components are required, they must be sold together. A device may control one or more types of units.

The requirements for Energy Star controlling devices specify that the device must have the capability of switching the unit it controls off, or into a low-power state. Monitor controlling devices must allow the user to easily select the idle period after which the low-power state shall be activated; at a minimum the device must be capable of triggering low power states after 15 minutes of inactivity, and automatically return the monitor to full operation after a user input.

Printer controlling devices must allow the user to easily select the idle period after which the low-power state shall be activated; at a minimum the device must be capable of triggering low power states after 30 minutes of inactivity, and must automatically return the printer to full operation after a print signal, without loss of the new print data.

Computer controlling devices must be capable of:

- allowing the user to easily select the idle period after which the low-power state shall be activated:
- turning the computer of at a predetermined time each day; and
- saving any open documents prior to turning off the system,
- returning the user to the exact position in files prior to the activation of the low-power state.

The test conditions are not specified, but it is clearly possible to test whether a product meets the criteria with the aid of a stopwatch, and simple observation of the state of the system before activation and after restart and system restoration.

F:2 Home Electronics

Televisions and VCRs are essentially identical products around the world and have a comparatively narrow production base. As a result there are no known problems with definitions between energy efficiency regulations used in APEC economies. APEC economies having energy efficiency regulations for TVs and VCRs are indicated in Table 106. Other home electronic devices subject to energy regulations are included in the last section for completeness.

Table 106: Energy efficiency regulations for TVs and VCRs by member economy

Type of air conditioner	China	Japan	Korea	Russia	USA
TV MEPS	✓			✓	
TV high impact targets[1]		✓[2]			
TV mandatory labelling					
TV award labelling			✓[4]		✓[4]
VCR MEPS					
VCR high impact targets[1]		✓[3]			
VCR mandatory labelling					
VCR award labelling			✓[4]		✓[4]

1 These are voluntary efficiency targets with a very high, if not total, compliance level
2 Targets have been in place since 1994 but new stricter targets will apply from 2003 (Top Runner)
3 New targets will apply from 2003 (Top Runner)
4 US EPA Energy Star criteria (called Energy Boy in Korea).

F:3 Televisions

F:3.1 China

Program: MEPS for televisions

Scope

Chinese TV energy efficiency regulations apply to colour TVs with diagonal screen sizes between 37 and 56 cm and to black and white TVs with diagonal screen sizes between 31 and 47 cm.

Summary of test procedure

The Chinese test procedure is defined in the MEPS regulations, GB12021.7-89: *The limited value and testing method of electrical energy consumption for broadcasting receiver of colour and monochromatic television.*

The only other standard referenced in this regulation is GB 10239-88.

The standard sets maximum permissible total power demand levels, and also maximum active sound output power levels, as a function of the screen size and TV type (colour or black and white). English versions of these test procedures are not yet available so it has not been possible to analyse the requirements for this report.

F:3.2 Japan

Program: Top Runner energy targets for televisions

Scope

Japanese TV energy efficiency regulations apply to all TVs and distinguish between types depending on the aspect ratio (4:3 or 16:9 widescreen format), the scan rate (normal or double speed), the functional configuration (basic TV or TV with VCR), and whether the resolution of double speed TVs is 'high vision' or not.

Summary of test procedure

The Japanese test procedure is JIS C 6101-88: *Measuring methods of receivers for television broadcast transmissions.* It makes no reference to any other test procedure.

Details

The procedure defines a variety of tests most of which are not concerned or related to the TV energy performance. The test conditions are such that their shall be no radio interference, the incident luminance incident on the tube surface is 75 lux, and the background noise level no more than 35 dB(A). The ambient temperature is 20°C and the air should have a relative humidity of 65%. The test input signal used to adjust the receivers should be –50 dB (mW) standard test input signal, for the video signal a test pattern signal is used, while the test sound carrier is a 1 kHz signal with 30% modulation of depth. The TV is tuned to give the best reception of the test signal and its contrast adjusted to minimise distortion of the resolution. The brightness is set within a beam current so that no blooming of is caused for each electron gun. The volume control is set to the position corresponding to the standard test output. Tone, balance, picture quality, colour saturation, hue and synchronisation controls are all set at specified positions. Each test is conducted once the receiver has reached 'sufficiently stable conditions'.

The power consumption and voltage of each part of the TV is measured under the standard test operating conditions. Voltage and current readings are expressed in RMS values.

There appear to be no measurement tests conducted with the TV in the standby active or standby passive modes; however, the Japanese target values for 2003 define the annual energy consumption of a TV in terms of a time weighted sum of power demands spent in the on-mode and standby mode as follows:

$E_M = \{ (P_0 - P_A / 4) \times 1642.5 + P_S \times 7117.5\} / 1000$

E_M is the annual energy consumption of the TV in kWh/yr.
P_0 is the power consumption in the on-mode measured according to JIS C 6101-88
P_A is the on-mode power consumption saved by power saving functions
P_S is the power consumption in the standby mode, t_1 is the estimated average on time per day (set at 4.5 hours) and t_2 is the estimated time spent in the standby mode (set at 19.5 hours).

The method of measuring P_A and P_S does not appear to be specified nor does the definition of the standby-mode.

F:3.3 Korea

Program: Energy Boy endorsement label for TVs

Scope

TVs in Korea are eligible to display the Energy Boy energy efficiency award label providing they meet the energy performance criteria established for the US EPA's Energy Star scheme. The details of this are described for the United States below.

F:3.4 Russia

Program: MEPS for televisions

Scope

Russian TV energy efficiency regulations apply to non-portable TVs with diagonal screen sizes between 40 and 67 cm and to portable TVs with diagonal screen sizes between 16 and 44 cm.

Summary of test procedure

The Russian test procedure is defined in the MEPS regulations, GOST 18198-89: *Television receivers.* The standard only applies to the on-mode consumption as at the time it was introduced there were no TVs with standby consumption on the Russian market. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

F:3.5 The United States of America

Program: Energy Star endorsement label for TVs

Scope

TVs in the USA are eligible to display the US EPA's Energy Star energy efficiency award label providing they use 3W or less when switched off (i.e. when in the standby mode). TV and VCR combinations should use 6W or less to be eligible.

Summary of test procedure

The US TV energy consumption test procedure is CFR 430 Subpart B, Appendix H, *Uniform test method for measuring the energy consumption of television sets.* This test procedure has been developed by the US DOE and is quoted in the Code of Federal Regulations concerned with the National Appliance Energy Conservation Act even though there are no MEPS in place for TVs.

It makes no reference to any other test procedure.

Details

On mode power consumption is tested as follows. The TV set is turned on and left to warm up for at least 5 minutes. The synchronisation controls are adjusted for a standard test pattern and a pre-specified standard white pattern is applied. All the controls, except the volume and synchronisation controls, are adjusted to give the maximum power reading on a wattmeter. Un-illuminated room luminance sensors are illuminated to give maximum power consumption and P_W, the white power consumption, is recorded. The signal source is changed to the pre-specified standard black pattern and all controls, except the volume and synchronisation controls, are adjusted to give the minimum power reading on a wattmeter. Room illuminance sensors are covered up to give minimum power consumption and P_B, the black power consumption, is recorded. The operating power consumption P_0, in Watts is recorded as:

$$P_0 = (P_w + P_B / 2)$$

[Note: equation is as recorded in the CFR - unclear whether this is correct.]

The standby power is measured as follows:

-for TVs without a vacation switch or remote control defeat switch, the power switch is turned off and the standby power measured after two minutes

-for TVs with a remote control defeat switch, a vacation switch or both, the standby power is measured as:

$$P_S = [(P_{max} - P_{min}) / 2] + P_{min}$$

where:

P_S = standby power in watts

P_{max} = power consumption, in watts, measured with the TV set power switch off and the vacation switch and remote control defeat switch in the highest energy consuming position.

P_{min} = power consumption, in watts, measured with the TV set power switch off and the vacation switch and remote control defeat switch in the lowest energy consuming position.

The average annual energy consumption, E, in kWh/year is determined as:

$$E = 2.2 \times P_0 + 6.56 \times P_S$$

which assumes that the TV is on for 2200 hours per year and that the standby is activated for 6560 hours per year. Only the standby power consumption is used to determine the Energy Star criteria.

F:4 Video Cassette Recorders (VCR)

F:4.1 Korea

Program: Energy Boy endorsement label for VCRs

Scope

VCRs in Korea are eligible to display the Energy Boy energy efficiency award label providing they meet the energy performance criteria established for the US EPA's Energy Star scheme. The details of this are described for the United States below.

F:4.2 Japan

Program: Top Runner energy targets for VCRs.

Scope

VCRs will be included in the Top Runner program from 2003. The main measurement of interest for this program is the standby energy consumption. As far as can be ascertained, the test procedure is the same as that specified for the USA below.

F:4.3 United States of America

Program: Energy Star endorsement label for VCRs

Scope

VCRs in the USA are eligible to display the US EPA's Energy Star energy efficiency award label providing they use 4W or less when switched off (i.e. when in the standby mode). TV and VCR combinations should use 6W or less to be eligible.

Summary of test procedure

The test procedure for VCR standby power consumption is defined by the US EPA. It is understood that the test method is used to determine the standby energy consumption. However, details were not available for this report.

F:5 Other Consumer Electronics & Equipment

This section contains details of miscellaneous electronic equipment as well as some requirements for office equipment in Russia.

F:5.1 China

Program: mandatory MEPS for radio receivers and recorders

Summary of Test Procedure

Energy efficiency requirements for radio receivers and recorders are set out in GB 12021.8-89 while the test procedure is specified in GB2018 and GB6163. English versions of these test procedures are not yet available so it has not been possible to analyse the requirements for this report.

F:5.2 Russia

Program: mandatory MEPS for amplifiers

Summary of Test Procedure

Energy efficiency requirements for amplifiers are set out in GOST 24388-88: Domestic sound frequency signal amplifiers. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

F:5.3 Russia

Program: mandatory MEPS for computers

Summary of Test Procedure

Energy efficiency requirements for computers are set out in GOST 27201-87: Personal computers. Types, basic parameters, general requirements. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

F:5.4 Russia

Program: mandatory MEPS for printers

Summary of Test Procedure

Energy efficiency requirements for printers are set out in GOST 21776-87: Printers. General specifications. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

F:5.5 Russia

Program: mandatory MEPS for graphical input devices

Summary of Test Procedure

Energy efficiency requirements for graphical input devices are set out in GOST 24593-87: Graphic input devices for electronic computers, General specifications. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

F:5.6 Russia

Program: mandatory MEPS for plotters

Summary of Test Procedure

Energy efficiency requirements for plotters are set out in GOST 19098-87: Plotters for electronic computers. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

F:5.7 Russia

Program: mandatory MEPS for computer monitors

Summary of Test Procedure

Energy efficiency requirements for computer monitors are set out in GOST 27954-88: Personal computer video monitors. Types, basic parameters, general technical requirements. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

F:5.8 Russia

Program: mandatory MEPS for general purpose digital computers

Summary of Test Procedure

Energy efficiency requirements for general purpose digital computers are set out in GOST 16325-88: General purpose digital computers. General technical requirements. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

ANNEX G: MISCELLANEOUS APPLIANCES AND EQUIPMENT

This section contains details of test procedures used to test a range of regulated equipment and appliances not covered in the previous sections. These include:

- Cooking appliances (ranges, ovens and rice cookers);
- Electric irons;
- Pumps
- Transformers

G:1 Cooking Equipment

Table 107: Summary of Cooker Energy Programs

	Australia	Brunei	Canada	Chile	China	Hong Kong, China	Indonesia	Japan	Korea	Malaysia	Mexico	New Zealand	Papua New Guinea	Peru	Philippines	Russia	Singapore	Chinese Taipei	Thailand	USA	Vietnam
Energy Labelling			M		M				U												
MEPS			M						U							M					

M = mandatory, V = voluntary, U = under consideration, T = Japanese Top Runner
Note: Program for China is rice cookers

G:1.1 Canada

Program: mandatory MEPS and energy labelling for cookers

Summary of Test Procedure

The test procedure for the measurement of energy consumption of electric cookers, which includes cooktops (which are also known as hobs), separate ovens and ranges (which is a cooktop and oven built into a free standing unit) are specified in the standard CAN/CSA-C358-M89, although CAN/CSA-C358-95 is expected to be adopted in 1999. This is harmonised with US CFR430 Appendix I, although the US does not use this test procedure at this stage for regulatory purposes. For cooktops, a standardised aluminium block (size varies depending on the hob size) is used to measure the energy consumption of the cooktop element during heating of the block to 80^{o}C above ambient. Power is then turned down to 25% and left running for a further 15 minutes. For ovens, the energy is measured to heat an aluminium test block up to 130^{o}C above ambient.

Details

The standard excludes from its scope microwaves, portable cookers, induction cooktops and those with a power rating of less than 250W. The nominal room temperature is set at 25°C.

For cooktops, there are two standardised aluminium blocks which are used to measure the heat transferred from the hob into item to be cooked. The larger block is 228.6mm diameter and 76 mm high (8.62 kg equivalent to 1980g of water) and is used on hobs over 175mm in diameter. The smaller block is 158mm diameter and 71mm high (3.85kg – equivalent to 885g of water) and is used on hobs less than or equal to 175mm in diameter. Both blocks are made of 6061 aluminium alloy which has a specific heat of 963 J/kg/°C and have a thermocouple inserted. The test block (at room temperature) is placed on the hob and this is turned to full power. When the block temperature rise is 80°C above ambient, the power is reduced to 25% and allowed to operate for a further 15 minutes. At the end of the test the temperature of the test block and the energy used during the test are recorded. The thermal efficiency is determined from the temperature rise of the block and the energy used to heat it. The annual energy service (useful output) delivered by a cooktop is based on US research and is assumed to be 277.7 kWh of delivered heat per year. The cooktop energy consumption is calculated as this value divided by the efficiency determined during the test.

For ovens, the small test block (at room temperature) is inserted at the geometric centre of the oven. The oven is turned on to normal bake at a temperature rise of 180°C (nominal temperature setting of 205°C). The energy and temperature of the block are noted during the test.. The oven is allowed to operate for a full thermostat cycle after the temperature rise has reached 130°C – the energy consumption is then interpolated for the thermostat cycle before and after to calculate the energy at a temperature rise of 130°C. The thermal efficiency is determined from the temperature rise of the block (130°C) and the energy used to heat it. The annual energy service (useful output) delivered by an oven is based on US research and is assumed to be 47.09 kWh of delivered heat per year. The oven energy consumption during use is calculated as this value divided by the efficiency determined during the test. The total energy consumption of an oven includes energy during use, energy consumed during self cleaning (assumed to be 11 times per year) and electric clock energy (measured separately). Oven space is also determined.

G:1.2 China

Program: mandatory MEPS for rice cookers

Summary of Test Procedure

Energy efficiency requirements for rice cookers are set out in GB12021.6-89 while the test procedure is specified in GB8968. English versions of these test procedures are not yet available so it has not been possible to analyse the requirements for this report.

G:1.3 Korea

Program: Mandatory energy labelling and MEPS for cookers – under consideration

Summary of test procedure

This program is under consideration, but the test procedures to be used have not yet been determined.

G:1.4 Russia

Program: mandatory MEPS for ranges

Summary of Test Procedure

Energy efficiency requirements for ranges are set out in GOST 14919-83E: Electric ranges. An English version of this test procedure is not yet available so it has not been possible to analyse the requirements for this report.

G:1.5 IEC 60350 – Cooktops and ranges

Summary of test procedure

IEC60350 was first published in 1971 and it was not until April 1999 that a new edition was released. This publication states and defines the principal performance characteristics of electric cooking ranges, hobs, ovens and grills and describes the standard methods for measuring performance characteristics. The standard is mainly concerned with the cooking and heating performance of cooking appliances rather than energy consumption. The few energy consumption tests that are included are somewhat dubious in nature.

Details

Tests are undertaken at an ambient temperature of 20^{o}C with a voltage supply regulated to within 1% of the rated value. The standard mandates a wide range of tests including:

- Hot plates – ability to heat water, temperature control, temperature overshoot and heat distribution (determined by cooking tests);
- Ovens – preheating test, accuracy of temperature control, energy consumption, heat distribution (determined by cooking tests);
- Grilling (grilling of meat and bread);
- Various tests for warming compartments and self cleaning ovens.

The tests of relevance to energy consumption are as follows:

Hotplates: water of 15^{o}C is heated in pan of specified size with a lid. The quantity of water varies from 1 to 2 litres, depending on the hob and pan size. Time taken and the energy consumption for a temperature rise of 75 K is determined. Test is repeated with the pan turned through 90^{o} and the results averaged.

Ovens: time and energy consumption is measured to preheat the oven for a temperature rise of 155 K for forced air and 180 K for natural convection ovens with the temperature control on maximum. The so called energy consumption test is determined with a wet brick at 5^{o}C inserted into the oven (yes it is true!). The temperature control on the oven is set for a temperature rise of 155 K for forced air and 180 K for natural convection ovens. The time and energy consumption is measured over the period that it takes for the temperature at centre of the brick to rise by 55 K.

G:1.6 Technical Issues Associated with the use of IEC60350

The majority of IEC60350 is concerned with cooking performance of cooking appliances. The few energy consumption tests included are rather dubious in nature and somewhat arbitrary. The use of water in pans as a means of measuring energy consumption of cooktops is known to have some repeatability problems and so is not recommended. The use of an aluminium block will probably give more repeatable results for cooktops. A steel base can be fitted to accommodate induction cooktops. The oven heat up test is rather unscientific as the potential cycling of the oven element is not taken into account. The use of a wet brick for the energy consumption test is rather arbitrary and is not representative of any cooking task. It is also likely to be unrepeatable given the impact of the evaporation of water during heatup. An alternative option would be to undertake a heat up test with an aluminium block. Once the oven has reached temperature (eg for baking) the heat absorbed by the food is insignificant, so a heat loss test (without a load) could provide a much more reliable measure of energy consumption per hour of use (together with a specified number of cold heatups). It is not recommended that IEC60350 be used for the regulation of energy consumption for cookers.

G:2 Electric Irons

G:2.1 China

Program: mandatory MEPS for electric irons

Summary of Test Procedure

Energy efficiency requirements for electric irons are set out in GB12021.5-89 while the test procedure is specified in GB4706.2-86 and GB10154. English versions of these test procedures are not yet available so it has not been possible to analyse the requirements for this report.

G:3 Fans

G:3.1 China

Program: mandatory MEPS for electric fans

Summary of Test Procedure

Energy efficiency requirements for electric fans, together with the method of test, are set out in GB12021.9-89. English versions of these test procedures are not yet available so it has not been possible to analyse the requirements for this report.

G:3.2 Chinese Taipei

Program: mandatory MEPS for industrial/commercial ventilating fans and household fans.

Summary of Test Procedure

While it is known that Chinese Taipei mandates MEPS levels for both household electric fans and commercial/industrial ventilating fans, the test procedures are not yet available so it has not been possible to analyse the requirements for this report. The test procedures for commercial/industrial ventilating fans are set out in CNS 7778 and CNS 7779 but apparently are being replaced with AMCA 210, AMCA 300 and/or ISO 5801.

G:4 Pumps

G:4.1 Mexico

Program: mandatory MEPS for electric pumps

Summary of Test Procedure

Energy efficiency requirements are set in Mexico as follows:

- NOM-001-ENER-1995 for vertical pumps - this is equivalent to ISO3555 - Centrifugal, mixed flow and axial pumps - code for acceptance tests, class B and possibly also ISO2548 (class C).
- NOM-004-ENER-1995 for centrifugal residential water pumps - this is also equivalent to ISO3555.
- NOM-006-ENER-1995 for deep well pumps - this is a local Mexican test procedure with no international equivalent.
- NOM-010-ENER-1996 for submersible pumps - this is also equivalent to ISO3555

Mexico is the only country that specifies the minimum energy efficiency of pump systems. The test procedure for most pump systems (except deep well pumps) in Mexico is already aligned with ISO standards for these products. There is currently no known relevant ISO standard for deep well pumps.

G:5 Transformers

G:5.1 Canada

Program: mandatory MEPS for transformers

Summary of Test Procedure

Energy efficiency requirements are proposed by NRCAN for Canada and within 2 provinces in Canada, but as of early 1999 no regulations were in force. Efficiency requirements and the test procedure are set out in CAN/CSA-C802-94. This test procedure covers distribution (up to 3 MVA), power (up to 10 kVA) and dry-type transformers (up to 7.5MVA). The test procedure for determining losses is set out in ANSI/IEEE C57.12.90 and ANSI/IEEE C57.12.91. Maximum no load and full load losses are set out in CAN/CSA-C802-94 for various types and sizes at no load and full load.

Canada is the only economy likely to regulate transformers in the near future and already uses a relevant regional test procedure.

G:5.2 USA

Program: Energy star in the USA currently applies to transformers.

Summary of Test Procedure

The test procedures used have not yet been determined.

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For APEC Secretariat
438 Alexandra Road
#14-00, Alexandra Point
Singapore 119958
Tel: +65 2761880 Fax: +65 2761775
Email: info@mail.apecsec.org.sg
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