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Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors —

Part 2:
Heating seasonal performance factor

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Climatiseurs à condenseur à air et pompes à chaleur air/air — Essais et méthodes de calcul des coefficients de performance saisonniers —

Partie 2: Coefficient de performance saisonnier de chauffage (COPSC)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 6, *Testing and rating of air-conditioners and heat pumps*.

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The parts of ISO 16358 are given below:

— *Part 1: Cooling seasonal performance factor*

— *Part 2: Heating seasonal performance factor*

— *Part 3: Annual performance factor*

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Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors —

Part 2: Heating seasonal performance factor

1 Scope

1.1 This part of ISO 16358 specifies the testing and calculating methods for seasonal performance factor of equipment covered by ISO 5151, ISO 13253 and ISO 15042. For the purposes of this part of ISO 16358, it is assumed that any make-up heating will be provided by electric heaters running concurrently with the heat pump.

1.2 This part of ISO 16358 also specifies the seasonal performance test conditions and the corresponding test procedures for determining the seasonal performance factor of equipment, as specified in 1.1, under mandatory test conditions and is intended for use only in marking, comparison, and certification purposes.

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1.3 This part of ISO 16358 does not apply to the testing and rating of:

a) water-source heat pumps or water-cooled air conditioners;

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b) portable units having a condenser exhaust duct;

c) individual assemblies not constituting a complete refrigeration system; or

d) equipment using the absorption refrigeration cycle.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5151, *Non-ducted air conditioners and heat pumps — Testing and rating for performance*

ISO 13253, *Ducted air-conditioners and air-to-air heat pumps — Testing and rating for performance*

ISO 15042, *Multiple split-system air-conditioners and air-to-air heat pumps — Testing and rating for performance*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5151, ISO 13253, ISO 15042 and the following apply.

3.1
defined heating load, L_h
heat defined as heating demand for a given outdoor temperature

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3.2
make-up heating
electric heat required to cover the deficiency of the heating capacity delivered by the heat pump for the heating load

3.3
heating seasonal total load
HSTL
total annual amount of heat, including make-up heat, which is added to the indoor air when the equipment is operated for heating in active mode

3.4
heating seasonal energy consumption
HSEC
total annual amount of energy consumed by the equipment, including make-up heat, when it is operated for heating in active mode

3.5
heating seasonal performance factor
HSPF
ratio of the total annual amount of heat that the equipment, including make-up heat, can add to the indoor air when operated for heating in active mode to the total annual amount of energy consumed by the equipment during the same period

3.6
part load factor
PLF
ratio of the performance when the equipment is cyclically operated to the performance when the equipment is continuously operated, at the same temperature and humidity conditions

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3.7
degradation coefficient, C_D
coefficient that indicates efficiency loss caused by cyclic operation

3.8
fixed capacity unit
equipment which does not have possibility to change its capacity

Note 1 to entry: to entry This definition applies to each cooling and heating operation individually.

3.9
two (2)-stage capacity unit
equipment where the capacity is varied by two steps

Note 1 to entry: This definition applies to each cooling and heating operation individually.

3.10
multi-stage capacity unit
equipment where the capacity is varied by 3 or 4 steps

Note 1 to entry: This definition applies to each cooling and heating operation individually.

3.11
variable capacity unit
equipment where the capacity is varied by five or more steps to represent continuously variable capacity

Note 1 to entry: This definition applies to each cooling and heating operation individually.

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3.12
heating full-load operation
operation with the equipment and controls configured for maximum continuous refrigeration capacity at H1 condition

Note 1 to entry: Unless otherwise regulated by the automatic controls of the equipment, all indoor units and compressors shall be functioning.

3.13
heating extended-load operation
operation of the equipment at maximum continuous refrigeration capacity at H2 condition

Note 1 to entry: Unless otherwise regulated by the automatic controls of the equipment, all indoor units and compressors shall be functioning.

3.14
minimum-load operation
operation of the equipment and controls at minimum continuous refrigeration capacity

Note 1 to entry: All indoor units shall be functioning

3.15
standard heating full capacity
heating capacity at H1 at full-load operating condition

3.16
standard heating full power input
electric power input at H1 at full-load operating condition

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3.17
standard heating half capacity
capacity which is 50 % of heating full capacity at H1 condition with all indoor units functioning

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3.18
standard heating half power input
electric power input when operated at 50 % of heating full capacity at H1 condition with all indoor units functioning

3.19
standard heating minimum capacity
capacity which is minimum heating capacity at H1 condition at the minimum-load operation

3.20
standard heating minimum power input
electric power input when operated at minimum heating capacity at H1 condition at the minimum-load operation

3.21
standard heating extended capacity
heating capacity when operated at H2 condition at the extended-load operation

3.22
standard heating extended power input
electric power input when operated at H2 condition at the extended-load operation

3.23
total heating seasonal performance factor
THSPF
ratio of the total annual amount of heat that the equipment, including make-up heat, can add to the indoor air to the total annual amount of energy consumed by the equipment, including the active, inactive and disconnected modes

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3.24
active mode
mode corresponding to the hours with a heating demand of the building and whereby the heating function of the unit is switched on

3.25
inactive mode
mode corresponding to the hours when the unit is not operating to meet heating demand

Note 1 to entry: This mode may include the operation of a crankcase heater.

3.26
disconnected mode
mode corresponding to the hours when the unit is electrically disconnected from the main power supply

Note 1 to entry: Power consumption is zero.

4 Symbols

Symbol	Description	Unit
C_{HSE}	heating seasonal energy consumption (HSEC)	Wh
$C_{OP}\ (t)$	heating coefficient of performance (COP) at continuous outdoor temperature t	W/W
$C_{OP}\ (t_j)$	heating coefficient of performance (COP) at outdoor temperature t_j	W/W
$C_{OP,\ ext}\ (t_h)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating extended capacity	W/W
$C_{OP,\ ext,\ f}\ (t_f)$	heating coefficient of performance (COP) when heating load is equal to frosting range heating extended capacity	W/W
$C_{OP,\ fe}\ (t_j)$	heating coefficient of performance (COP) in non-frosting variable operation between full and extended capacity at outdoor temperature t_j	W/W
$C_{OP,\ fe,\ f}\ (t_j)$	heating coefficient of performance (COP) in frosting variable operation between full and extended capacity at outdoor temperature t_j	W/W
$C_{OP,\ ful}\ (t_a)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating full capacity	W/W
$C_{OP,\ ful,\ f}\ (t_g)$	heating coefficient of performance (COP) when heating load is equal to frosting range heating full capacity	W/W
$C_{OP,\ haf}\ (t_d)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating half capacity	W/W
$C_{OP,\ haf,\ f}\ (t_e)$	heating coefficient of performance (COP) when heating load is equal to frosting range heating half capacity	W/W
$C_{OP,\ hf}\ (t_j)$	heating coefficient of performance (COP) in non-frosting variable operation between half and full capacity at outdoor temperature t_j	W/W
$C_{OP,\ hf,\ f}\ (t_j)$	heating coefficient of performance (COP) in frosting variable operation between half and full capacity at outdoor temperature t_j	W/W
$C_{OP,\ mh}\ (t_j)$	heating coefficient of performance (COP) in non-frosting variable operation between minimum and half capacity at outdoor temperature t_j	W/W
$C_{OP,\ mh,f}\ (t_j)$	heating coefficient of performance (COP) in frosting variable operation between minimum and half capacity at outdoor temperature t_j	W/W
$C_{OP,\ min}\ (t_q)$	heating coefficient of performance (COP) when heating load is equal to non-frosting range heating minimum capacity	W/W

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Symbol	Description	Unit
$C_{OP, min,f}$ (t_r)	heating coefficient of performance (COP) when heating load is equal to frosting range heating minimum capacity	W/W
F_{HSP}	heating seasonal performance factor (HSPF)	–
F_{PL} (t_j)	part load factor (PLF) at outdoor temperature t_j	–
F_{THSP}	total heating seasonal performance factor (THSPF)	–
L_{HST}	heating seasonal total load (HSTL)	Wh
$L_h(t_j)$	defined heating load at outdoor temperature t_j	W
n	number of temperature bins	–
n_j	bin hours	h
$P(t)$	heating power input calculated by equation of $P(t_j)$ at continuous outdoor temperature t	W
$P(t_j)$	heating power input applicable to any capacity at outdoor temperature t_j	W
$P_{ext}(t_j)$	non-frosting range heating extended power input at outdoor temperature t_j	W
$P_{ext}(-7)$	heating extended power input at outdoor temperature −7 °C	W
$P_{ext}(2)$	calculated heating extended power input at outdoor temperature 2 °C	W
$P_{ext, f}(t_j)$	frosting range heating extended power input at outdoor temperature t_j	W
$P_{ext, f}(2)$	heating extended power input at H2 temperature condition	W
$P_{fe}(t_j)$	heating power input in variable operation between full and extended capacity at outdoor temperature t_j	W
$P_{ful}(t_j)$	non-frosting range heating full power input at outdoor temperature t_j	W
$P_{ful}(7)$	heating full power input at H1 temperature condition	W
$P_{ful}(-7)$	heating full power input at outdoor temperature −7 °C	W
$P_{ful}(2)$	calculated heating full power input at outdoor temperature 2 °C	W
$P_{ful, f}(t_j)$	frosting range heating full power input at outdoor temperature t_j	W
$P_{ful, f}(2)$	heating full power input at H2 temperature condition	W
$P_{haf}(t_j)$	non-frosting range heating half power input at outdoor temperature t_j	W
$P_{haf}(7)$	heating half power input at H1 temperature condition	W
$P_{haf}(-7)$	heating half power input at outdoor temperature −7 °C	W
$P_{haf}(2)$	calculated heating half power input at outdoor temperature 2 °C	W
$P_{haf, f}(t_j)$	frosting range heating half power input at outdoor temperature t_j	W
$P_{haf, f}(2)$	heating half power input at H2 temperature condition	W
$P_{hf}(t_j)$	heating power input in variable operation between half and full capacity at outdoor temperature t_j	W
$P_{mf}(t_j)$	heating power input in second stage cyclic operation between minimum and full capacity at outdoor temperature t_j	W
$P_{mh}(t_j)$	heating power input in variable operation between minimum and half capacity at outdoor temperature t_j	W
$P_{min}(t_j)$	non-frosting range heating minimum power input at outdoor temperature t_j	W
$P_{min}(7)$	heating minimum power input at H1 temperature condition	W
$P_{min}(-7)$	heating minimum power input at outdoor temperature −7 °C	W
$P_{min}(2)$	calculated heating minimum power input at outdoor temperature 2 °C	W

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Symbol	Description	Unit
$P_{min, f}(t_j)$	frosting range heating minimum power input at outdoor temperature t_j	W
$P_{min, f}(2)$	heating minimum power input at H2 temperature condition	W
$P_{RH}(t_j)$	make-up heating energy at outdoor temperature t_j	Wh
t	general continuous outdoor temperature	°C
t_j	outdoor temperature corresponding to each temperature bin	°C
t_a	outdoor temperature when heating load is equal to non-frosting range heating full capacity	°C
t_d	outdoor temperature when heating load is equal to non-frosting range heating half capacity	°C
t_e	outdoor temperature when heating load is equal to frosting range heating half capacity	°C
t_f	outdoor temperature when heating load is equal to frosting range heating extended capacity	°C
t_g	outdoor temperature when heating load is equal to frosting range heating full capacity	°C
t_h	outdoor temperature when heating load is equal to non-frosting range heating extended capacity	°C
t_q	outdoor temperature when heating load is equal to non-frosting range heating minimum capacity	°C
t_r	outdoor temperature when heating load is equal to frosting range heating minimum capacity	°C
$X(t_j)$	ratio of load to capacity at outdoor temperature t_j	–
$X_{fe}(t_j)$	ratio of excess capacity over load to capacity difference between full and extended capacity at outdoor temperature t_j	–
$X_{hf}(t_j)$	ratio of excess capacity over load to capacity difference between half and full capacity at outdoor temperature t_j	–
$X_{mf}(t_j)$	ratio of excess capacity over load to capacity difference between minimum and full capacity at outdoor temperature t_j	–
$X_{mh}(t_j)$	ratio of excess capacity over load to capacity difference between minimum and half capacity at outdoor temperature t_j	–
$\phi(t)$	heating capacity calculated by equation of $\phi(t_j)$ at continuous outdoor temperature t	W
$\phi(t_j)$	heating capacity applicable to any capacity at outdoor temperature t_j	W
$\phi_{ext}(t_j)$	non-frosting range heating extended capacity at outdoor temperature t_j	W
$\phi_{ext}(-7)$	heating extended capacity at outdoor temperature −7 °C	W
$\phi_{ext}(2)$	calculated heating extended capacity at outdoor temperature 2 °C	W
$\phi_{ext, f}(t_j)$	frosting range heating extended capacity at outdoor temperature t_j	W
$\phi_{ext, f}(2)$	frosting range heating extended capacity at H2 temperature condition	W
$\phi_{ful}(t_j)$	non-frosting range heating full capacity at outdoor temperature t_j	W
$\phi_{ful}(7)$	heating full capacity at H1 temperature condition	W
$\phi_{ful}(-7)$	heating full capacity at outdoor temperature −7 °C	W
$\phi_{ful}(2)$	calculated heating full capacity at outdoor temperature 2 °C	W
$\phi_{ful, f}(t_j)$	frosting range heating full capacity at outdoor temperature t_j	W
$\phi_{ful, f}(2)$	frosting range heating full capacity at H2 temperature condition	W

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Symbol	Description	Unit
$\phi_{haf}(t_j)$	non-frosting range heating half capacity at outdoor temperature t_j	W
$\phi_{haf}(7)$	heating half capacity at H1 temperature condition	W
$\phi_{haf}(-7)$	heating half capacity at outdoor temperature −7 °C	W
$\phi_{haf}(2)$	calculated heating half capacity at outdoor temperature 2 °C	W
$\phi_{haf,f}(t_j)$	frosting range heating half capacity at outdoor temperature t_j	W
$\phi_{haf,f}(2)$	frosting range heating half capacity at H2 temperature condition	W
$\phi_{min}(t_j)$	non-frosting range heating minimum capacity at outdoor temperature t_j	W
$\phi_{min}(7)$	heating minimum capacity at H1 temperature condition	W
$\phi_{min}(-7)$	heating minimum capacity at outdoor temperature −7 °C	W
$\phi_{min}(2)$	calculated heating minimum capacity at outdoor temperature 2 °C	W
$\phi_{min,f}(t_j)$	frosting range heating minimum capacity at outdoor temperature t_j	W
$\phi_{min,f}(2)$	frosting range heating minimum capacity at H2 temperature condition	W

5 Tests

5.1 General

These tests are additional to those in ISO 5151, ISO 13253 and ISO 15042.

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The accuracy of the instruments used for tests shall conform to the test methods and uncertainties of measurements specified in ISO 5151, ISO 13253 and ISO 15042.

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5.2 Test conditions

Temperature and humidity conditions as well as default values for calculation shall be as specified in Table 1.

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Table 1 — Temperature and humidity conditions and default values for heating

Test	Characteristics	Fixed	Two-stage	Multi-stage	Variable	Default value
Standard heating capacity Indoor DB 20°C WB 15 °C Max. Outdoor DB 7°C WB 6°C	Full capacity $\phi_{ful}(7)$ (W)	■	■	■	■	
	Full power input $P_{ful}(7)$ (W)					
	Half capacity $\phi_{haf}(7)$ (W)	—	—	■	■	
	Half power input $P_{haf}(7)$ (W)					
	Minimum capacity $\phi_{min}(7)$ (W)	—	■	○	○	
	Minimum power input $P_{min}(7)$ (W)					
Low temperature heating capacity Indoor DB 20°C WB 15°C Max. Outdoor DB 2°C WB 1°C	Extended capacity $\phi_{ext,f}(2)$ (W)	—	—	■[a]	■[a]	
	Extended power input $P_{ext,f}(2)$ (W)					
	Calculated extended capacity $\phi_{ext}(2)$ (W)	—	—	b	b	$1{,}12\phi_{ext,f}(2)$
	Calcul'd extended power input $P_{ext}(2)$ (W)					$1{,}06P_{ext,f}(2)$
	Full capacity $\phi_{ful,f}(2)$ (W)	■[c]	■[c]	□[ac]	□[ac]	$\phi_{ful}(2)/1{,}12$[d]
	Full power input $P_{ful,f}(2)$ (W)					$P_{ful}(2)/1{,}06$[d]
	Half capacity $\phi_{haf,f}(2)$ (W)	—	—	○[c]	○[c]	$\phi_{haf}(2)/1{,}12$[d]
	Half power input $P_{haf,f}(2)$ (W)					$P_{haf}(2)/1{,}06$[d]
	Minimum capacity $\phi_{min,f}(2)$ (W)	—	○[c]	—	—	$\phi_{min}(2)/1{,}12$[d]
	Minimum power input $P_{min,f}(2)$ (W)					$P_{min}(2)/1{,}06$[d]
Extra-low temperature heating capacity Indoor DB 20°C WB 15°C Max. Outdoor DB −7°C WB −8°C	Extended capacity $\phi_{ext}(-7)$ (W)	—	—	○	○	$0{,}734\phi_{ext}(2)$
	Extended power input $P_{ext}(-7)$ (W)					$0{,}877P_{ext}(2)$
	Full capacity $\phi_{ful}(-7)$ (W)	○	○	○	○	$0{,}64\phi_{ful}(7)$
	Full power input $P_{ful}(-7)$ (W)					$0{,}82P_{ful}(7)$
	Half capacity $\phi_{haf}(-7)$ (W)	—	—	○	○	$0{,}64\phi_{haf}(7)$
	Half power input $P_{haf}(-7)$ (W)					$0{,}82P_{haf}(7)$
	Minimum capacity $\phi_{min}(-7)$ (W)	—	—	—	—	$0{,}64\phi_{min}(7)$
	Minimum power input $P_{min}(-7)$ (W)					$0{,}82P_{min}(7)$
Cyclic heating Indoor DB 20°C WB 15°C Max. Outdoor DB 7°C WB 6°C	Degradation coefficient C_D Full capacity	○	—	—	—	0,25
	Half capacity	—	—	○	—	0,25
	Minimum capacity	—	○	○	—	0,25

■ required test.

○ optional test.

□ test required when there is not an extended mode.

[a] When the equipment has an extended mode, low temperature extended capacity measurement is mandatory and low temperature full capacity measurement is optional. When the equipment has not an extended mode, low temperature full capacity measurement is mandatory.

[b] This value shall be calculated using default value.

[c] When this value is measured, $\phi_x(2)$ and/or $P_x(2)$ shall not be calculated from this value, but the equations in footnote d shall be used instead.

[d] The following two equations apply to the full capacity, half capacity and minimum capacity data when $\phi_{x,f}(2)$ and $P_{x,f}(2)$ are calculated:

$$\phi_x(2)=\phi_x(-7)+\frac{\phi_x(7)-\phi_x(-7)}{7-(-7)}\times\big(2-(-7)\big),\quad P_x(2)=P_x(-7)+\frac{P_x(7)-P_x(-7)}{7-(-7)}\times\big(2-(-7)\big)$$

NOTE Voltage(s) and frequency(ies) shall be as given in the three referenced standards.

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5.3 Test methods

5.3.1 Standard heating capacity tests

The standard heating capacity tests shall be conducted in accordance with Annex A of ISO 5151 and Annex B of ISO 13253 and ISO 15042. The heating capacity and effective power input shall be measured during the standard heating capacity tests.

The half capacity test shall be conducted at 50 % of full load operation. The test tolerance shall be ± 5 % of full load capacity for continuously variable equipment. For multi-stage equipment, if 50 % capacity is not achievable, then the test shall be conducted at the next step above 50 %.

The minimum capacity test shall be conducted at the lowest capacity control setting which allows steady-state operation of the equipment at the given test conditions.

If the minimum capacity tests are conducted, but if the required uncertainty of measurement specified in ISO 5151, ISO 13253 and ISO 15042 cannot be achieved, the alternative method of calculation shall be used. (Refer to 6.6.4 and 6.7.4.)

The manufacturer shall provide information on how to set the capacity if requested by the testing laboratories.

5.3.2 Low temperature heating capacity test

The low temperature heating capacity test shall be conducted at H2 condition in accordance with Annex A of ISO 5151 and Annex B of ISO 13253 and ISO 15042. The heating capacity and effective power input shall be measured during the low temperature heating capacity test.

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The half capacity test shall be conducted at 50 % of full load operation. The test tolerance shall be ± 5 % of full load capacity for continuously variable equipment. For multi-stage equipment, if 50 % capacity is not achievable, then the test shall be conducted at the next step above 50 %.

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The minimum capacity test shall be conducted at the lowest capacity control setting which allows steady-state operation of the equipment at the given test conditions.

If the minimum capacity tests are conducted, but if the required uncertainty of measurement specified in ISO 5151, ISO 13253 and ISO 15042 cannot be achieved, the alternative method of calculation shall be used. (Refer to 6.6.4 and 6.7.4.)

The manufacturer shall provide information on how to set the capacity if requested by the testing laboratories.

5.3.3 Extra-low temperature heating capacity test

The extra-low temperature heating capacity test shall be conducted at H3 condition in accordance with Annex A of ISO 5151 and Annex B of ISO 13253 and ISO 15042. The heating capacity and effective power input shall be measured during the extra-low temperature heating capacity test. If the test is not conducted, default values as given in Table 1 shall be used.

The half capacity test shall be conducted at 50 % of full load operation. The test tolerance shall be ± 5 % of full load capacity for continuously variable equipment. For multi-stage equipment, if 50 % capacity is not achievable, then the test shall be conducted at the next step above 50 %.

The manufacturer shall provide information on how to set the capacity if requested by the testing laboratories.

5.3.4 Cyclic heating test

The cyclic heating test shall be conducted in accordance with Annex C. If the test is not conducted, default values as given in Table 1 shall be used.

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