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

Part 1:
Cooling seasonal performance factor

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

Partie 1: Coefficient de performance saisonnier de refroidissement (COPSR)

Reference number
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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*.

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*

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

Part 1: Cooling 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.

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. For the purposes of this part of ISO 16358, the rating conditions are those specified under T1 in the reference standards in 1.1. The procedures in this part of ISO 16358 may be used for other temperature conditions.

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;

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 cooling load, L_C
heat defined as cooling demand for a given outdoor temperature

3.2
cooling seasonal total load
CSTL
total annual amount of heat that is removed from the indoor air when the equipment is operated for cooling in active mode

3.3
cooling seasonal energy consumption
CSEC
total annual amount of energy consumed by the equipment when it is operated for cooling in active mode

3.4
cooling seasonal performance factor
CSPF
ratio of the total annual amount of heat that the equipment can remove from the indoor air when operated for cooling in active mode to the total annual amount of energy consumed by the equipment during the same period

3.5
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

3.6
degradation coefficient, C_D
coefficient that indicates efficiency loss caused by cyclic operation

3.7
fixed capacity unit
equipment which does not have possibility to change its capacity

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

3.8
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.

3.9
multi-stage capacity unit
equipment where the capacity is varied by three or four steps

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

3.10
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.

3.11
cooling full-load operation
operation with the equipment and controls configured for the maximum continuous refrigeration capacity specified by the manufacturer and allowed by the unit controls

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

3.12
minimum-load operation
operation of the equipment and controls at minimum continuous refrigeration capacity

Note 1 to entry: All indoor units shall be functioning during the minimum-load operation.

3.13
standard cooling full capacity
cooling capacity at T1 at full-load operating conditions

3.14
standard cooling full power input
electric power input at T1 at full-load operating conditions

3.15
standard cooling half capacity
capacity which is 50 % of cooling full capacity at T1 condition with all indoor units functioning

3.16
standard cooling half power input
electric power input when operated at 50 % of cooling full capacity at T1 condition with all indoor units functioning

3.17
standard cooling minimum capacity
capacity at T1 condition at the minimum-load operation

3.18
standard cooling minimum power input
electric power input at T1 condition at the minimum-load operation

3.19
total cooling seasonal performance factor
TCSPF
ratio of the total annual amount of heat that the equipment can remove from the indoor air to the total annual amount of energy consumed by the equipment, including the active, inactive and disconnected modes

3.20
active mode
mode corresponding to the hours with a cooling demand of the building and whereby the cooling function of the unit is switched on

3.21
inactive mode
mode corresponding to the hours when the unit is not operating to meet cooling demand

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

3.22
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_{CSE}	cooling seasonal energy consumption (CSEC)	Wh
$E_{ER}(t)$	energy efficiency ratio (EER) at continuous outdoor temperature t	W/W

Symbol	Description	Unit
$E_{ER}(t_j)$	energy efficiency ratio (EER) at outdoor temperature t_j	W/W
$E_{ER, ful}(t_b)$	energy efficiency ratio (EER) when cooling load is equal to cooling full capacity	W/W
$E_{ER, haf}(t_c)$	energy efficiency ratio (EER) when cooling load is equal to cooling half capacity	W/W
$E_{ER, hf}(t_j)$	energy efficiency ratio (EER) in variable operation between half and full capacity at outdoor temperature t_j	W/W
$E_{ER, mh}(t_j)$	energy efficiency ratio (EER) in variable operation between minimum and half capacity at outdoor temperature t_j	W/W
$E_{ER, min}(t_p)$	energy efficiency ratio (EER) when cooling load is equal to cooling minimum capacity	W/W
F_{CSP}	cooling seasonal performance factor (CSPF)	–
$F_{PL}(t_j)$	part load factor (PLF) at outdoor temperature t_j	–
F_{TCSP}	total cooling seasonal performance factor (TCSPF)	–
L_{CST}	cooling seasonal total load (CSTL)	Wh
$L_c(t_j)$	defined cooling load at outdoor temperature t_j	W
n_j	bin hours	h
k, p, n, m	number of temperature bins	–
$P(t)$	cooling power input calculated by equation of $P(t_j)$ at continuous outdoor temperature t	W
$P(t_j)$	cooling power input applicable to any capacity at outdoor temperature t_j	W
$P_{ful}(t_j)$	cooling full power input at outdoor temperature t_j	W
$P_{ful}(35)$	cooling full power input at T1 temperature condition	W
$P_{ful}(29)$	cooling full power input at outdoor temperature 29 °C	W
$P_{haf}(t_j)$	cooling half power input at outdoor temperature t_j	W
$P_{haf}(35)$	cooling half power input at T1 temperature condition	W
$P_{haf}(29)$	cooling half power input at outdoor temperature 29 °C	W
$P_{hf}(t_j)$	cooling power input in variable operation between half and full capacity at outdoor temperature t_j	W
$P_{mf}(t_j)$	cooling power input in second stage cyclic operation between minimum and full capacity at outdoor temperature t_j	W
$P_{mh}(t_j)$	cooling power input in variable operation between minimum and half capacity at outdoor temperature t_j	W
$P_{min}(t_j)$	cooling minimum power input at outdoor temperature t_j	W
$P_{min}(35)$	cooling minimum power input at T1 temperature condition	W
$P_{min}(29)$	cooling minimum power input at outdoor temperature 29 °C	W
t	general continuous outdoor temperature	°C
t_j	outdoor temperature corresponding to each temperature bin	°C
t_b	outdoor temperature when cooling load is equal to cooling full capacity	°C
t_c	outdoor temperature when cooling load is equal to cooling half capacity	°C
t_p	outdoor temperature when cooling load is equal to cooling minimum capacity	°C
$X(t_j)$	ratio of load to 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	–

Symbol	Description	Unit
$X_{mf}(t_j)$	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	–
$\phi(t)$	cooling capacity calculated by equation of $\phi(t_j)$ at continuous outdoor temperature t	W
$\phi(t_j)$	cooling capacity applicable to any capacity at outdoor temperature t_j	W
$\phi_{ful}(t_j)$	cooling full capacity at outdoor temperature t_j	W
$\phi_{ful}(35)$	cooling full capacity at T1 temperature condition	W
$\phi_{ful}(29)$	cooling full capacity at outdoor temperature 29 °C	W
$\phi_{haf}(t_j)$	cooling half capacity at outdoor temperature t_j	W
$\phi_{haf}(35)$	cooling half capacity at T1 temperature condition	W
$\phi_{haf}(29)$	cooling half capacity at outdoor temperature 29 °C	W
$\phi_{min}(t_j)$	cooling minimum capacity at outdoor temperature t_j	W
$\phi_{min}(35)$	cooling minimum capacity at T1 temperature condition	W
$\phi_{min}(29)$	cooling minimum capacity at outdoor temperature 29 °C	W

5 Tests

5.1 General

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

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.

5.2 Test conditions

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

Table 1 — Temperature and humidity conditions and default values for cooling at T1 moderate climate condition of ISO 5151, ISO 13253 and ISO 15042

Test	Characteristics	Fixed	Two-stage	Multi-stage	Variable	Default value
Standard cooling capacity Indoor DB 27°C WB 19°C Outdoor DB 35°C WB 24°C	Full capacity $\phi_{ful}(35)$ (W)	■	■	■	■	—
	Full power input $P_{ful}(35)$ (W)					
	Half capacity $\phi_{haf}(35)$ (W)	—	—	○	■	$\phi_{haf}(29)/1,077$
	Half power input $P_{haf}(35)$ (W)					$P_{haf}(29)/0,914$
	Minimum capacity $\phi_{min}(35)$ (W)	—	○	○	○	$\phi_{min}(29)/1,077$
	Minimum power input $P_{min}(35)$ (W)					$P_{min}(29)/0,914$

■ required test.

○ optional test.

NOTE 1 If the minimum capacity test is measured, min(29) test is conducted first. Min(35) test may be measured or may be calculated by using default value.

NOTE 2 Voltage(s) and frequency(ies) are as given in the three referenced standards.

Table 1 *(continued)*

Test	Characteristics		Fixed	Two-stage	Multi-stage	Variable	Default value
Low temperature cooling capacity Indoor DB 27°C WB 19°C Outdoor DB 29°C WB 19°C	Full capacity $\phi_{ful}(29)$ (W)		■	■	■	—	1,077 × $\phi_{ful}(35)$
	Full power input $P_{ful}(29)$ (W)						0,914 × $P_{ful}(35)$
	Half capacity $\phi_{haf}(29)$ (W)		—	—	■	○	1,077 × $\phi_{haf}(35)$
	Half power input $P_{haf}(29)$ (W)						0,914 × $P_{haf}(35)$
	Minimum capacity $\phi_{min}(29)$ (W)		—	■	○	○	—
	Minimum power input $P_{min}(29)$ (W)						
Low humidity and cyclic cooling Indoor DB 27°C WB 16°C or lower Outdoor DB 29°C WB -	Degradation coefficient C_D	Full capacity	○	—	—	—	0,25
		Half capacity	—	—	○	—	0,25
		Minimum capacity	—	○	○	—	0,25

■ required test.

○ optional test.

NOTE 1 If the minimum capacity test is measured, min(29) test is conducted first. Min(35) test may be measured or may be calculated by using default value.

NOTE 2 Voltage(s) and frequency(ies) are as given in the three referenced standards.

5.3 Test methods

5.3.1 Standard cooling capacity tests

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

The low temperature cooling capacity test shall be conducted in accordance with Annex A of ISO 5151 and Annex B of ISO 13253 and ISO 15042. 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 tests 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.

5.3.3 Low humidity cooling test and cyclic cooling test

The low humidity cooling test and cyclic cooling 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.

6 Calculations

6.1 Cooling seasonal performance factor (CSPF) and total cooling seasonal performance factor (TCSPF)

The cooling seasonal performance factor (CSPF), F_{CSP}, of the equipment shall be calculated by Formula (1).

$$F_{CSP} = \frac{L_{CST}}{C_{CSE}} \tag{1}$$

In case of calculating the total cooling seasonal performance factor (TCSPF), refer to Annex B.

6.2 Defined cooling load

The defined cooling load shall be represented by a value and the assumption that it is linearly changing depending on the change in outdoor temperature.

Defined cooling load which shall be used is shown in Table 2.

Table 2 — Defined cooling load

Parameter	Load zero (0)	Load 100 %
Cooling load (W)	0	$\phi_{ful}(t_{100})$
Temperature (°C)	t_0	t_{100}

where t_{100} is the outdoor temperature at 100 % load and t_0 is the outdoor temperature at 0 % load.

Reference values of defined cooling load to be used shall be as follows:

t_0 = 20 °C and t_{100} = 35 °C

In case of setting other cooling load, refer to the setting method as described in Annex D.

Defined cooling load $L_c(t_j)$ at outdoor temperature t_j, which is necessary to calculate the cooling seasonal energy consumption, shall be determined by Formula (2).

$$L_c(t_j) = \phi_{ful}(t_{100}) \times \frac{t_j - t_0}{t_{100} - t_0} \tag{2}$$

where $\phi_{ful}(t_{100})$ is the cooling capacity at t_{100} at full-load operating conditions.

6.3 Outdoor temperature bin distribution for cooling

Table 3 shows the reference outdoor temperature bin distribution.

Cooling seasonal performance factor (CSPF) shall be calculated at the reference climate condition in Table 3.

The calculation of cooling seasonal performance factor may also be done for other climate conditions.

Table 3 — Reference outdoor temperature bin distribution

Bin number j	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Outdoor temperature t_j °C	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	—
Fractional bin hours	0,055	0,076	0,091	0,108	0,116	0,118	0,116	0,100	0,083	0,066	0,041	0,019	0,006	0,003	0,002	
Bin hours n_j	n_1	n_2	n_3	n_4	n_5	n_6	n_7	n_8	n_9	n_{10}	n_{11}	n_{12}	n_{13}	n_{14}	n_{15}	—
Reference bin hours (n_j) h	100	139	165	196	210	215	210	181	150	120	75	35	11	6	4	1 817

Bin hours of each outdoor temperature may be calculated by multiplying the fractional bin hours by the total annual cooling hours if the fractional bin hours are applicable.

In case of setting other outdoor temperature bin distribution, refer to the setting method as described in Annex D.

6.4 Cooling seasonal characteristics of fixed capacity units

Operational performance at each test, which is used for calculation of seasonal performance factor, shall be in accordance with Table 1.

6.4.1 Capacity characteristics against outdoor temperature

Capacity $\phi_{ful}(t_j)$ (W) of the equipment when it is operated for cooling at outdoor temperature t_j linearly changes depending on outdoor temperatures as shown in Figure A.1 in Annex A, and it is determined by Formula (3) from two characteristics, one at 35 °C and the other at 29 °C.

$$\phi_{ful}(t_j) = \phi_{ful}(35) + \frac{\phi_{ful}(29) - \phi_{ful}(35)}{35 - 29} \times (35 - t_j) \quad (3)$$

6.4.2 Power input characteristics against outdoor temperature

Power input $P_{ful}(t_j)$ (W) of the equipment when it is operated for cooling at outdoor temperature t_j linearly changes depending on outdoor temperatures as shown in Figure A.1 in Annex A, and it is determined by Formula (4) from two characteristics, one at 35 °C and the other at 29 °C.

$$P_{ful}(t_j) = P_{ful}(35) + \frac{P_{ful}(29) - P_{ful}(35)}{35 - 29} \times (35 - t_j) \quad (4)$$

6.4.3 Calculation of cooling seasonal total load (CSTL)

Cooling seasonal total load (CSTL), L_{CST}, shall be determined using Formula (5) from the total sum of cooling load at each outdoor temperature t_j multiplied by bin hours n_j.

$$L_{CST} = \sum_{j=1}^{m} L_c(t_j) \times n_j + \sum_{j=m+1}^{n} \phi_{ful}(t_j) \times n_j \quad (5)$$

a) In the range of $L_c(t_j) \leq \phi_{ful}(t_j)$ (j = 1 to m):

$L_c(t_j)$ shall be calculated by Formula (2).

b) In the range of $L_c(t_j) > \phi_{ful}(t_j)$ (j = m+1 to n):

$\phi_{ful}(t_j)$ shall be calculated by Formula (3).

