



RS 7/C/008 - 2018

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EUROVENT RATING STANDARD
for
DX AIR COOLERS
AIR COOLED CONDENSERS
DRY COOLERS

RS 7/C/008 - 2018

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Modifications as against last version:

No.	Modifications	Section	Page
1	Amendment of the testing requirements for sound performances	IV. 3	7
2	Clarification of rating requirements on fan speeds	V.1	7
3	Update of the correction factors table	V.3	9
4	Change of the title to "Acceptance Criteria ", removal of the acceptance criteria for "sound pressure level "	VII	12

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I. PURPOSE

The purpose of this standard is to establish definitions and specifications for the related programme, in accordance with Operational Manual OM-2, for testing and rating of Heat Exchangers divided in 3 *types of products*:

- Direct Expansion Forced Convection Unit Air Coolers for Refrigeration, designated as “Dx Air Coolers”;
- Forced Convection Air Cooled Condensers for Refrigeration, designated as “Air Cooled Condensers”;
- Forced Convection Air Cooled Liquid Coolers, designated as “Dry Coolers”.

II. SCOPE

The scope of the certification programme is defined in OM-2 (see II. SCOPE).

III. DEFINITIONS

III.1 Product types and modularity

Direct Expansion Forced Convection Unit Air Cooler for Refrigeration (“Dx Air Coolers”): As defined within EN 328:2014.

Forced Convection Air Cooled Condenser for Refrigeration (“Condenser”): As defined within EN 327:2014.

Forced Convection Air Cooled Liquid Cooler (“Dry Cooler”): As defined within EN 1048:2014.

Dx Air Coolers Configuration: Arrangement of components in relationship with the airflow. The following abbreviation shall be used:

SD-B	Single Discharge, Blow through
SD-D	Single Discharge, Draw through
DD-B	Dual Discharge, Blow through
DD-D	Dual Discharge, Draw through

Modularity: a range of Heat Exchanger is considered modular when each module is composed by a coil, a fan motor and a casing having the same following common data:

- tube type and diameter
- fin type
- fin spacing
- coil height and number of tubes
- coil depth and number of rows
- finned length
- fan motor type
- casing construction

III.2 Capacity and energy efficiency

Standard capacity:

- For Dx Air Coolers, dry cooling capacity for R404A of the Dx Air Cooler at the standard conditions stated in EN 328:2014
- For Air Cooled Condensers, capacity for R404A of the Air Cooled Condenser at the standard conditions stated in EN 327:2014
- For Dry Coolers, capacity of the Dry Cooler for water at the standard conditions stated in EN 1048:2014

Nominal capacity:

- Standard capacity of the Dx Air Cooler corrected for refrigerant, operating temperature difference, humidity and fin material.
- Standard capacity of the Air Cooled Condenser corrected for refrigerant, operating temperature difference and fin material.
- Standard capacity of the Dry Cooler corrected for fluid, operating temperature difference and fin material.

Reference capacity of a modular range: Average of the capacities (at SC2 condition for Dx Air Coolers) of the models of the modular range that can be tested in the independent laboratory.

Modular capacity: Reference capacity multiplied by the number of modules (for modular units that cannot be tested in the independent laboratory).

III.3 Surface area

a. Tubes and fins

Surface area: The Surface Area, SA, per tube, per meter-finned length is:

$$SA = (2 / S_{fin} / 1000) \cdot r \cdot \left(S_h \cdot S_d - \frac{\pi}{4} \cdot (d_T^2 + n \times d_h^2) \right) + \pi \cdot d_T / 1000^1$$

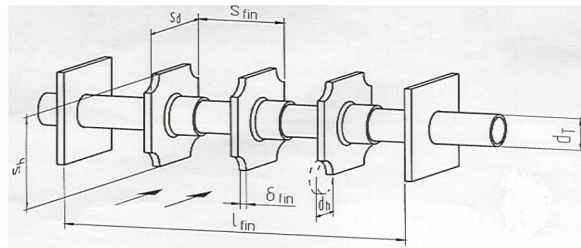


Figure 1: Definitions for declared surface area calculation

The Total Surface area, TS [m²] is:

$$TSA = SA \times l_{fin} \times \text{Number of tubes}$$

Where: S_h = fin height per tube [mm]

S_d = fin depth per tube [mm]

S_{fin} = fin spacing [mm]

r = ratio of enhanced fin surface area to flat, claimed by applicant (to be supported by drawing and calculations if greater than 1)

d_T = tube outside diameter [mm]

d_h = diameter of other holes in fin, e.g. heater holes [mm]

l_{fin} = finned length [m]

n = number of other holes (d_h) per tube holes (d_T).

A drawing shall be provided for each fin type submitted, clearly showing all holes or shapes that enhance or reduce the surface area, together with the calculation model used to calculate the surface area if this differs from that set out above.

¹ Note: The effect of fin thickness δ_{fin} on the surface area is usually very small (less than 1%) and has, therefore, been excluded.

b. Micro-channels

Micro-channel Air-side Heat Transfer Surface

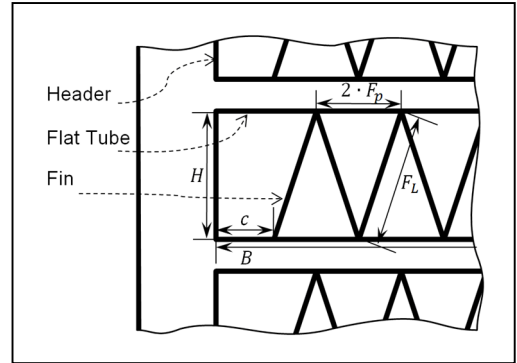
$$A = A_f + A_{Ta} \quad [m^2]$$

Fin Surface A_f

$$A_f = 2 \cdot F_L \cdot T_d \cdot n_{LFP} \cdot n_r \quad [m^2]$$

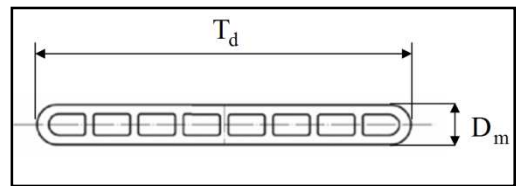
$$n_{LFP} = \frac{B - 2c}{F_p} \quad [-]$$

$$F_L = \sqrt{H^2 + F_p^2} \quad [m]$$



Flat Tube-Air-side Surface A_{Ta}

$$A_{Ta} = [2 \cdot (T_d - D_m) + D_m \cdot \pi] \cdot B \cdot n_T \quad [m^2]$$



Where:

F_L = fin length [mm]

n_r = number of fin rows [-]

n_{LFP} = number of fin pitch widths [-]

B = coil width without headers [mm]

c = no fin area [mm]

F_p = fin pitch [mm]

H = fin height [mm]

T_d = flat tube width [mm]

D_m = flat tube height [mm]

n_T = number of flat tubes in coil [-]

III.4 Heat Flux

Heat flux: Standard capacity divided by the total heat transfer surface area (air side).

III.5 Basic Model Group

Basic Model Group: Set of the same type of Heat Exchangers (COOL, COND, DCOOL), having the same reference geometry.

IV. TESTING REQUIREMENTS

IV.1 Refrigerant

Tests shall be performed with R507A for Dx Air Coolers and Air Cooled Condensers, and water for Dry coolers.

IV.2 Air flow and Thermal performance

Standard ratings shall be verified by tests conducted at standard rating conditions in accordance with:

- EN 328:2014 for Dx Air Coolers (reported in Table 1)
- EN 327:2014 "Test procedures for establishing performance of forced convection air cooled refrigerant condensers" for Air Cooled Condensers
- EN 1048:2014 for Dry Coolers

Table 1: Standard Conditions (SC's) for Dx Air Coolers [EN 328]

Standard Conditions for Refrigerants	Air Inlet Temperature (°C)	Evaporating Temperature (°C)
SC1	10	0
SC2	0	-8
SC3	-18	-25
SC4	-25	-31

The temperature difference for the test on Air Cooled Condensers is 15 K, but can be reduced to 10 K in special cases (see V.4).

IV.3 Sound performance

Sound performance shall be verified *with* tests conducted with the following standard: EN 13487:2003 "Heat Exchanger - Forced convection air cooled refrigerant condensers and dry coolers - sound measurement".

For the 2018 campaign, sound performance shall be verified according to both methods covered by the EN 13487 Standard: ISO 9614-1 and ISO 3744 (parallelepiped surface). The certification will be based on the ISO 9614-1 results.

Sound deviations shall be expressed as an integer following the below rounding rule:

2,4 -> 2

2,5 -> 2

2,6 -> 3

IV.4 Correction for Liquid Pressure Drop for Dry Coolers

For evaluation of Liquid Pressure Drop, the following equation shall be used:

$$\frac{\left(\frac{\Delta P}{Q_m^{1.8}}\right)_{\text{measured}} - \left(\frac{\Delta P}{Q_m^{1.8}}\right)_{\text{declared}}}{\left(\frac{\Delta P}{Q_m^{1.8}}\right)_{\text{declared}}}$$

Where: ΔP : Liquid side pressure drop [kPa]

Q_m : Mass flow rate of the liquid [kg/s]

V. RATING REQUIREMENTS

V.1 Fan speeds

For AC fans, the performance shall be declared under the low speed for a star configuration and the high speed for a delta configuration.

For EC fans, performance can be declared at up to 5 fan speeds for variable speed fans.

V.2 Sound data

Sound data levels shall be calculated in accordance with EN 13487:2003 at 10 m distance For Condensers and Dry Coolers.

V.3 Correction factors

a. Correction for wet coil factors for Dx Air Coolers

Standard capacities are measured under dry conditions, without condensation or frost formation on the Dx Air Cooler surface.

A Dx Air Cooler can be rated in literature with:

- Nominal capacities plus Standard capacities, or
- Nominal capacities plus Wet enhancement factors relating to the standard conditions covered.

The nominal capacities at standard conditions shall be calculated as:

$$\text{Nominal Capacity Wet} = \text{Standard Capacity Dry} \times C1$$

where the relationship factors C1 are given in Table 2:

Table 2: Wet coil factor (C1) for Dx Air Coolers at standard conditions

Standard Conditions	RH	Wet Enhancement Factor
SC 1	85%	1.35
SC 2	85%	1.15
SC 3	95%	1.05
SC 4	95%	1.01

Under other conditions the wet factor enhancement shall be based on the following graph (Figure 2). In any case, the maximum enhancement factor, dry to wet, excluding any other correction for DT1, fin material etc., shall not exceed 1.35.

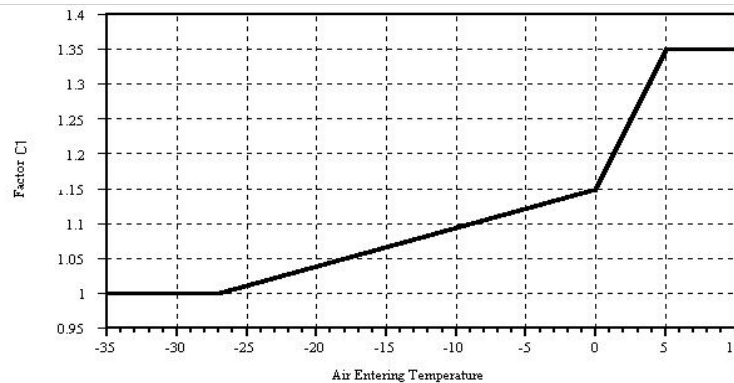


Figure 2: Wet coil factor (C1) for Dx Air Coolers at other conditions

Note: The graph is based on the entering air and not on the dew point evaporating temperature.

b. Correction for temperature differences (C2) for Dx Air Coolers and Air Cooled Condensers

For refrigerants with low (below 1 K for Dx Air Coolers and below 3 K for Air Cooled Condensers) or no glide, the capacity shall be assumed to vary directly with the temperature difference DT1 between the entering air and dew point evaporating temperature, i.e.:

$$\text{Nominal Capacity (2)} = \text{Nominal Capacity Wet (1)} \times C2$$

where $C2 = \text{Required DT1} / \text{Standard DT1}$

Standard DT1 = 15 for Air Cooled Condensers

Higher glide refrigerants are currently excluded from the scope of this standard.

c. Refrigerant and Ethylene Glycol correction factors (C3)

Unless independently substantiated, at standard conditions, the following average relationship shall exist between the capacities:

Table 1: Refrigerant correction factors (C3)

Product type Condition Refrigerant	Dx Air Coolers				Air Cooled Condensers	Glide @ 40° C (information only)
	SC 1	SC 2	SC 3	SC 4	DT1 = 15 K or DT1 = 10 K	
R404A (reference)	1	1	1	1	1	0.5
R134a	0.93	0.91	0.85	-	0.96	0
R507A [REFPROP 9.1]	0.97	0.97	0.97	0.97	1	0
R407A	1.19	1.24	1.28	1.32	0.89	4.5
R407C	1.21	1.26	1.31	1.36	0.87	5.06
R407F	1.19	1.24	1.29	1.35	0.89	
R448A	1.23	1.26	1.28	1.31	0.89	4.82
R449A	1.21	1.23	1.24	1.26	0.89	4.65
R452A	0.92	0.91	0.84	-	0.93	0.63
R450A	1.1	1.12	1.13	1.15	0.93	3.43
R513A	0.91	0.91	0.85	-	0.95	0.17

These factors may, if required, be presented using a different base refrigerant.

$$\text{Nominal Capacity (3)} = \text{Nominal Capacity (2)} \times C3$$

-For 34% Ethylene Glycol by volume, the capacity and pressure drop at the standard conditions shall be assumed to be:

$$\text{Nominal Capacity (3)} = \text{Standard Capacity (water)} \times C3, \text{ where } C3 = 0.95$$

$$\text{Pressure Drop} = \text{Standard Pressure Drop (water)} \times 1.2$$

-For 34% Propylene Glycol by volume, the capacity and pressure drop at the standard conditions shall be assumed to be:

$$\text{Nominal Capacity (3)} = \text{Standard Capacity (water)} \times C3, \text{ where } C3 = 0.92$$

d. Correction for fin materials (C4)

For other fin materials where the thickness is not less than the standard thickness, the following relationship shall be assumed to apply. Other factors may be used if independently substantiated:

Table 4: Fin material correction factors (C4)

Fin Material	Factor C4
Aluminium	1
Coated Aluminium	0.97
Copper	1.03

$$\text{Nominal Capacity (4)} = \text{Nominal Capacity (3)} \times C4$$

e. Correction for altitude (C5)

$$\text{Nominal Capacity (5)} = \text{Nominal Capacity (4)} \times C5$$

$$\text{Where: } C5 = (1 - 0.000075 \times H)$$

$$H = \text{Altitude above sea level [m]}$$

This altitude correction may be presented if required.

V.4 Additional temperature difference for Air cooled condensers

For all Air Cooled Condensers, if the proportionality to TD from 15K to 10K is respected, capacities under TD 10K can be published without supplementary test. If the proportionality is not respected, a test under 10K is mandatory.

V.5 Energy ratio and classes

Energy Ratio R:

- For Dx Air Coolers: Nominal capacity [kW] divided by the total certified power input of the fan motors Fan power [kW] at the standard rating conditions, multiplied by the square root of (the fin spacing divided by 4.5).
If rated at SC2, standard capacity shall be at SC2 under wet conditions.

$$R_{\text{DXaircoolers}} = \frac{\text{Capacity @ SC2 wet}}{\text{Fan power}} \times \sqrt{\frac{\text{fin spacing}}{4.5}}$$

Otherwise, we will use minimum of the equation below between the different SCs, where $C_{\text{label, wet}}$ is given in Table 5:

$$R_{\text{DXaircoolers}} = \frac{P_{\text{SC,wet}} \times C_{\text{label,wet}}}{\text{Fan power}} \times \sqrt{\frac{\text{fin spacing}}{4.5}}$$

- For Air Cooled Condensers and Dry Coolers: Nominal capacity at DT1 = 15 K [kW] divided by the total certified power input of the fan motors [kW] at the standard rating conditions.

$$R_{\text{Condensers, Dry coolers}} = \frac{\text{Capacity @ DT1 = 15K}}{\text{Fan power}}$$

Energy Class: Letter corresponding to an Energy Ratio in a range defined in Table 6.

Table 5: Correction factor $C_{\text{label,wet}}$ for determination of R for Dx Air Coolers

wet	C1	DT	$C_{\text{label, wet}}$ $1,15/C1^{*8}/DT$
SC1	1.35	10	0.68
SC2	1.15	8	1
SC3	1.05	7	1.25
SC4	1.01	6	1.52

Table 6: Energy classes thresholds

Class	Energy consumption	Dx Air Coolers	Condensers, Dry coolers
		$R_{\text{DXaircoolers}} = \frac{P_{\text{SC,wet}} \times C_{\text{label,wet}}}{\text{Fan power cons}} \times \sqrt{\frac{\text{fin spacing}}{4.5}}$	$R_{\text{Condensers, Dry coolers}} = \frac{\text{Capacity @ DT1 = 15K}}{\text{Fan power cons}}$
A+	Extremely low	$R \geq 73$	$R \geq 226$
A	Very Low	$47 \leq R < 73$	$169 \leq R < 226$
B	Low	$35 \leq R < 47$	$109 \leq R < 169$
C	Medium	$25 \leq R < 35$	$69 \leq R < 109$
D	High	$16 \leq R < 25$	$37 \leq R < 69$
E	Very high	$R < 16$	$R < 37$

VI. CERTIFIED PERFORMANCE ITEMS

The following performance items shall be certified by tests:

- Standard capacity (using water for Dry coolers) [kW]
- Fan power input [W]
- Energy Ratio R [-]
- Energy class [-]
- Air volume flow [m^3/h]
- Liquid side pressure drop for Dry Coolers [kPa]
- A-weighted sound pressure level for Air Cooled Condensers and Dry Coolers [dB(A)]
- A-weighted sound power level for Air Cooled Condensers and Dry Coolers [dB(A)]

VII. ACCEPTANCE CRITERIA

When tested in independent laboratory, the characteristics obtained shall not differ from the claimed values by more than:

- Standard capacity -8 %
- Fan power input +10 % with a minimum of 3W
- Air volume flow +/-10 %
- *Dimensions and number of fins:*
 - Finned length ± 0,5 %, with a minimum of 5 mm
 - Height of the coil ± 5 mm
 - Depth (width) of the coil ± 5 mm
 - Total number of fins* ± 4 %, at least 2 fins
 - Diameter of (expanded) tube outside the coil* ± 1 mm
- (*) except for the micro-channels
- Liquid side pressure drop +20 %
- A-weighted sound power level +2 dB(A)

Only the sound power level is measured. The sound pressure level is calculated by a numeric Formula (see below):

$$L_{pd} = L_w - 10 \times \lg \left(\frac{S_d}{S_o} \right)$$

For each model of a modular range, the capacity claimed by the Participants shall not differ from the modular capacity by more than +8%. The average of the positive differences between the modular capacities and claimed capacities shall not exceed +5%.