RS 8/C/001-2017

Published February 2017

RATING STANDARD
for the
CERTIFICATION
of
AIR TO AIR PLATE AND TUBE HEAT EXCHANGERS

RS 8/C/001-2017

Published February 2017
Supersedes RS/8/001-2016

Editing (date):	Anthony BAILLAU	*October 2016*
Checking (date):	Jean FOURCROY	*8 December 2016*
Approval (date):	Compliance Committee for AAHE	*15 December 2016*
Approval (date):	CPPC	*17 January 2017*
Comes into effect from:		*03 February 2017*

Modifications as against last version:

Nb	Modifications	Section	Page
1	*Correction of Table 2: Testing point conditions for plate heat exchangers with and without humidity transfer*	*IV.3*	*5*
2	*150 Pa is added as a new possibility for Nominal Pressure Drop*	*IV.3*	*5*
3	*If a unit cannot resist the "Influence of Pressure Difference on Pressure Drop" test, the Nominal Pressure Drop shall be rerated to a lower value so that the exchanger can bear five times the nominal pressure drop as a pressure difference. If the Nominal Pressure Drop is already 50 Pa, then the exchanger cannot be certified, and thus cannot be included in the selection software.*	*IV.3*	*5*
4	*All AAHE shall be tested at 250 Pa. Should an exchanger not meet the tolerance on the leakage, it shall be considered as a component failure. In case the failure is caused by the design of the unit (regular production), the unit shall be removed from the selection software.*	*IV.2*	*5*
5	*Editorial revisions*	*VARIOUS*	

Published by Eurovent Certita Certification SAS
48-50 rue de la Victoire
75009 Paris, France

Tel: + 33 (0)1-7544-7171
E-mail: a.baillau@eurovent-certification.com

TABLE OF CONTENTS

I. PURPOSE

The purpose of this Rating Standard is to establish definitions and specifications for testing and rating of Air-to-Air Plate and Tube Heat Exchangers for the related Certification Programme, in accordance with Operational Manual OM-8.

II. SCOPE OF THE PROGRAMME

This Certification Programme applies to all ranges of Air-to-Air Plate and Tube Heat Exchangers (with and without humidity transfer) which are included in the certified public selection software of the Applicant/Participant.

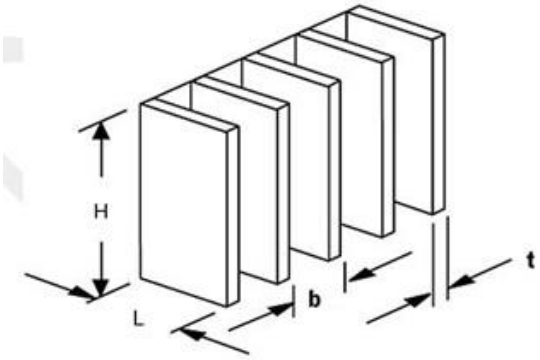
III. DEFINITIONS

Air-to-Air Plate and Tube Heat Exchangers: Heat exchanger designed to transfer thermal energy (sensible or total) from one air stream to another without moving parts. Heat transfer surfaces are in form of plates or tubes. This exchanger may have parallel flow, cross flow or counter flow construction or a combination of these.

Product range: Family of products of different size built according the same design and using the same selection procedure.

Plates dimensions:

L = Plate length
H = Plate height
b = Plate spacing
(plate interval + 1 plate thickness)
t = Plate thickness



Temperature efficiency (temperature ratio) dry (η_t) [%]: Ratio of dry temperature differences:

Eq. 1 $$\eta_t = \frac{t_{22} - t_{21}}{t_{11} - t_{21}}$$ (without condensation)

with: t temperature [°C]
11 Exhaust air inlet
12 Exhaust air outlets
21 Supply air inlets
22 Supply air outlets

Temperature efficiency wet (η_{tw}) [%]: Ratio of dry bulb temperature differences when condensation occurs:

Eq. 2 $$\eta_{tw} = \frac{t_{22} - t_{21}}{t_{11} - t_{21}}$$ (with condensation)

Humidity (latent) efficiency (η_x) [%]: Ratio of absolute humidity differences:

Eq. 3 $$\eta_x = \frac{x_{22} - x_{21}}{x_{11} - x_{21}}$$

Pressure drop (DP) [Pa]: Loss in total pressure between the inlet and the outlet of a unit. It is mandatory to display in the outputs the pressure drop under the standard conditions. It is allowed to display any other pressure drop values if accompanied by the underlying air density.

Internal air leakage: Air leakage between two air streams.

Air leakage (q_{mil}/q_{mn}) [%]: Air leakage relative to nominal air flow.

Nominal pressure drop (P_{nom}) [Pa]: Pressure drop at nominal conditions. The nominal pressure drop of each unit must be defined by the manufacturer. Possible values are 50 Pa, 100 Pa*, 150 Pa* or 200 Pa.

Nominal air flow (NAF) [m^3/h]: Air flow which causes the nominal pressure drop. It is mandatory to display on the outputs actual exhaust and supply air flows.

IV. TESTING REQUIREMENTS

IV.1 Test standard

Performance ratings claimed by manufacturers shall be verified by tests performed in the independent laboratory selected by Eurovent Certita Certification.

The following standard shall be used as a basis for these tests:

EN 308:1997: Heat Exchangers - Test procedures for establishing performance of air to air and flue gases heat recovery devices.

IV.2 Test pre-quisites

Before testing, the laboratory shall check outer dimensions and air leakage. The following tolerances are acceptable:

- Dimensions: +/- 2mm
- Plate spacing: +/- 1% or +/- 1 plate

If a unit is not corresponding to the ordered dimensions, the laboratory shall not perform the test and contact Eurovent Certita Certification who shall ask the Participant to send a new unit.

Air leakage shall be checked according to EN 308:1997 and noted (in % with 1 decimal place; normally rounded). The following tolerances are acceptable:

- Air leakage + 0.5 % for models without humidity transfer
  + 1.0 % for models with humidity transfer

All units must be tested under a pressure difference of 250 Pa. If a unit is not compliant *with the above maximum leakages, it is considered as a component failure. The* laboratory shall stop the test and contact the Participant to repair or send another unit. *In case the failure is caused by the design of the unit (regular production), the unit shall be removed from the selection software.*

IV.3 Test specifications

The units shall be tested under the EN 308:1997 conditions.

The following particular specifications shall be applied during the test in the independent laboratory selected by Eurovent Certita Certification.

- Pressure drop shall be measured at a pressure difference equal to five times the nominal pressure drop. The obtained value will be called “Influence of pressure difference on pressure drop*”. If a unit cannot resist the “Influence of Pressure Difference on Pressure Drop” test, the Nominal Pressure Drop shall be rerated to a lower value so that the exchanger can bear five times the nominal pressure drop as a pressure difference. If the Nominal Pressure Drop is already 50 Pa, then the exchanger cannot be certified, and thus cannot be included in the selection software.*
- Pressure drop shall be measured for at least three air-flow rates corresponding to the pressure drop of 50, 100 and 150% of the nominal pressure drop, each +/- 10%, at least +/-5 Pa.
- Temperature efficiencies (dry or wet) and humidity efficiency shall be measured for three air-flow rates corresponding to 50, 100 and 150% of the nominal pressure drop, each +/- 10%, at least +/-5 Pa.

These last two bullet points result in the following table.

Table 1: Possibilities of air-flow conditions and associated acceptable deviations

Possible nominal pressure drop [Pa]		50	100	*150*	200
Corresponding nominal air flow [m^3/h]		NAF_{50}	NAF_{100} or q_{mn}	*NAF_{150}*	NAF_{200}
500% P_{nom}	Pressure difference [Pa]	250	500	*750*	1000
50% P_{nom}	50% of nominal pressure drop [Pa]	25	50	*75*	100
	Acceptable deviation [Pa]	+/- 5	+/- 5	*+/- 7.5*	+/- 10
100% P_{nom}	100% of nominal pressure drop [Pa]	50	100	*150*	200
	Acceptable deviation [Pa]	+/- 5	+/- 10	*+/- 15*	+/- 20
150% P_{nom}	150% of nominal pressure drop [Pa]	75	150	*225*	300
	Acceptable deviation [Pa]	+/- 8	+/- 15	*+/- 22.5*	+/- 30

- Winter test for efficiency with condensation shall be performed under the following conditions:
  - The nominal pressure drop (without condensation, +/- 10%, at least +/-5 Pa) for plate heat exchangers with and without humidity transfer
  - 50 and 150% of nominal air flow for plate heat exchangers with humidity transfer (see table above)
  - The mass flow ratio of 1.0
  - The warm air temperature of about 25°C with a humidity ratio between 45% and 75%. The inlet temperature of cold air at 0°C to -5°C (humidity is not defined.)
- Fixed summer test for efficiency shall be performed under the following fixed conditions for plate heat exchangers with humidity transfer:
  - The nominal pressure drop, 50 and 150%
  - The mass flow ratio of 1.0
  - The warm air temperature of about 35°C with randomly one of the following humidity conditions: 50% relative humidity. The inlet temperature of cold air at 25°C and 50% humidity.
- Random summer test for efficiency shall be performed under the following conditions for plate heat exchangers with humidity transfer:
  - The nominal pressure drop
  - The mass flow ratio of 1.0

- The warm air temperature of about 35°C with randomly one of the following humidity conditions: 14-22 g/kg. The inlet temperature of cold air at 25°C and 50% humidity.

- All efficiencies (in percent) shall be measured at a mass flow ratio of 1.0 with 1 decimal place and rounded normally.

The Table 2 summarizes the testing conditions and related tested performances

Table 2: Testing point conditions for plate heat exchangers with and without humidity transfer

Product type		Any type (regular point)	Without humidity transfer	With humidity transfer		
Conditions		Winter “dry”	Winter “condensation”	Winter “condensation”	Summer “dry”	Summer “random”
Mass flow ratio [-]		1.0	1.0	1.0	1.0	1.0
Warm air - temperature [°C]		~25°C	~25°C	~25°C	~35°C	~35°C
Warm air - humidity		wet bulb < 14 °C	45%-75%	45%-75%	50%	14-22 g/kg
Cold air inlet - temperature [°C]		5°C	0 to -5°C	0 to -5°C	25°C	25°C
Cold air inlet - humidity		undefined	undefined	undefined	50%	50%
50% P_{nom}	Temperature efficiency dry [%]	Y	N	N	Y	N
	Temperature efficiency wet [%]	N	N	Y	N	N
	Humidity efficiency	N	N	Y	Y	N
100% P_{nom}	Temperature efficiency dry [%]	Y	N	N	Y	Y
	Temperature efficiency wet [%]	N	Y	Y	N	N
	Humidity efficiency	N	N	Y	Y	Y
150% P_{nom}	Temperature efficiency dry [%]	Y	N	N	Y	N
	Temperature efficiency wet [%]	N	N	Y	N	N
	Humidity efficiency	N	N	Y	Y	N

- For measuring the efficiency of the cross-flow exchangers, these shall be installed into the test rig diagonally, i.e. standing on edge, as it is common in practice. This shall no longer require any instructions of the manufacturer according to EN 308:1997, section 5.1.
- The pressure drop (in Pa, no decimal place, normally rounded) shall be measured in the test rig in diagonal installation, i.e. standing on edge, as it is common in practice. This shall no longer require any instructions of the manufacturer according to EN 308:1997, section 5.1. The pressure difference should be kept zero between both outgoing flows.

If any of individual points of measurement shows a deviation larger than the acceptable tolerance, the failure shall be declared and the failure procedure applied. Participants shall be free to adapt their selection documentation as they like; however the penalty test should confirm the test data.

IV.4 Verification after the test

After testing the performance the laboratory shall also check the plate thickness even if the unit has to be damaged. The allowed tolerance is:

- Thickness of the plate : +/- 10%

IV.5 Checking specifications

When calculating the deviation between the claimed values and the measured values using the selection software under the tests conditions, Eurovent Certita Certification shall use the following inputs:

- for airflows: exhaust air inlet (1.1) and supply air outlet (2.2);
- for temperature: exhaust air inlet (1.1) and supply air inlet (2.1);
- for humidity: exhaust air inlet (1.1) and supply air inlet (2.1).

IV.6 Consistency check of the performances for multiple units

Concerning tests of heat exchangers that cannot be tested in the laboratory and built of N * N equal modules the following shall apply (only valid for cross-flow plate heat exchangers without humidity transfer):

1) Calculate the efficiency and pressure drop of a single module;
2) The NTU value will be calculated from the single module claimed efficiency using the method described in APPENDIX A.
3) Unless proven to Eurovent Certita Certification the claimed efficiency of the complete unit built of N*N equal modules shall not be higher than the one calculated using the following formula:

Eq. 4 $$\eta_{dry} = 1 - \exp\left(\frac{1}{C_r}(N * NTU)^{0.22}(\exp(-C_r * (N * NTU)^{0.78}) - 1)\right)$$

No further tolerance shall be applied;

4) Uness proven to Eurovent Certita Certification the claimed pressure drop shall not be lower than the one calculated likewise by multiplying the claimed pressure drop of the single module by N. No further tolerance shall be applied;
5) The wet efficiency will not be checked.

IV.7 Consistency check of the performances for combination of units

This section applies to all types of combination of two or more heat exhangers (for instance in parallel, in series, etc …).

Unless proven to Eurovent Certita Certification, the claimed performances for these kind of combinations shall be in line with the claimed performances of the individual heat exchangers:

- the efficiency of the combination shall not be higher than the efficiency which could be obtained using the claimed efficiencies of each individual heat exchangers. No additional tolerance shall be applied.
- the pressure drops of the combination shall not be lower than the pressure drops which could be obtained using the claimed pressure drops of each individual heat exchangers. No additional tolerance shall be applied.

V. CERTIFIED PERFORMANCE ITEMS

The following performance items shall be certified.

- Under standard conditions (20°C, 50% rel. humidity and 1.013 10^5 Pa - or 1.20 kg/m³ density):
  - Airflow
  - Pressure drop
- Under winter conditions (warm air temperature: 25°C, 60% rel. humidity; inlet temperature of cold air: -3°C, 90% humidity)
  - Temperature efficiency dry [%]
  - Temperature efficiency wet [%]
  - Humidity efficiency for plate heat exchangers with humidity transfer [%]
- Under summer conditions for plate heat exchangers with humidity transfer (warm air temperature: 35°C, 50 % rel. humidity; inlet temperature of cold air: 25 °C, 50 % rel. humidity)
  - Temperature efficiency dry [%]
  - Temperature efficiency wet [%]

- Humidity efficiency [%]

VI. TOLERANCES

For the test to be acceptable, the testing unit shall not differ from the delared model from more than the following tolerance values:

- Dimensions: +/- 2mm
- Plate spacing: +/- 1% or +/- 1 plate
- Plate thickness: +/- 10%

For the test to be acceptable, leakage shall be below:

- Air leakage + 0.5 % for models without humidity transfer
  + 1.0 % for models with humidity transfer

When tested in the laboratory the obtained performance data shall not differ from the declared values by more than the following tolerance values:

- Influence of pressure difference on pressure drop: + 10%, at least 15 Pa
- Pressure drop at standard conditions: + 10%, at least 15 Pa
- Temperature efficiency dry: - 3 percentage points
- Temperature efficiency wet: - 5 percentage points
- Humidity efficiency: - 5 percentage points

APPENDIX A. DESCRIPTION OF THE NTU METHOD

For the NTU (Number Transfer Unit) method, the temperature effectiveness of a cross flow heat exchanger with both fluids unmixed is given by the following equation:

Eq. 5 $$\eta_{dry} = 1 - \exp\left(\frac{\exp\left(-(N*NTU)\cdot C_r\cdot(N*NTU)^{-0.22}\right)-1}{(N*NTU)^{-0.22}\cdot C_r}\right)$$

C_r is the dimensionless heat capacity rate ratio between the warm fluid and the cold fluid:

Eq. 6 $$C_r = \frac{C_{min}}{C_{max}}$$

Where C_{min} and C_{max} depends on the relative magnitudes of the hot and cold fluid heat capacity rates.

For air to air plate heat exchangers with balanced airflows it is assumed that $C_r = 1$.

The NTU value can be calculated with an iteration process.

Introducing

Eq. 7 $$arg = \left(\frac{\exp\left(-NTU\cdot C_r\cdot NTU^{-0.22}\right)-1}{NTU^{-0.22}\cdot C_r}\right),$$

we have

Eq. 8 $$\eta_{dry} = 1 - \exp(arg)$$

And

Eq. 9 $$arg = \ln\left(1 - \eta_{dry}\right).$$

We have $C_r = 1$ and $n_i = NTU_i^{-0.22}$ (i is the iteration index)

Therefore,

Eq. 10 $$arg = \frac{\exp(-NTU\cdot n_i)-1}{n_i}$$

Eq. 11 $$\exp(NTU\cdot n_i) = \frac{1}{1+n_i\cdot arg} = a_i$$

Eq. 12 $$NTU_i = \frac{1}{n_i}\cdot\ln(a_i)$$

To use the method, one shall start from a “step 0” value n_0 (for instance 0.5), and use a dichotomy method until a neglictible error value is reached (to be used: $1.00E^{-06}$).

Example:

The efficiency of the single exchanger is $\eta_{dry} = 70\ \%$. The step 0 value is taken as $n_0 = 0.5$.

$$arg = -1.203972804$$

Eq. 13 $$NTU_0 = \frac{1}{n_0}\cdot\ln(a_0) = 1.842538218$$

Eq. 14 $$n_0' = NTU_0^{-0.22} = 0.874195102$$

The error is calculated as:

Eq. 15 $$\epsilon = \frac{abs(n_0 - n_0')}{n_0}$$

If the error is not satisfying, a new iteration begins with

Eq. 16 $$n_1 = \frac{n_0 + n_0'}{2}$$

For this example, here is a table summing up the iteration process:

Table 3: Result of the iteration process for calculating NTU

i	n_i	a_i	NTU_i	n'_i	$Error_i$
0	0,5	2,51247697	1,84253822	0,8741951	0,7483902
1	0,687097551	5,78860363	2,55551936	0,81349443	0,18395768
2	0,750295989	10,3451093	3,11412284	0,77887208	0,03808643
3	0,764584035	12,5846927	3,31223396	0,76837527	0,00495856
4	0,766479653	12,9568348	3,34206319	0,76686122	0,00049782
5	0,766670436	12,9955115	3,34511924	0,76670703	4,7736E-05
6	0,766688735	12,9992332	3,34541289	0,76669223	4,5554E-06
7	0,766690481	12,9995885	3,34544092	0,76669081	4,3452E-07

The table below provides the NTU values for a given set of dry efficiencies of single modules and the corresponding maximum dry efficiencies allowed for a unit built of N*N modules with N=2.

Table 4: Example of NTU values and the corresponding maximum allowed dry efficiencies for C_r = 1 and N=2

η_{dry}	NTU	2*NTU	$\eta_{dry\ max}$ (N=2)
5%	0,054	0,108	9,4%
10%	0,1154	0,2308	17,9%
15%	0,1853	0,3706	25,7%
20%	0,2651	0,5302	32,8%
25%	0,3569	0,7138	39,2%
30%	0,4635	0,927	45,1%
35%	0,5889	1,1778	50,5%
40%	0,7388	1,4776	55,5%
45%	0,9215	1,843	60,0%
50%	1,15	2,3	64,1%
55%	1,4456	2,8912	67,9%
60%	1,8458	3,6916	71,3%
65%	2,4242	4,8484	74,6%
70%	3,3454	6,6908	77,7%
75%	5,0486	10,0972	81,0%
80%	8,86	17,72	84,8%
85%	18,37	36,74	89,0%
90%	44,3	88,6	93,2%
95%	146,5	293	96,9%
99%	1035	2070	99,5%