Product Group 'Air Handing Units' PP – 2020-12-18

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Eurovent Proposal for a simplified method for calculating the corrected power consumption of the fans and the SFP_{int} based on the OACF and EATR

In a nutshell

In this paper, Eurovent puts forward a simplified and easy to apply method for calculating the power consumption of the fans and the SFP_{int} corrected due to internal leakages occurring in the bidirectional NRVUs with heat recovery (in particular with rotary heat exchangers). The method is based on OACF and EATR factors. Eurovent members believe that the implementation of this method in the revised Regulation 1253/2014 would significantly contribute to the effective improvement in the energy efficiency of NRVUs and IAQ.

1. Background

Original Eurovent proposal

In the previous position papers on the revision of Regulation (EU) 1253/2014, Eurovent tabled a number of proposals for improvements in respect of internal air leakages in bidirectional NRVUs. The proposals aimed at further reduction of energy consumption and improvement of indoor air quality.
The pivotal proposals were the following:

- set limits for the EATR and OACF values,
- if EATR > 1%, compensate air flows and correct SFP_{int} accordingly.

A general method for compensating air flows and correcting SFP_{int} was proposed in the Eurovent Recommendation 6/15 - 2020. The recommendation also presents the potential magnitude of internal leakages in case of the incorrect AHU design.

Given the potentially high implementation costs in the AHU selection software of the complete calculation methodology presented in Recommendation 6/15, Eurovent members developed a simplified method (without the need of iteration). It still yields very accurate outcomes but is much easier to implement by all manufactures and could form a common industry standard. The simplified method is explained in paragraph 6 and the related calculation examples are presented in paragraph 7.

Task 6 proposal

The current proposal for amendments to the VU Regulation presented in the Task 6 report provides for the EATR and OACF limits but does not introduce the need for compensating air flows and correcting SFP_{int}. From the ventilation system design perspective it is still assumed that $q_{SUP} = q_{ODA}$, which in many cases is not the case.

Eurovent welcomes the proposal for setting EATR and OACF limits which is a step in the right direction to eliminate the worst cases from the market. However, in our opinion the lack of SPF_{int} correction and thus of a demonstration of the actual impact of leakages on energy consumption may hinder any significant improvement in energy efficiency of NRVUs in the European market. Arguments supporting this position are set out in the following paragraphs.

2. Estimation the impact of internal leakages in EU 28 countries

According to the data of the Review Study documents and Eurovent Market Intelligence statistics, 45% of all AHUs annually placed on the EU28 marked are equipped with rotary heat exchangers which gives approximately

40 000 units with 80 000 fans. The average air flow rate and average pressure increase are estimated respectively to 2 m^3/s and 600 Pa.

The impact of internal leakages (including recirculation of outdoor air, recirculation of exhaust air and pressure loses that are needed to balance the installation), with assumption of the EATR equal to 3% and OACF equal to 1.08, can be estimated to 10 - 15%.

This estimate, together with statistical market data, allows the following assessment of additional power consumption in AHUs due to internal leakages:

-	Average air flow	2	m^3/s
-	Average pressure increase range	600	Pa
-	With 60% total fan efficiency we can estimate that the total fan power consumption with these units is: $2 \cdot 2 \cdot 600 / 0.6$	4	kW
-	Multiplied with 40 000 units	160	MW
-	With average annual running time of 3000-4000 hours	480 – 640	GWh
-	With 10%-15% of impact on power consumption due to internal leakages	16 – 24	MW
	Additional electric energy consumption due to internal leakages: (relating to one-year sales)	**~ 48 – 96**	**GWh / year**

3. Anticipated impact of currently proposed amendments

The TASK 6 final report puts forward the following new requirements in respect of internal air leakages:

- the maximum EATR at nominal flow and nominal pressure is 5%,
- the OACF at nominal flow and nominal pressure must be within 0.90 and 1.10,
- no impact on the declared performance data (SFP_{int}).

The proposed amendments mean that:

- Recirculation of outdoor air may be up to 10%,
- Recirculation of extract air may be up to 5%.

In the opinion of Eurovent members, this change will obviously improve the situation and eliminate from the market the worst products that feature very high internal leakages rates (mainly due to adverse position of fans). However, it will not drive the development of HRS components towards better sealing systems, as it does not penalize any performance data of AHUs. The undesirable redundant energy consumption estimated in Paragraph 2 will not be eliminated either.

Only the mandatory correction of SFP due to internal leakages will drive industry to seek solutions for considerable reducing or eliminating internal leaks.

4. Arguments for the introduction of SFP_{int} correction

Because of Internal leakages in NRVUs there is both recirculation of extract air and significant energy losses. The recirculation can be avoided through design and the energy losses can be accounted for in the calculation of absorbed power and SFP values. The numerous arguments in support of the SFP_{int} correction are as follows:

- **High impact on SFP_{int} of the proposed limits for OACF and EATR**
  As estimations presented in the paragraph 7 show, the impact on energy consumption may high and significant.

- **Feasibility of implementation**
  In Sweden the leakages have been included in the calculation of power consumption since the 1990s, which shows that it is possible to do. The effect has been positive because manufactures set the EATR to zero by including additional pressure drop where needed so recirculation is minimized. Sealing and balancing systems have been improved with a minimum of cost.
  The simplified method developed by Eurovent makes the implementation even easier.
- **Improved transparency of product performance and a level playing field**
  Many manufacturers already applied the SFP_{int} correction or are ready to implement it at short notice. The declared performance of products without correction is naturally better, which puts the producers applying the correction at a competitive disadvantage. Introducing a mandatory correction would eliminate this problem and level the playing field.
  Using the correction will promote fair competition and transparency between manufacturers and between energy recovery types.
- **Improvement of energy efficiency at low cost**
  Introduction of the SFP_{int} correction will provide a great opportunity to improve the energy efficiency of NRVUs at minimum cost.
- **Facilitating the commissioning of ventilation systems**
  OACF correction will reduce the difference between the values measured at the AHU commissioning and the calculated values. A common practise is that commissioning engineers adjust the exhaust fan to achieve the design extract air flowrate. This means that at high OACF the airflow rate and power input of exhaust fan located downstream the exchanger will be higher than the values considered in the conformity assessment.
- **Limiting the risk of airborne infections spread**
  With the elimination of EATR we will develop installations that are more resilient against the spread of air borne infectious deceases with less risk of cross contamination of the supply air with aerosols carrying infectious diseases. The Correction of EATR will drive the industry to solution where no exhaust air leakage takes place in AHU.
- **Alignment with EPBD provisions**
  EN 16798-3 Energy performance of buildings states in section 9.8 that leakages, including the internal leakages, shall be avoided. The standard also defines OACF and EATR.

5. Effects of ignoring the impact of internal leakages on NRVUs power consumption

- There will be no signification leakages-related improvement in energy efficiency of NRVU in the EU market.
- Only the worst cases (EATR > 5% and 0.9<OACF>1.1) will be excluded with the proposed limitations.
- If the corrected performance (power input) is not demonstrated, there will be no real impact on the marketplace, customers will not pay any attention to the EATR and OACF figures.
- The regulation would favour rotary heat exchangers over other types of energy recovery because it considers the high thermal efficiency and lower pressure loss of the rotors but ignores the leakages which affect rotors.
- The potential for better sealing systems for rotors will go undeveloped as long as there is no incentive to development. Inclusion of the leakages in the calculation of power consumption for a NVRU would provide that incentive. Better sealing would reduce recirculation of air and improve the indoor air quality.

6. Proposal for a simplified method for calculating the power consumption of the fans and the SFP_{int} based on the OACF and EATR without the need for iteration

6.1 General introduction

It is assumed that AHU manufacturers use rotors having a DLL[1] that is implemented with AHU selection software and provides OACF and EATR values. The vast majority of rotary heat exchanger manufactures offer DLLs with this functionality (including all Eurovent Certified suppliers).

The general method for calculating the corrected SFP_{int} using OACF and EATR, which involves an iteration process, is given in Chapter 9 and Annex 1 of the Eurovent Recommendation 6/15 – 2020.

The simplified method does not require the iteration. Instead, it introduces a correction factor to allow for the fact that no iteration is conducted. The value of correction factor was determined based on a multi-variant AHU calculation study with real data.

The generic explanation of the simplified calculation process could be for instance presented in the FAQ document to the revised Regulation.

6.2 Description of the simplified method

The manufacturer must include the impact of internal leakages in the calculation of the SFP_{int}. The manufacturer is responsible for the design and testing of the unit construction to minimise the leakage.

The method proposed here uses the design data to calculate the EATR and OACF for the unit. For the heat exchanger these should be provided by the DLL of the supplier of the heat exchanger. The AHU manufacturer should have the remaining EATR and OACF for the unit from testing.

The OACF and EATR must be within limits otherwise something must be improved. That could be either the arrangement and/or reduction of the pressure difference, which might be done by throttling if the fans are in the appropriate position.

The four new airflows and associated component pressure drops in each of the connections to the heat exchanger can now be calculated. The fans are then calculated using the corrected airflow rates and pressures. This gives the corrected fan power, efficiency, fan speed, etc.

In a proper iteration process the changed flow rates will change the pressure difference at the rotor and this leads to a further increase in the air flow rates and pressure drops. To avoid iteration a correction factor is introduced. The corrected pressure mentioned above is multiplied by a factor to compensate.

With the corrected power it is now possible to calculate the SFP.

Simplified method – summary

- OACF and EATR shall be given by the DLL provided by the component suppliers.
- All 4 airflows are corrected using the OACF and EATR.
- Pressure drops are corrected using the corrected airflows.
- Fan performance recalculated with the new flows and pressures

[1] Dynamic-link library (DLL) – an internal sub-programme integrated with the AHU selection software to calculate component (HRS, fan, etc.) performance based on the AHU selection input data. Developed and provided by the component supplier.

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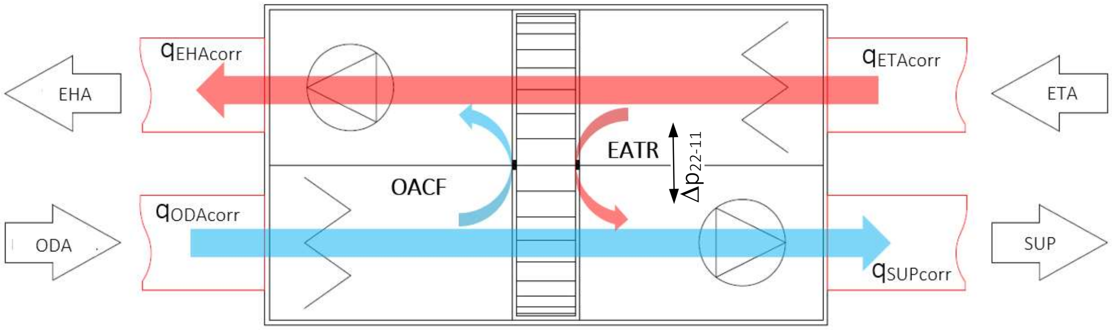

Figure 1. Corrected air flows at AHU connections

6.3 The process step by step

1. Calculate the pressure difference of $\Delta p_{22\text{-}11}$ with design data
2. Call rotor DLL for OACF and EATR values
3. If EATR is > 5% or OACF > 1.1 or OACF < 0.9 then change the arrangement of fans or take other design measures to decrease the $\Delta p_{22\text{-}11}$ (e.g. throttling)
4. Repeat 2 and 3 until EATR and OACF are withing limits
5. If EATR < 1% then EATR =0% for correction, not for printout
6. Calculate new air flows in each of air connection of the AHU as per Eurovent recommendation document
   $q_{SUPcorr} = q_{SUP} \cdot (1+ EATR)$
   $q_{ETAcorr} = q_{ETA} + q_{SUP} \cdot EATR$
   $q_{ODAcorr} = q_{SUPcorr} \cdot OACF$
   $q_{EHAcorr} = q_{ETAcorr} + q_{SUPcorr} \cdot (OACF-1)$
7. Calculate the new Pressure losses in the AHU including possible throttling and multiply these corrected pressure losses by factor 1.05 to allow for the fact that no iteration is conducted.
8. Use the new air flows and pressure increases to calculate the fan data from fan DLL.
9. Calculate ErP parameters (e.g. SFP_{int}) with corrected data.
10. Calculate other SFP values with corrected data, if applicable.
11. Use corrected pressures and fan powers in selection result data.
12. It is advised that both the requested ventilation air flow rates and the corrected flow rates are provided so that the unit can be correctly commissioned.

6.4 Additional clarifications and proposed amendments to the Regulation

- The throttling referred in Paragraph 6.3.3 may be performed by means of a device (e.g. damper) installed in the AHU or in the ductwork.
  For consistency in the content of the Regulation it is proposed to update the definition of 'reference configuration on a BVU' as follows:

  'reference configuration of a BVU' means a product configured with a casing, at least two fans with variable speed or multi-speed drives, a HRS, a clean fine filter on the inlet-side, a clean medium filter on the exhaust-side **and the throttling pressure drop necessary for compliant EATR**.

- Correction factor of 1.05 indicated in Paragraph 6.3.7 refers to:
  - Adjustment due to lack of iteration to calculate AHU pressure losses at corrected air flows,

- simplified consideration of the impact of the change in external pressure losses due to corrected q_{ODA} and q_{EHA}.

7. Calculation examples with the simplified method

This section provides examples of the corrected power input and SFP calculation carried out on the basis of performance of real units. The selections are made only with functions included in the reference configuration and at an external static pressure of 200 Pa (for the system layout refer to **Figure 1**). Thus, the demonstrated increase of power input corresponds to the reference configuration. Example 1 analyses in detail the impact on SFP_{int} and SFP_v.

Example 1 – Maximum EATR and OACF values

A ventilation unit with rotary heat exchanger operating at an air flow of 1 m^3/s and external pressure of 200 Pa.

The EATR is 5% and the OACF is 1.1

Electrical power to fans in clean filter state before correction is made:

Supply:	0.76 kW
Exhaust:	0. 71 kW
Clean pressure drop of the outdoor filter:	70 Pa
Clean pressure drop of the extract filter:	38 Pa
SFP_v	1.47 $kW/m^3/s$
SFP_{int}	835 $W/m^3/s$ (SPF_{int_limit} 1078 $W/m^3/s$)

Correction procedure:

a) Correct the supply air flow rate: $q_{SUPcorr} = 1\ m^3/s \cdot (1 + 0.05) = 1.05\ m^3/s$
b) Correct the extract air flow rate: $q_{ETAcorr} = 1\ m^3/s + (1 \cdot 0.05) =1.05\ m^3/s$
(the additional supply air flow is balanced in the extract flow)
c) Correct the outdoor air flow rate: $q_{ODAcorr} = 1.05\ m^3/s \cdot 1.1 = 1.155\ m^3/s$
d) Correct the exhaust air flow rate: $q_{EHAcorr} = 1.05\ m^3/s + 1.05 \cdot (1.1 - 1) = 1.155\ m^3/s$

Calculate the new pressure drop in the filters:
Outdoor air filter increases from 70 Pa to 83 Pa. Adding 5% (due to non-iterative calculation) gives 87 Pa.
Extract filter increases from 38 Pa to 41 Pa. Adding 5% gives 43 Pa.

Recalculate the fans with the new flow and pressure:
The electric power to the supply fan increases from 0.76 kW to 0.83 kW i.e. + 9.2%
The electric power to the extract fan increases from 0.71 kW to 0.92 kW i.e. + 29.6%

The SFP_v increases from 1.47 to 1.75 kW/ m^3/s **i.e. +19 %**

The SFP_{int} increases from 835 to 1072 W/ m^3/s **i.e. +28 %** (SPF_{int_limit} 1078 $W/m^3/s$)

As the example shows, including the impact of internal leakages the corrected SPF_{int} is very close to the limit. Under more adverse conditions, considering internal leakages, compliance may not be met.

Example 2 – Medium EATR and OACF values

A ventilation unit with rotary heat exchanger operating at an air flow of 1 m^3/s and external pressure of 200 Pa.

The EATR is 3% and the OACF is 1.08

Electrical power to fans in clean filter state before correction is made:

Supply:	0.94 kW
Exhaust:	0.86 kW
Clean pressure drop of the outdoor filter:	70 Pa
Clean pressure drop of the extract filter:	38 Pa

Correction procedure:

e) Correct the supply air flow rate: $q_{SUPcorr}$ = 1 $m^3/s \cdot (1 + 0.03)$ = 1.03 m^3/s
f) Correct the extract air flow rate: $q_{ETAcorr}$ = 1 $m^3/s + (1 \cdot 0.03)$ =1.03 m^3/s
(the additional supply air flow is balanced in the extract flow)
g) Correct the outdoor air flow rate: $q_{ODAcorr}$ = 1.03 $m^3/s \cdot 1.08$ = 1.11 m^3/s
h) Correct the exhaust air flow rate: $q_{EHAcorr}$ = 1.03 $m^3/s + 1.03 \cdot (1.08 - 1)$ = 1.11 m^3/s

Calculate the new pressure drop in the filters:
Outdoor air filter increases from 70 Pa to 79 Pa. Adding 5% (due to non-iterative calculation) gives 83 Pa.
Extract filter increases from 38 Pa to 40 Pa. Adding 5% gives 42 Pa.

Recalculate the fans with the new flow and pressure:
The electric power to the supply fan increases from 0.94 kW to 1.00 kW i.e. + 6.4%
The electric power to the extract fan increases from 0.86 kW to 1.04 kW i.e. + 20.9%

The SFP_v increases from 1.80 to 2.04 kW / m^3/s **i.e. +13.3 %**

Example 3 – low EATR and OACF values

A ventilation unit with rotary heat exchanger operating at an air flow of 1 m^3/s and external pressure of 200 Pa.

The EATR is 1.5% and the OACF is 1.04

Electrical power to fans in clean filter state before correction is made:

Supply:	0.94 kW
Exhaust:	0.86 kW
Clean pressure drop of the outdoor filter:	70 Pa
Clean pressure drop of the extract filter:	38 Pa

Correction procedure:

a) Correct the supply air flow rate: $q_{SUPcorr}$ = 1 $m^3/s \cdot (1 + 0.015)$ = 1.015 m^3/s
b) Correct the extract air flow rate: $q_{ETAcorr}$ = 1 $m^3/s + (1 \cdot 0.015)$ =1.015 m^3/s
(the additional supply air flow is balanced in the extract flow)
c) Correct the outdoor air flow rate: $q_{ODAcorr}$ = 1.015 $m^3/s \cdot 1.04$ = 1.056 m^3/s
d) Correct the exhaust air flow rate: $q_{EHAcorr}$ = 1.015 $m^3/s + 1.015 \cdot (1.04 - 1)$ = 1.056 m^3/s

Calculate the new pressure drop in the filters:

Outdoor air filter increases from 70 Pa to 74 Pa. Adding 5% (due to non-iterative calculation) gives 78 Pa.

Extract filter increases from 38 Pa to 39 Pa. Adding 5% gives 41 Pa.

Recalculate the fans with the new flow and pressure:

The electric power to the supply fan increases from 0.94 kW to 0.97 kW i.e. + 3.2%

The electric power to the extract fan increases from 0.86 kW to 0.95 kW i.e. + 10.5%

The SFP_v increases from 1.80 to 1.92 kW/m^3/s **i.e. +6.7 %**

Example 4 – zero EATR and low OACF + extra 50Pa throttling on extract to get EATR = 0

A ventilation unit with rotary heat exchanger operating at an air flow of 1 m^3/s and external pressure of 200 Pa.

The EATR is 0 % and the OACF is 1.05

in addition, extra 50 Pa throttling is applied on the extract side to reduce $\Delta p_{22\text{-}11}$ and get the EATR = 0

Electrical power to fans in clean filter state before correction is made:

Supply:	0.94 kW
Exhaust:	0.86 kW
Clean pressure drop of the outdoor filter:	70 Pa
Clean pressure drop of the extract filter:	38 Pa

Correction procedure:

a) Correct the supply air flow rate: $q_{SUPcorr}$ = 1 m^3/s · (1 + 0) = 1.0 m^3/s
b) Correct the extract air flow rate: $q_{ETAcorr}$ = 1 m^3/s + (1 · 0) =1.0 m^3/s
c) Correct the outdoor air flow rate: $q_{ODAcorr}$ = 1.0 m^3/s · 1.05 = 1.05 m^3/s
d) Correct the exhaust air flow rate: $q_{EHAcorr}$ = 1.0 m^3/s + 1.0 · (1.05 - 1) = 1.05 m^3/s

Calculate the new pressure drop in the filters:

Outdoor air filter increases from 70 Pa to 74 Pa. Adding 5% gives 78 Pa.

Extract filter increases from 38 Pa to 38 Pa. Adding 5% gives 40 Pa.

Recalculate the fans with the new flow and pressure:

The electric power to the supply fan increases from 0.94 kW to 0.95 kW i.e. + 1.1%

The electric power to the extract fan increases from 0.86 kW to 1.05 kW i.e. + 22.1%

The SFP_v increases from 1.80 to 2.0 kW/ m^3/s **i.e. +11.1 %**

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3. How European is the association?	**4. How representative is the organisation?**
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