Internal Leakage in Air Handling Units

– the Outdoor Air Correction Factor (OACF) and Exhaust Air Transfer Ratio (EATR)

WILLIAMS LAWRANCE
Senior Product Manager AHU,
Swegon

The benefits of good ventilation and indoor air quality for comfort, health and productivity in both places of work and homes is undisputed. According to WHO "poorly ventilated buildings affect air quality and can contribute to the spread of disease"

Leakage of air in ventilation systems is, of course, wasteful but it can also affect the indoor air quality so we need to minimise leakage to both optimise the energy consumption and ensure the best possible air quality.

During recent years more attention has been focused on the subject of internal leakage in air handling units and now we see that progress has been made in defining test methods and also setting requirements. The testing standard for heat exchangers for air to air heat recovery, EN 308: 2022 includes methods for measuring the OACF (Outdoor Air Correction Factor) and EATR Exhaust Air Transfer Ratio). We will explain those terms later in this article. In November 2023 a new certification scheme was agreed within Eurovent Certita. The new rules include a requirement to declare OACF and EATR, so customers will see those properties in the technical submittals from Eurovent Certified AHU manufactures. The testing of the power consumption of the AHU will, from now on, include the effect of the internal leakages.

Already, manufacturers of the heat exchangers provide the OACF and EATR so that AHU manufactures can include the information and use the data in the calculation of unit performance.

It is also quite likely that the next version of the ErP Regulation for non-residential ventilation units will include the requirement to declare the OACF and EATR.

So, what does it mean?

We differentiate between internal and external leakage. External leakage is the leakage through the unit casing between the inside and outside of the unit while internal leakage occurs between the dividing walls of the internal sections.

All types of air handling unit have a potential leakage of air past the filters which will have a negative impact on the air quality as well as dirty ducting with increased cleaning costs as a result.

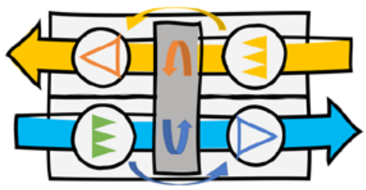
Filter bypass leakage is classified according to the filter class with the intention that the design of the filter frame and sealing is appropriate for the filtration required. Testing should be carried out in accordance with EN 1886:2007. Eurovent certified air handling units are independently tested by third party laboratories and the results are published on the Eurovent home page.

Heat exchangers for energy recovery are also potential sources for leakage. Plate heat exchangers should have small levels of leakage in themselves but a poor installation in the air handling unit can give rise to considerable leakage with energy losses and degraded air quality as a result. Well installed plate heat exchangers will have very low leakage but depending on the position of the fans and the construction of the unit there is a potential for leakage of extract air to supply air.

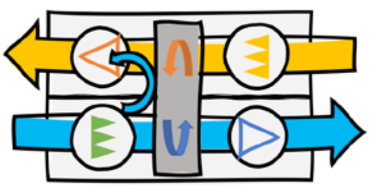
Rotary heat exchangers offer the advantage of a high efficiency with small space requirement and very little need for defrosting. But because they rotate, they are more difficult to seal effectively.

With rotary heat exchangers there are essentially four modes of leakage.

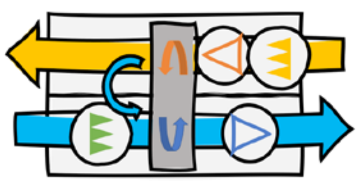
The first is the peripheral leakage. Leakage around the periphery of the rotor will have a direct effect on the overall heating power of the rotor. The reduction in temperature efficiency can be quite significant and leakage past the periphery seals will also contribute significantly to the leakage between airflows so it is important that the periphery seal is effective.



The second mode of leakage is that from the outdoor air side to the exhaust air side. Normally there will be a large pressure difference between the outdoor air side of the rotor and the exhaust side. This pressure drop drives a leakage from the supply to exhaust air side. Leakage in that direction will not affect the air quality but it will have an effect on the energy consumption. When we have the correct airflow at the supply air fan, we will have a higher airflow at the fresh air filter and that means we will have a higher pressure drop there. We must also compensate on the exhaust side to ensure that we get the correct extract airflow. This is quite a complex calculation to make requiring an iteration to arrive at the correct result but without it, the power consumption of the fans will not be correct and that means any annual energy calculation will also be wrong.



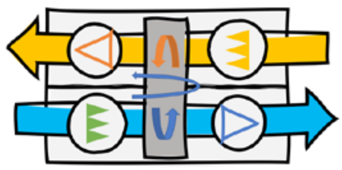
If the extract fan is placed on the extract side of the rotor, then the leakage will be in the other direction:



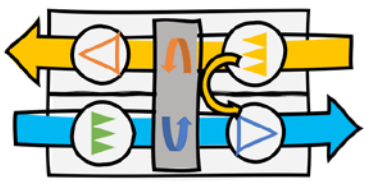
This will have a serious effect on the air quality and is not recommended at all.

To be able to minimise the leakage of air between the airflows the recommended arrangement of the fans is upstream of the rotor on both sides.

Rotary heat exchangers can carry extract air over to the supply air. This carry over leakage can be effectively eliminated by means of a purging sector. A small sector of the rotor is shielded off so that extract air cannot enter the rotor there and outdoor air is bled through the rotor in both directions to purge it of extract air. This purging function cleans the rotor of impurities and ensures a high quality of supply air. To drive this purging flow, we need a pressure difference; which must be created by the extract fan. The purging flow must also be added to the flow rate of the extract fan.



The fourth mode of leakage is from extract to supply on the room side of the rotor like this:

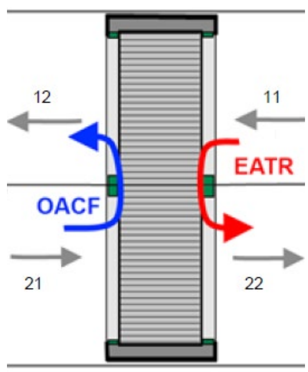


This leakage will depend on the pressure difference between the extract and the supply and if the fans are correctly positioned as shown, can be eliminated by throttling the extract air so that the pressure difference is in the right direction. This extra pressure drop must be included in the exhaust fan.

The leakages described in modes two to four above are defined in EN 16798-3:2018 (Energy performance of buildings) by two ratios:

Outdoor air correction factor (OACF)

Exhaust air transfer ratio (EATR)



OACF is the ratio of the outdoor air inlet and the supply air outlet flow:

$$OACF = \frac{q_{m,21}}{q_{m,22}}$$

From an air quality point of view, the OACF should be greater than one, because that means the leakage is from supply to exhaust. If it is less than one, then there is leakage from exhaust to supply and we want to avoid that.

EATR is the percentage of exhaust air recirculating to the supply air:

$$EATR = \frac{q_{m,22} - q_{m,22,net}}{q_{m,22}} = 1 - \frac{q_{m,22,net}}{q_{m,22}}$$

EATR is the leakage by the seal at the rotor on the room together with the carry-over leakage.

We need to consider these two leakage measures together. Both of them need to be kept within limits.

As mentioned above, test methods for OACF and EATR are defined in EN 308:2022

What is the impact on the power consumption?

To correct for the EATR it is necessary to ensure a correct pressure balance and that often means that the extract air needs to be throttled which means that an additional pressure drop is introduced. Obviously, that increases the power consumption of the extract fan.

The OACF needs to be compensated for by increasing the airflow in the extract fan so that also increases the power consumption. The OACF also means that the airflow through the intake sections of the system through to the heat exchanger needs to be a little more than the required supply airflow. That means higher pressure drop for the supply fan.

An example illustrates how much this impacts the total power consumption:

Consider a ventilation unit with rotary heat exchanger with an air flow of 1 m^3/s and external static pressure 200 Pa. The EATR is 3% and the OACF is 1.08

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

Supply: 0.94 kW, Exhaust 0.86 kW

Clean pressure drop of the outdoor filter is 70 Pa.

Clean pressure drop of the extract filter is 38 Pa.

1. The supply air flow is increased by 3% to compensate for the EATR. To maintain the pressure balance in the building the extract air flow is also increased by 3%.
2. The outdoor air flow is corrected by an additional 8% to compensate for the OACF and the exhaust air flow is also corrected by that 8%
3. The pressure drop through the filters recalculated at the new air flow rates and become 83 Pa and 42 Pa respectively.

The result is that the supply air fan operates at 3% higher air flow and 13 Pa higher pressure while the extract fan operates at 11% higher airflow and 2 Pa higher pressure.

The fans are recalculated 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 increases from 1.80 to 2.04 kW/m^3/s i.e. +13.3 %

This is a typical example but the result depends, of course, on several factors so it varies from case to case.

When the power consumption is calculated in this way with the inclusion of the effect of the leakages one can be assured that it is made at the ventilation flow rate required and that the indoor air quality will not be compromised. We can also compare ventilation units with different heat recovery solutions without worrying about the impact of leakage.

References

EN 1886:2006 Ventilation for buildings-Air handling units - Mechanical performance.

EN 308:2022 Heat exchangers – Test procedures for establishing performance of air to air heat recovery components.

EN 16798-3:2017 Energy performance of buildings - Ventilation for buildings - Part 3: For non-residential buildings -Performance requirements for ventilation and room-conditioning systems.

Technical certification rules of the Eurovent Certified performance mark, air handling units, ECP 05, Revision 01-2024; www.eurovent-certification.com/en/third-party-certification/certification-programmes/ahu. ■