Energy Savings with Aeroseal Ductwork Sealing in Europe

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This paper presents the results of 7 ductwork sealing projects through aerosols injection in Europe. The ductwork leakages were reduced from 87% up to 98% with an average of 93%. The impact on the energy consumption is quantified, with savings reaching up to 36 k€/year (for a 30 000 m² building).

Keywords: Ductwork leakage, sealing, aerosol, energy savings, fan consumption, Aeroseal

For years, ventilation and air-conditioning systems have played an increasingly important role in ensuring sufficient air exchange in buildings. With time buildings are becoming more and more airtight to avoid energy losses through uncontrolled air leakage and mechanical ventilation systems are installed to ensure a good indoor air quality. What is a good approach in theory can fail in practice due to leaky ductwork. Various studies have shown a low awareness on this issue in most European countries [1], with leaky ductworks impacting the energy use, the indoor air quality or generating noise [2].

One solution applicable both to new ductwork systems not meeting the expected air tightness class and existing leaky ductwork, is a sealing through aerosols injection. This technique explained in [3] and patented as the Aeroseal process, allows to seal air duct systems from the inside within a short time and without having to search for leaks beforehand. Leakages with gaps of up to 15 mm are permanently eliminated by using a sealant that is certified according to VDI 6022. As reported by European resellers, almost 700 sealing projects have been carried out using this method since 2015 in Europe.

This paper presents the results of 7 ductwork sealing projects performed during the year 2021 on existing (mostly non-residential) buildings located in 7 different European countries: Germany, France, Ireland, Czech Republic, the Netherlands, Poland and Switzerland. An extended paper was presented at the Rotterdam AIVC conference, including more data and calculation details, and presenting also on-site experience from the sealing operators [4].

Methodology

Aeroseal air duct sealing technique

The aerosol-based sealing process was developed in the 1990s at the University of Berkeley, USA [5], [6], and was patented as the Aeroseal process (see **Figure 1**). The innovation consists in sealing ductwork from the inside, within a short time and without having to search for leaks beforehand. Chemically speaking, this technique is based on an emulsion of water and vinyl acetate polymer, a stable, non-toxic and non-flammable mixture, that is aerosolized into 4–10 micron-sized particles [7].

The resulting aerosol is distributed under pressure inside the ventilation ductwork system [3]. The particles seal little by little leaks with gaps of up to 15 mm forming a robust air sealing that will last for years while staying pliable and flexible and remains effective over a wide range of operating pressures, temperatures and humidity levels found in residential, commercial and industrial air duct systems [7]. Contrary to a coating process, the particles deposit only at the leaks and not elsewhere in the ductwork.

Until today the Aeroseal process has been applied in more than 125 000 ductwork systems of both residential and non-residential buildings, mostly in the USA. In Europe the product was introduced in the market in 2015 by Mez-Technik located in Germany and since then there have been almost 700 sealing projects in over 20 countries thanks to Aeroseal partners companies from 18 countries.

Case study: selected 7 buildings across Europe

In order to evaluate the performance of this aerosol-based sealing technique, a survey was sent to 7 Aeroseal partners across Europe to collect detailed data on ductwork sealing projects performed in 2021.

Figure 2 presents the buildings' characteristics of the selected sealing projects, the reasons why a sealing was requested and the initial ductwork airtightness level. The building selection was made in order to cover a wide range of parameters for both the buildings (location, type, surface, year of construction) and the ventilation systems (flowrate capacities ranging from 6 000 m³/h for the CZ project to 301 407 m³/h for the IE project; exhaust, supply and balanced ventilation systems all represented).

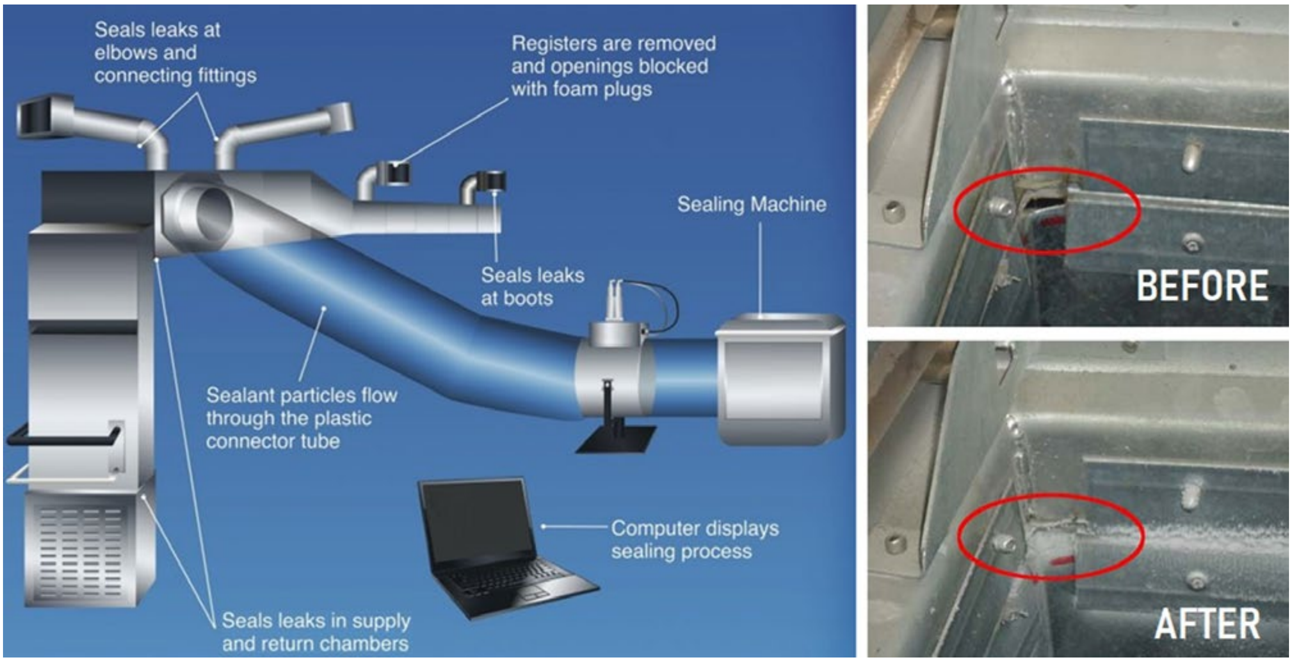

Figure 1. Aeroseal sealant technology (Image courtesy of Aeroseal LLC).

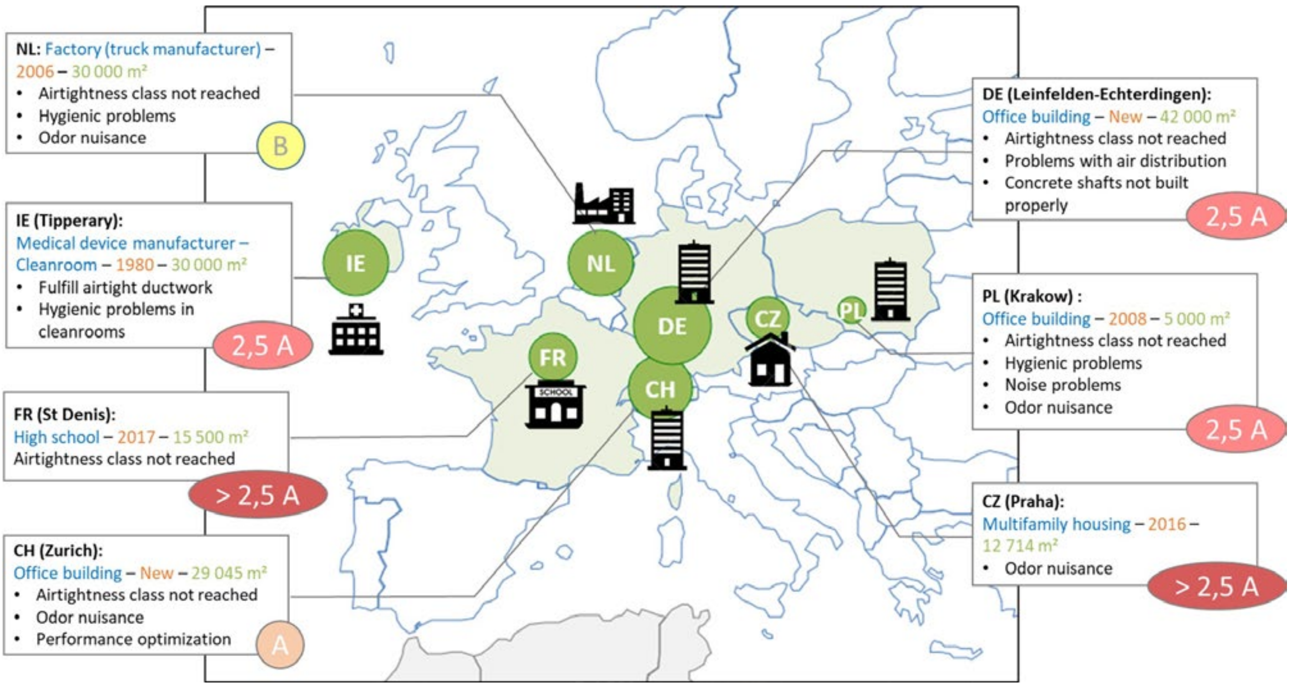

Figure 2. Details on the studied buildings, reasons for ductwork sealing, and initial ductwork airtightness level.

Data Analysis: energy savings calculation

The energy savings on the fan power are estimated in this study considering that fans fully compensate for ductwork leakage. When the fan cannot, or only partially, compensate for leakage, it is the environmental air quality that is impacted [8].

Ductwork sealing can also induce significant heating/cooling savings [9] [2], when conditioned air leaks in a non-conditioned area. They were not calculated in this study as it would require detailed data that were not available [8].

Fan power calculation

Apart from the IE project, the fan powers before/after sealing were not known by the survey respondents, and were therefore calculated as follows:

$$P_{AHU,i} = \frac{\Delta p_{AHU,i} \times Q_{AHU,i}}{\eta_{AHU,i} \times 3600} \qquad (1)$$

With:

- i = *bef* / *aft*: ductwork state: before / after the sealing
- P_{AHU}: the power of the air handling unit (AHU) (W)
- Δp_{AHU}: the pressure difference at the AHU (Pa)
- Q_{AHU}: the air flowrate at the AHU (m³/h)
- η_{AHU}: the AHU efficiency (-)

Air flowrates calculation

The AHU flowrate after the sealing was considered to be the flowrate capacity provided:

$$Q_{AHU,aft} = Q_{AHU,nom} \qquad (2)$$

The flowrate before the sealing is deduced from the value after and from the leakage flowrates (Q_{leak}) measured before and after the sealing:

$$Q_{AHU,bef} = Q_{AHU,aft} + Q_{leak,bef} - Q_{leak,aft} \qquad (3)$$

Fan efficiency

The fan efficiency varies with its flowrate. After sealing it was calculated with Equation (1) when the flowrate and pressure where known. Otherwise, a default value of 0.4 was taken.

The fan efficiency before the sealing was estimated using an equation from the support Excel sheet of standard EN 16798-5-1:

$$\eta_{AHU,bef} \approx \sqrt{\frac{Q_{AHU,bef}}{Q_{AHU,aft}}} \times \eta_{AHU,aft} \qquad (4)$$

Results

Leakage reduction

All sealing projects allowed significant leakage reductions in percentages, as illustrated in **Figure 3**. On average the leakage flowrates were indeed reduced by 93.4%, with a minimum of 87.2% for the IE project and a maximum of 97.6% for the FR project. This is done in a rather short time with cumulated aerosol injection times for the whole projects ranging from about 1 and a half hour (for the CZ project with the smallest ductwork area) to 62 hours (for the FR project with over 50 different AHU units).

Impact of ductwork leakage on energy savings

The fan power savings by ductwork sealing with the Aeroseal process are calculated for all projects according to the methodology described in paragraph "Data Analysis: energy savings calculation" and presented in **Table 1**.

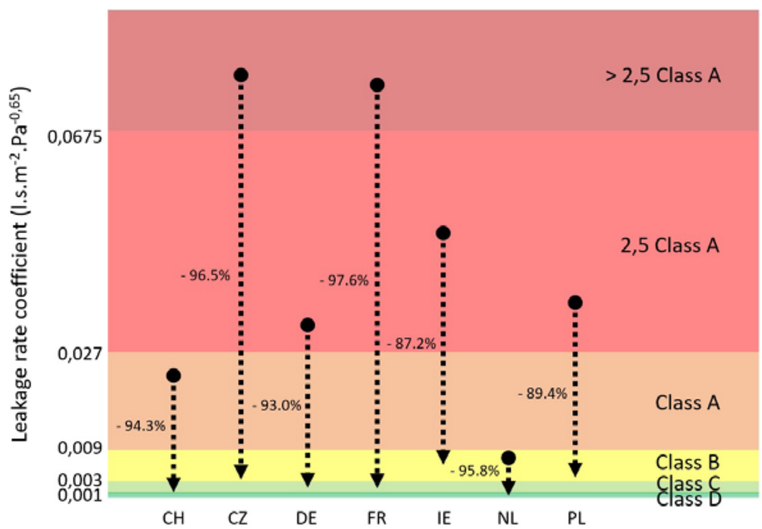

Figure 3. Ductwork leakage rate decreases with the Aeroseal sealing process.

The absolute fan power savings vary a lot depending on the sealing project (between 0.6 and 38 kW) due to the wide range of fan powers and initial leakage rates. In percentage of the initial total fan power, the savings represent from 1% (for NL project with the tightest initial ductwork) to 65% (for the FR project with the worst initial airtightness level).

The energy and cost savings are also calculated assuming a fan operating full time and according to national electricity prices. The IE project has the highest savings (about 331 000 kWh/year corresponding to about 36 000 €/year) since it is the project with the largest ductwork, one of the highest initial fan power and leakage rates. On the other hand, the CZ project has the lowest savings (about 5 000 kWh/year corresponding to about 900 €/year) despite having the highest initial leakage coefficient, as it is the project with the smallest ductwork area and initially lower fan power.

As illustrated in **Figure 4**, the percentage of initial fan power saved by ductwork sealing is proportional to the initial percentage of leakage compared to the flowrate capacity. The linear regression shows indeed a good correlation between these two parameters, with a coefficient of determination R^2 of 0.987. As a result, it seems that for a given ductwork, the percentage of initial fan power that can be saved by an Aeroseal sealing process is about twice the percentage of leakage compared to the flowrate capacity:

$$\frac{(P_{AHU,bef} - P_{AHU,aft})}{P_{AHU,bef}} \approx 2 \times \frac{Q_{leak,bef}}{Q_{AHU,bef}} \qquad (5)$$

The annual cost savings can therefore be roughly estimated as in Equation (6).

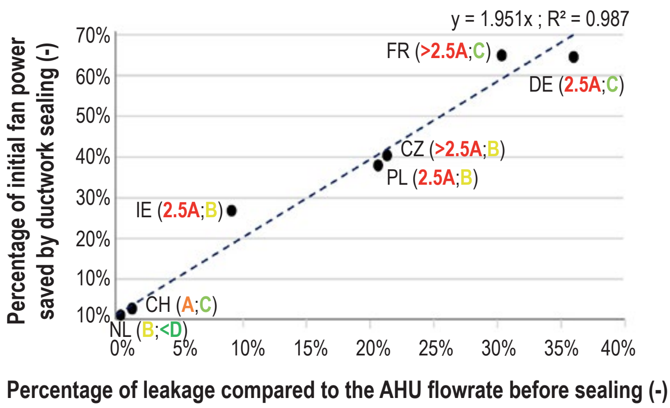

Figure 4. Percentage of initial fan power saved by sealing the ductwork according to the initial percentage of leakage compared to the AHU flowrate (airtightness classes before and after the sealing given into the brackets).

$$\text{savings } (€) \approx 2 \times P_{AHU,bef}(\text{kW}) \times \frac{Q_{leak,bef}}{Q_{AHU,bef}} \times t_{AHU,annual}(\text{h}) \times price_{elec}(€/\text{kWh}) \qquad (6)$$

Table 1. *Calculation of fan power, energy and cost savings by ductwork sealing.*

Project reference	CH	CZ	DE1	FR	IE	NL	PL
Total ductwork area (m^2)	440	131	1202	844.24	2750	800	2210
Aerosol injection time (h)	36.1	1.4	21.1	61.5	49.6	2.1	35.9
Electricity price (€/kWh)	0.204	0.180	0.228	0.110	0.110	0.178	0.150
Total AHU flowrate before sealing (103 m^3/h)	128.7	7.1	18.1	28.0	299.9	271.8	79.0
Total required fan electrical power BEFORE sealing (kW)	149.1	1.405	5.089	15.72	139.3	140.0	29.99
Fan power savings							
Total saved fan power (kW)	3.9	0.57	3.08	10.3	37.8	1.6	11.5
Percentage of initial total fan power saved (-)	2.6%	41%	60%	65%	27%	1.1%	38%
Energy and cost savings for fan operating full time (8760 h/year)							
Total saved energy (103 kWh/yr)	34.1	5.0	26.9	90.0	331.0	14.0	100.3
Total cost savings (€/yr)	6 956	902	6 144	9 901	36 414	2 490	15 049

Conclusions

The Aeroseal process, already widely used worldwide, allows to seal ductworks from the inside after their installation. Technical details from 7 sealing projects performed in 2021 across Europe, on a large variety of buildings and ventilation systems, were collected through a survey and analyzed in this paper. It allows to conclude that the Aeroseal ductwork sealing process:

- is **efficient**: ductwork leakages reduced on average by 93% (from 87% up to 98%);
- is **rather fast**: the cumulated injection time for the whole project varies from about 1 to 60 hours depending on the ventilation system's size and complexity (usually less than 1h per injection point);
- **saves fan energy use and money**: from 5 000 to 331 000 kWh per year leading respectively to about 900 € and 36 000€ of savings each year, depending on the initial fan consumption and airtightness level.

Moreover, it is observed with a linear correlation that the percentage of initial fan power that can be saved by an Aeroseal sealing process is about twice the percentage of leakage compared to the flowrate capacity. This allows to roughly estimate of the savings before sealing the ductwork with Equation (6).

These findings rely on only 7 sealing projects but a future study on a large number of projects is expected as more technical details will now be systematically filled in by the operators for each sealed ductwork.■

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References

[1] V. Leprince, F. R. Carrié, and M. Kapsalaki, 'Building and ductwork airtightness requirements in Europe – Comparison of 10 European countries', in *AIVC*, Nottingham, UK, Sep. 2017.

[2] V. Leprince, N. Hurel, and M. Kapsalaki, 'VIP 40: Ductwork airtightness - A review', *AIVC*, Apr. 2020.

[3] M. Modera, 'Fixing Duct Leaks in Commercial Buildings', *Ashrae Journal*, Jun. 2005.

[4] N. Hurel, V. Leprince, and S. Tölke, 'Field experience with ductwork airtightness improvement after completion in Europe', presented at the 42nd AIVC-10th TightVent- 8th venticool conference, Rotterdam, The Netherlands, Oct. 2022.

[5] M. Modera, D. J. Dickerhoff, O. Nilssen, H. Duquette, and J. Geyselaers, 'Residential field testing of an aerosol-based technology for sealing ductwork.', in *Proceedings of the 1996 Summer Study on Energy Efficiency in Buildings, 'Profiting from Energy Efficiency'*, USA, Washington DC, 1996.

[6] F. R. Carrié and M. P. Modera, 'Particle Deposition in a Two-Dimensional Slot from a Transverse Stream', *Aerosol Science and Technology*, vol. 28, no. 3, pp. 235–246, Jan. 1998, doi: 10.1080/02786829808965524.

[7] Mez-Aeroseal, 'Aeroseal Duct Seal Data Sheet'. [Online]. Available: https://www.mez-technik.de/media/wysiwyg/Download/MEZ-AEROSEAL_Sealant-Data-Sheet_2022_EN.pdf.

[8] N. Hurel and V. Leprince, 'Ductwork leakage: practical estimation of the impact on the energy overconsumption and IAQ', presented at the 42nd AIVC-10th TightVent- 8th venticool conference, Rotterdam, The Netherlands, Oct. 2022.

[9] N. Hurel and V. Leprince, 'Impact of ventilation non conformities: calculation methodology and on-site examples', presented at the 42nd AIVC-10th TightVent- 8th venticool conference, Rotterdam, The Netherlands, Oct. 2022.