Airtight ductwork – The Scandinavian success story

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Scandinavia is a forerunner in high-quality airtight ventilation systems. This is a result of a long development process after the problem of leakage was first identified in the 1950s, leading to the first contractual requirements on ductwork airtightness in the 1960s (most notably the Swedish trade norm VVS AMA). Since then, the requirements have become more stringent concurrently with advances in duct technology. There is now strict control in Sweden, Finland and Denmark, so most installations comply with these stringent requirements after commissioning. Approximately 90~95% of ductwork in Scandinavia is now circular steel ductwork with factory-fitted airtight gasket joints (certified with airtightness Class C or better).

This article describes the development from the Scandinavian point of view, giving recommendations on how it can be adopted in other countries. It is based on ASIEPI Information Paper 187, which also gives a complete list of references taken up in this summary. This, and other ASIEPI publications, can be downloaded from http://www.asiepi.eu/

Airtightness standards

Duct airtightness classes A to D **(figure 1 & table 1)** are defined in European Standard EN 12237 for circular ducts and EN 1507 for rectangular ducts respectively. Another standard for testing and classification of airtightness of ductwork components (EN 15727) was approved in 2010. Class "A" is counterintuitively the worst class, but this established class scale cannot now be changed. The leakage test method for system commissioning is described in EN 12599. Airtightness classes for air handling units are defined in EN 1886 (classes L1 to L3, where L1 is the best, equivalent to duct class C). System standards like EN 13779 give further recommendations for airtightness class selection for different purposes.

Table 1. Duct airtightness classes, measured at a test pressure of 400 Pa. Area is calculated according to EN 14239

Airtightness class	Limiting leakage (l/s)/m²
A – worst	< 1.32
B	< 0.44
C	< 0.15
D – best	< 0.05

The historical development of duct airtightness over the last 50 years

In Scandinavia, the problem of leakage was first identified in the 1950s, when ducts were mainly rectangular, prepared on site, and little attention was given to airtightness, airflow balancing, energy performance, or cleanliness. This decade also saw the world's first Spiro Tubeformer **(figure 2)**, a machine for making revolutionary spiral ductwork. In 1966 the seminal trade norm "AMA" defined two airtightness 'norms' A and B, to be spot-checked by the contractor. These two classes were soon adopted by Eurovent (doc. 2/2). The 1970s and 80s saw growing use of round ductwork, and further breakthroughs in product quality, such as rubber gaskets which replaced putty and tape that had been used before. Also,

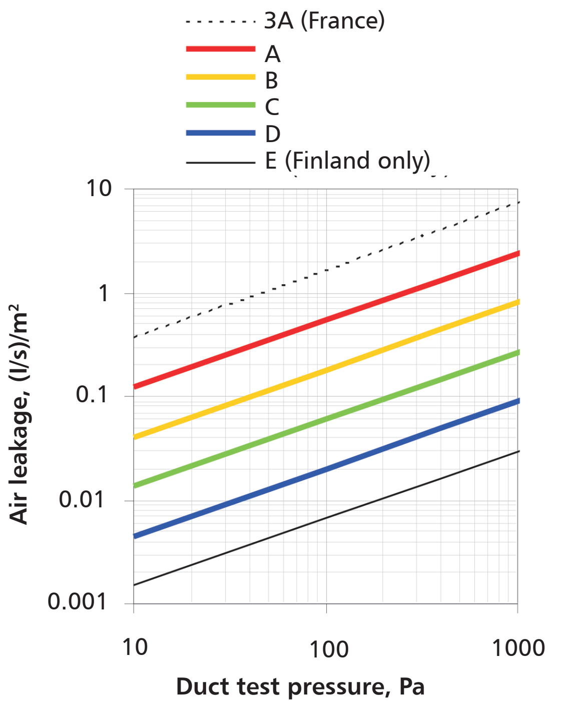

Figure 1. *Illustration of duct airtightness classes listed in table 1 (with exponent 0.65) Special classes in France (3A) and Finland (E) are also shown*

Figure 2. *Example of a machine for manufacturing spiral ducts [Spiro Tubeformer]*

duct dimensions were standardized. Airtightness Class C was introduced in the 1983 revision of AMA (and adopted in revision of Eurovent 2/2) together with requirements for commissioning and maintenance. In the late '80s, Finland took up the gauntlet and introduced new ventilation regulations with mandatory airtightness requirements, including air handling units (AHU), and gave attention to system and ductwork cleanliness, commissioning and maintenance. The late 90's saw Class D was added to AMA (1998) and the new European standard on duct cleanliness (EN 12097). In the early 2000s CEN standards on airtightness were published, based largely on Nordic experiences [EN 12237, EN 1507, EN 1751 (dampers and valves), EN 1886 (AHUs)]. Finland introduced Classes D and E at a regulatory level (Class E is only for some special applications).

Today's practice in Scandinavia

Approximately 90~95% of ductwork installed in Scandinavia is spiral-seam steel circular ducts with factory-fitted sealing gaskets (e.g. **figure 3**), with airtightness Class C or better. This type of prefabricated duct is becoming increasingly popular in Western and Central Europe, not least in The Netherlands. When assembled on a building site, the overall airtightness class of a ventilation system is often one class less than the actual factory-tested class of the individual duct components. One reason for this is the use of pressed saddle taps **(figure 4a)**, which a popular alternative to tee pieces (**figure 4b**) because they simplify fitting, but they are less aerodynamic and poor workmanship can leave gaps between the collar and the duct. To counter this, manufacturers of duct systems should ensure that their duct systems meet their claimed airtightness class with a good margin.

The minimum requirements in Sweden today is Class C for round duct systems with surface areas > 20 m². This applies to most buildings. The Finnish building regulations require minimum Class B for the whole system, and give experience-based recommendations to generally use ducts and components of Class C (minimum default) or better, and air handling units of Class L3 or better. In Denmark and Norway, systems normally fulfill at least Class B using Class C products, just as in Finland. Norway is the only country without widespread pressure testing.

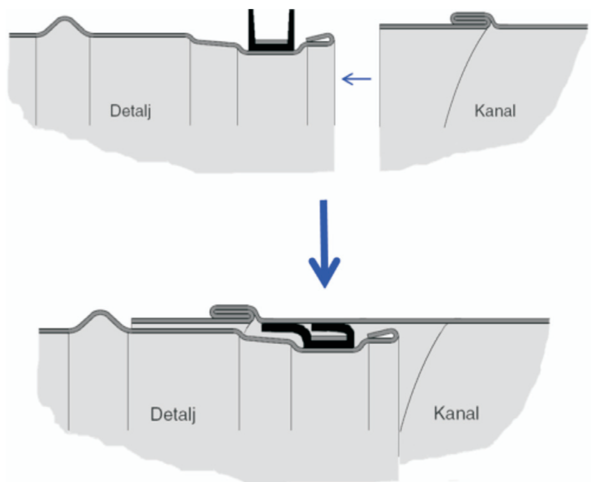

Figure 3. *Cross section of circular duct joint with double gasket, giving airtightness Class D. Single gaskets generally achieve Class C, but there are other factors that affect airtightness, such as roundness and flatness of seams at the joints. [Lindab]*

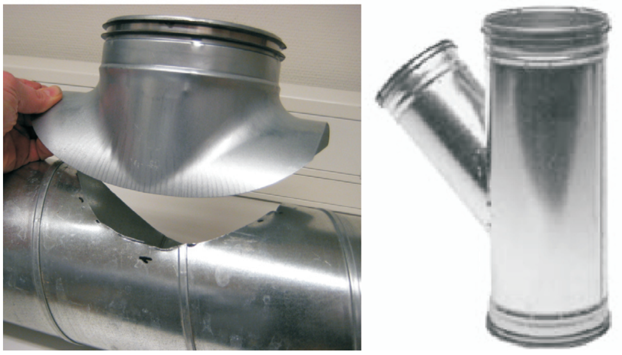

Figure 4. ***(a)*** *Collar saddle for in-situ tees [source: L.A.Matsson].* ***(b)*** *Tee with low flow resistance and airtightness Class D [Lindab]*

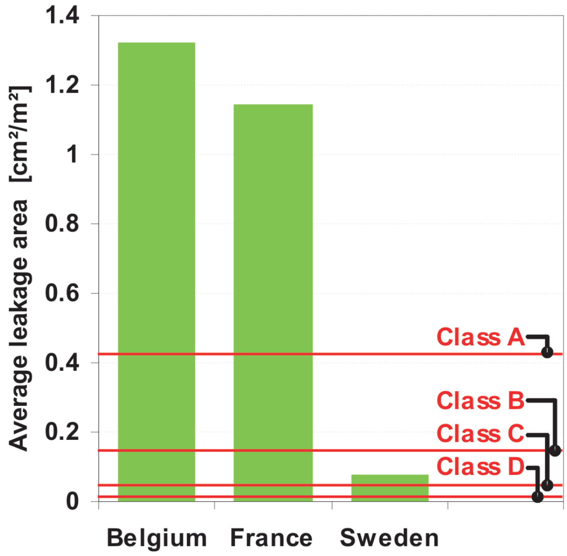

Figure 5. Comparison of average measured duct leakage in Belgium, France & Sweden. Data source: EU project SAVE-DUCT.

Scandinavia has also long been aware of the need for hygiene in ventilation systems. Ductwork is delivered to building sites with end caps. Numerous inspection hatches should be installed, before leakage testing, to provide access to the ductwork interior (in accordance with EN 12097). Cleaning is undertaken as needed after inspections. The recommended inspection interval is 2~9 years depending on building & system type. A European Standard is in preparation for further guidance on system cleanliness (prEN 15780), and the best Nordic practice is in more detail found in REHVA Guidebook 8 "Cleanliness of ventilation systems".

What about other countries?

Elsewhere in Europe, rectangular metal ducts are more commonplace. These have flange connections that should ideally be dismantled occasionally for maintenance to keep good airtightness. Round ducts are still often sealed in-situ using duct tape in combination with screws or mastic (screws/mastic are sometimes omitted). Next to metal ducts, an important part of the market for air-conditioned buildings in warm climates is site-assembled duct-boards made of insulating material. Mastic and fastening clamps are often omitted though they are required by the duct manufacturers, and the clamps (if installed at all) and taped seals can fail or loosen with age. In conclusion, ductwork airtightness in these countries depends a lot on workmanship and materials.

Outside of Scandinavia, leakage tests have seldom been performed in standard buildings, as there are no incentives to do so. This has led to poor ductwork installations in much of the building stock. Field studies suggest that duct systems in Belgium and in France are typically 3 times leakier than Class A (**figure 4**). Studies in USA show a similar or worse pattern. Analysis of specific cases indicates that leakage drastically affects overall system performance. Duct leakage therefore probably has a large energy impact outside of Scandinavia.

Impact on energy use

The impact of airtightness is recognized in European energy performance standards (EN 15242):

- typically 6% leakage in ducts of class A
- typically 2% leakage in AHUs of class L3
- but 2,5 times higher leakages are given as default, reflecting the true European situation (**figure 4**)

Airtight systems can have a lower total airflow rate and thus lower fan power. Class C round ductwork has typically 30% less fan power than traditional Class A ductwork. Fan power is further reduced by the fact that round ductwork has lower pressure drop than rectangular ductwork with the same velocity. Airtight systems also facilitate exploitation of the full benefit of other energy efficiency measures, including more optimal demand-control, and heat recovery, and energy for heating & cooling is reduced by approx. 15%.

The energy impact is difficult to quantify at a European level. However, even a rough estimation of the saving potential gives surprisingly high figures. If the airtightness of systems are improved from the present European average to the most common Nordic practice (Class B for ducts and Class L2 for AHUs) the easily achievable savings in fan energy consumption in Europe is estimated to be 25 TWh/year, ignoring the saving potential in heating and cooling energy, which is roughly the same magnitude.

Airtight systems — a must anyway

Energy aside, the immediate advantage of reduced leakage is that the air needed to maintain the indoor environment flows exactly where it is intended to go (i.e. the right amount in the right place at the right time, in the right conditions). Hence the whole system can be dimensioned and balanced exactly as it should without compensating for leakage, ensuring a good indoor environment. Numerous other substantiated benefits of using airtight round ductwork are highlighted in the ASIEPI Information Paper.

Of course airtightness is not the only key issue — proper balancing, regular maintenance, inspection, monitoring and cleaning are the elements needed to provide the specified indoor environment with minimum energy cost and environmental load. —.and if the system is leaky we cannot achieve this!

Recommendations: The 3 ingredients for success

The Scandinavian experience has shown that there are 3 basic steps in a market transformation to more airtight duct systems:

- ***Market pull:*** Increased awareness among the building and industry professionals, on the benefits of airtight systems,
- ***Technology push:*** Support a market transformation to better products. Huge reductions in duct leakage can be achieved simply by adopting round ducts as an industry standard, even when testing is not required/ practiced as part of commissioning.
- ***Regulatory push:*** Establish trade norms that are included in standard building contracts (e.g. Swedish VVS AMA) and requirements for both (i) duct airtightness as a parameter in the national Energy Performance calculations, and (ii) pressure-testing. There must be penalties or incentives to prevent noncompliance.