Why should we care about ductwork airtightness ?
And how to test it?

AIVC WORKSHOP,

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What is ductwork airtightness?

Table 12-4. HVAC system air leakage classifications

Air Tightness Class[1,2]	Air Leakage Limit, L/s per m² (cfm per 100 ft²)
A	$0.027\ (19.2)\ p_{test}^{0.65}$
B	$0.009\ (6.4)\ p_{test}^{0.65}$
C	$0.003\ (2.1)\ p_{test}^{0.65}$
D	$0.001\ (0.7)\ p_{test}^{0.65}$

[1]CEN Standard EN 12237-2003 (circular ducts)

[2]CEN Standard EN 1507-2006 (rectangular ducts)

p_{test} =test pressure, Pa (in. of water)

Bad airtightness

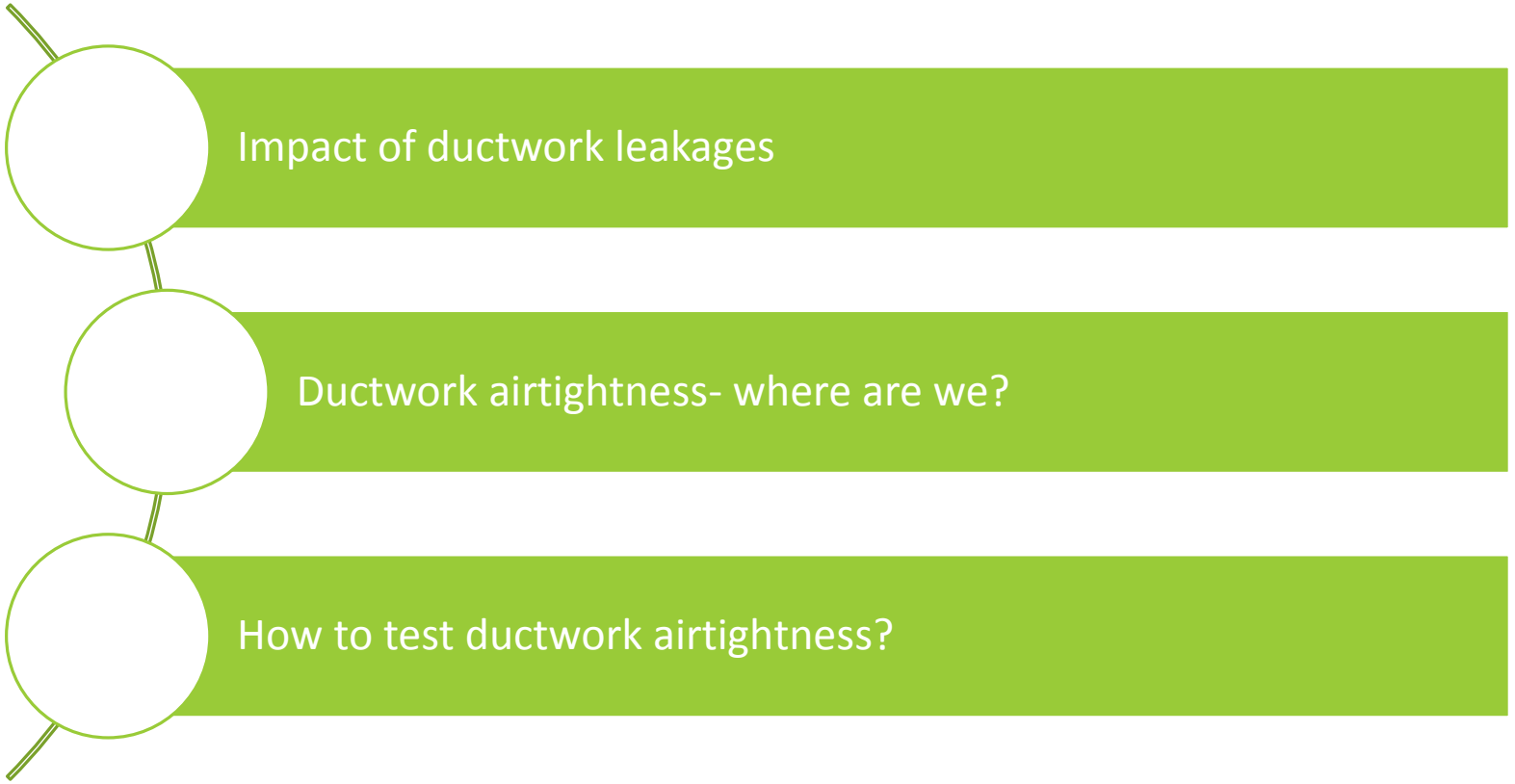
- Part of the flowrate produced by the fan leaves through leaks instead of ATD
- Either the fan compensates or IAQ deteriorates

Very good airtightness

- All flowrate produced by the fan goes through ATD

*When the airtightness of the ductwork system and the HVAC system has been improved (from 1.5*class A to class C) the average concentration of CO2 has dropped from 1400 ppm to 650 ppm.*
Richieri et al, 2018

Outline


Impact of ductwork leakages
Ductwork airtightness- where are we?
How to test ductwork airtightness?

Impact of ductwork airtightness on energy use

FAN ENERGY USE AND HEATING AND COOLING LOADS

Ductwork leakages and fan energy use

Fan power scale with flowrate multiplied with the pressure at the fan

$$P_{el} = \frac{\Delta P * Q}{\eta * 3600}$$

- The more flowrate is needed the more power is needed, and
- The more pressure drop the fan has to withstand the more power is needed

A tool based on EN 16798-5-1 (CEN, 2016) has been developed to calculate the fan energy saving induced by air tightening the ductwork of existing building .

Leprince&Carrié, 2018

For VAV system a duct leakage model has been developed for Energy Plus to take into account ductwork leakages on fan energy use (on each side of VAV system).

Wray&Sherman, 2010

Ductwork leakages and fan energy use

Pressure losses in the ductwork are the sum of

- Friction losses (linear losses)
- Dynamic losses (singularity losses)

$$\Delta p = \left(\frac{1000 f}{D_h} + \sum C\right)\left(\frac{\rho V^2}{2}\right)$$

It scales with the square of the flow speed and then with the square of the flowrate

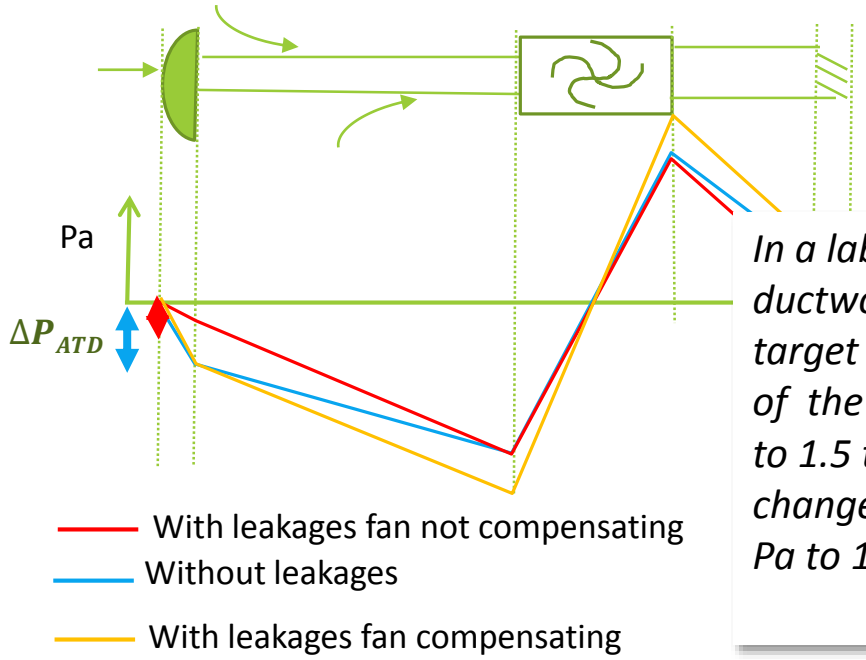
$\Delta P \alpha Q^2$

Ductwork leakages and fan energy use

Fan and pressure losses

- To maintain hygienic flowrate the fan needs to compensate for additional flowrate and additional pressure drop
- Around 10 Pa needed at ATD (fix ATD)

$q_{ATD} = C\ \Delta P_{ATD}^{\ n}$

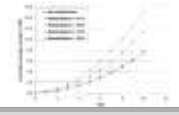


In a laboratory replication of residential ductwork to maintain the flowrate target at ATD, when the airtightness of the ductwork decreases (from class C to 1.5 times class A), it is necessary to change the setpoint of the fan from 90 Pa to 120 Pa.

Berthault, 2014

Ductwork Leakages and fan energy use

At the European level, the save duct project has shown that the cumulative savings potential over a period of 10 years appears to be in the region ***of 10 TW h.***



Carrié & al, 2000

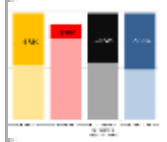
After the complete refurbishment of the ventilation system of the bunker not only the C02 concentration has been divided by 2 but in the meantime the ***fan power has been reduced by 71%*** *in one zone to* ***78%*** *in the other.*

Richieri & al, 2018

In commercial building, detailed simulations have shown an ***increase of 60%*** *of the fan power due to 20% duct leakage (split equally between upstream and downstream of the VAV boxes).*

Franconi & al, 1998

*Tightening the ductwork from 1.5*class A to class C can* ***divide almost by 2 the fan energy use*** *a case study on a laboratory replication of a residential ductwork.*



Berthault & al, 2014; Leprince 2018

Impact on heating and cooling load

SUPPLY DUCTWORK

EXTRACT DUCTWORK

Loss of pre-conditioned air

In US in average + 10 / +30% escape by leaks

Oregon, 2004

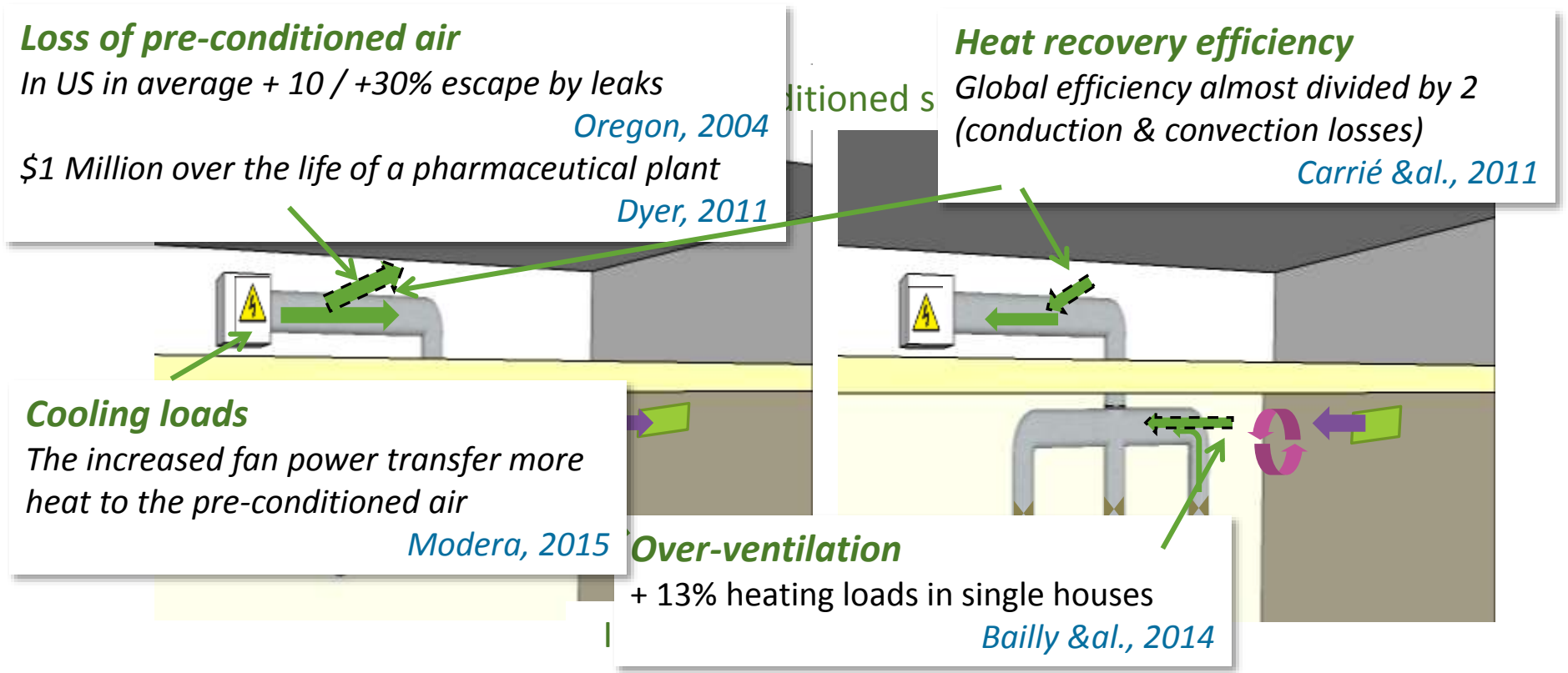
$1 Million over the life of a pharmaceutical plant

Dyer, 2011

Heat recovery efficiency

Global efficiency almost divided by 2 (conduction & convection losses)

Carrié &al., 2011



Cooling loads

The increased fan power transfer more heat to the pre-conditioned air

Modera, 2015

Over-ventilation

+ 13% heating loads in single houses

Bailly &al., 2014

Where are we?

REGULATION AND DUCTWORK LEAKAGE : LEVEL

Ductwork airtightness in regulation and programmes

In **Sweden** ductwork airtightness is required
- Since 1966
- Since 2007: **Class C** required (even rectangular)

In **Portugal** for large buildings
- Since 2006 ductwork leakage below **1.5 l/s.m² under 400 Pa**
- **Seldom complied:**
  - **Few tests performed per year**
  - **Only 4 out of the 11 biggest companies have a measuring device**

In **UK**
- **Test mandatory** for high pressure ductwork (BESA DW 143)
- For low pressure ducting no test required but taken into account in calculation through in-use factor
- Test typically performed by ducting contractor

Ductwork airtightness in regulation and programmes

In **Belgium**

- Taken into account in calculation method, but no minimum requirement

In **France**

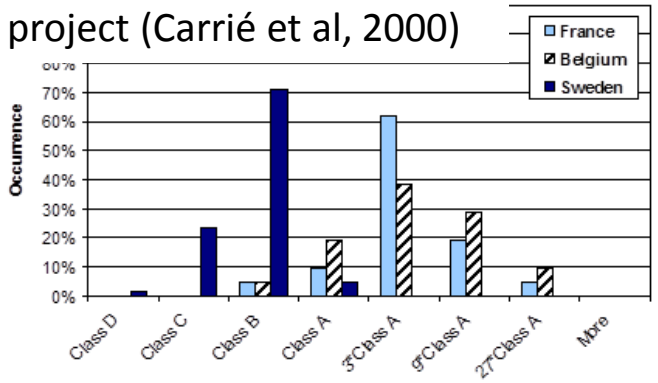
- Since 2013, Effinergie + label requires **Class A**
- Test has to be performed by a **qualified** independent **technician**
- **Ductwork class input of EP-calculation**
  - No minimum requirement
  - No impact on fan energy use (only heating/cooling loads)

In **USA**

- IECC code (2009) requirement:
  - ≤12 CFM25 (per 100 ft2 of conditioned floor area) for total duct leakage,
  - ≤8 CFM25 if the duct leakage to-outside is measured instead

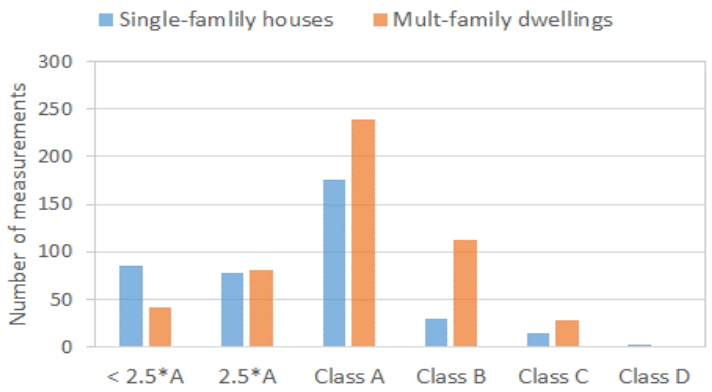
Ductwork airtighness measurement

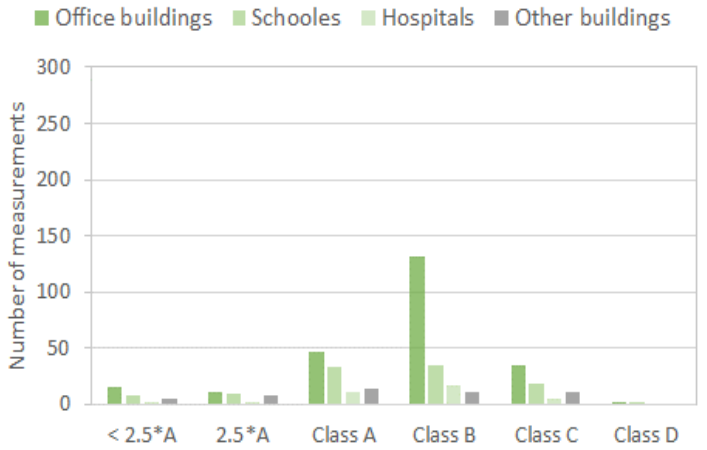
Save duct project (Carrié et al, 2000)



In the US: duct leakage in 11 large buildings shown to represent on average 28% of the fan flow.

Modera, 2013





Distribution of ductwork airtightness measured classes by qualified testers (Moujalled et al. 2018)

How to measure ductwork airtightness?

EUROPEAN STANDARDS AND NATIONAL GUIDANCE

European standards

The main problem: as many standards as ductwork types

- EN 12237:2003 Ventilation for buildings - Ductwork. Strength and leakage of circular sheet metal ducts (CEN, 2003)
- EN 1507:2006 Ventilation for buildings - Sheet metal air ducts with rectangular section Requirements for strength and leakage (CEN, 2006)
- EN 13403:2003. Ventilation for buildings. Not metallic ducts. Ductwork made from insulation ductboards.
- EN 15727:2010 Ventilation for buildings - Ducts and ductwork components, leakage classification and testing (CEN, 2010)
- EN 14239: Measurement of surface area
- EN 13180, EN 13403, EN 1751, EN 1886

An inspection standard

- EN 12599:2012: Ventilation for buildings. Test procedures and measurement methods to hand over air conditioning and ventilation systems
- Under revision

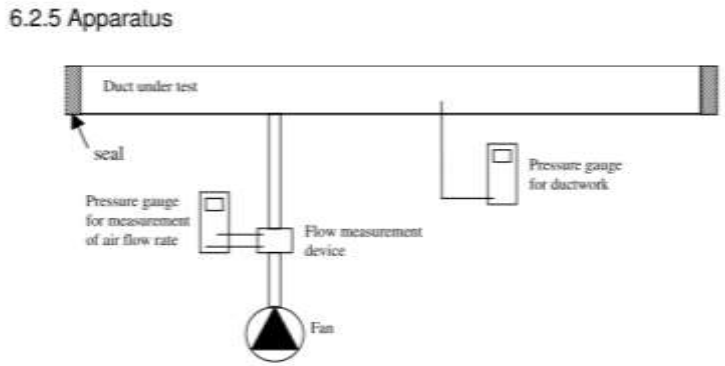


Figure 30: Fan pressurisation measurement principle and equipment

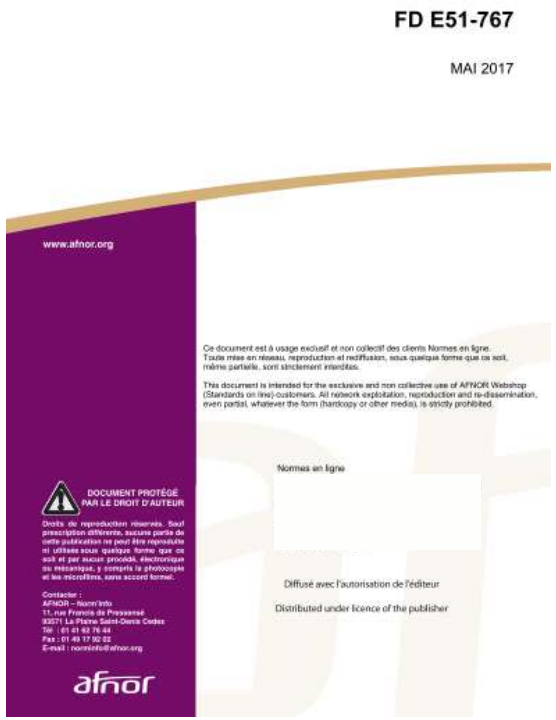
National guidance

National guidance: What is included? ex FD 51- 767

How to use test standard with various types of ductwork (rigid, flexible, etc.)

How to sample

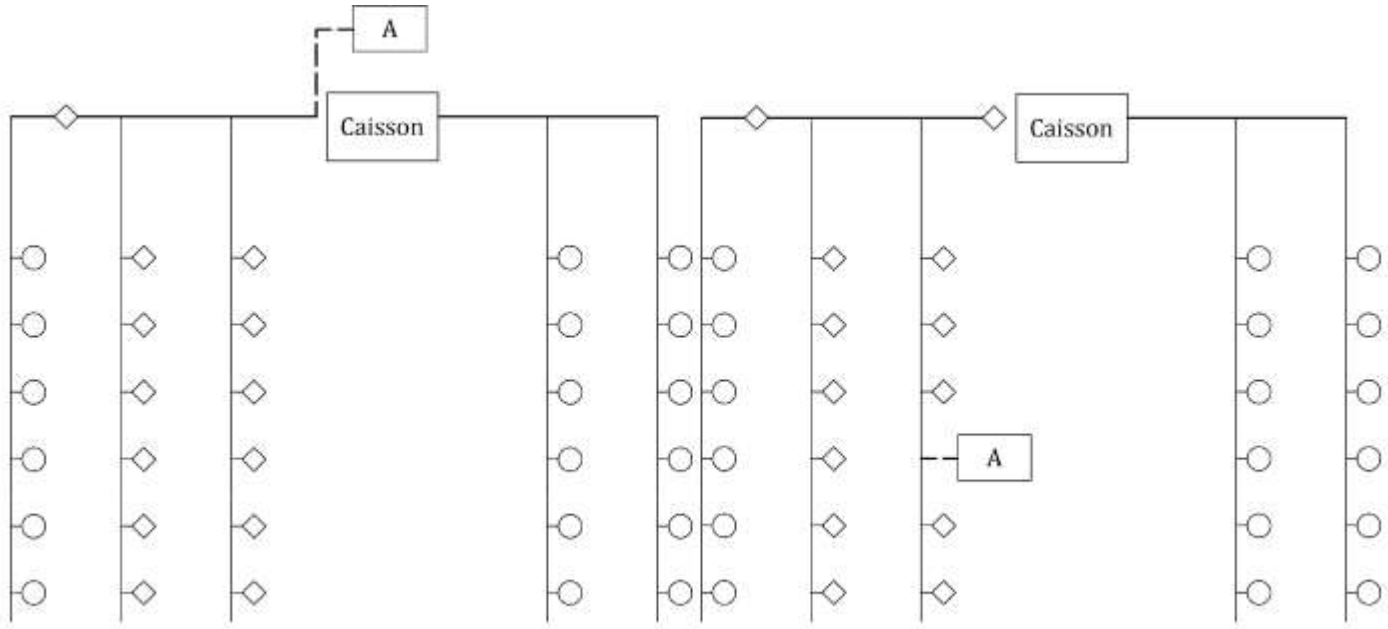
How to take into account specific devices (plenum, etc.)



National guidance: What is included? ex FD 51- 767

How to use test standard with various types of ductwork (rigid, flexible, etc.)

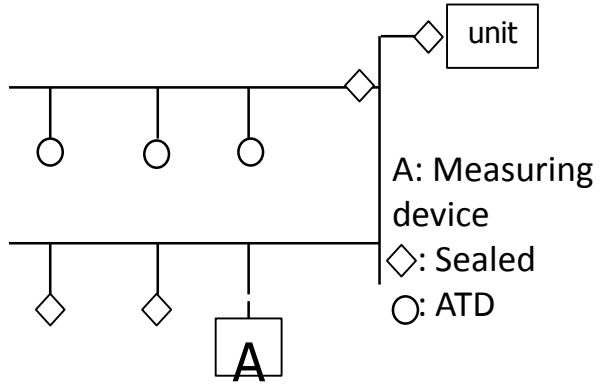
- The tested section shall be representative of all shape, size, materials used in the ductwork.

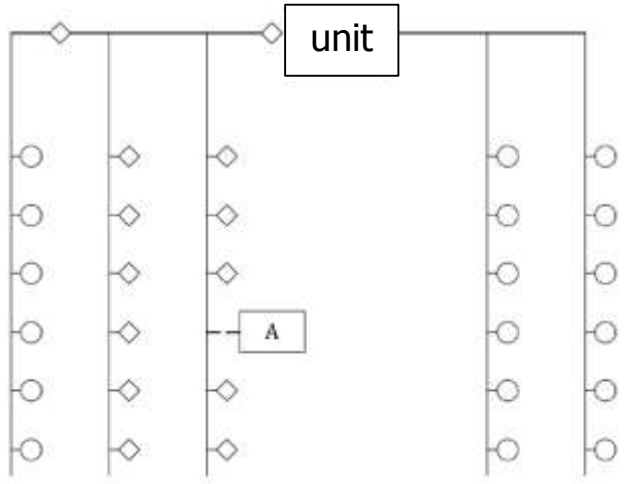


National guidance: What is included? ex FD 51- 767

How to sample:

- One of those requirement shall be met:
  - L/Aj ≥ 1 and Aj > 10 m2 and Aj > 10 %
  - At least one **whole floor** to the ventilation unit and Aj > 10 m2 and Aj > 20%
  - At least **one whole column** to the ventilation unit and Aj > 10 m2 and Aj > 20%
- If there are “N” AHU:
  - If N ≤ 5, each shall be tested
  - If N > 5, at least 5 + 40% x (N-5) shall be tested





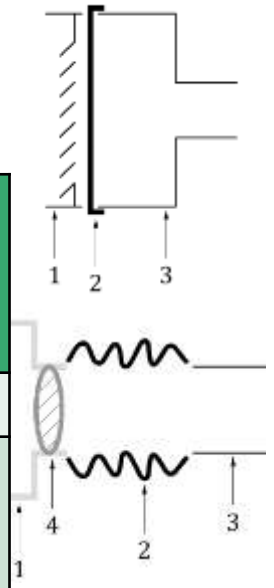
National guidance: What is included? ex FD 51- 767

How to take into account specific devices (plenum, etc.)

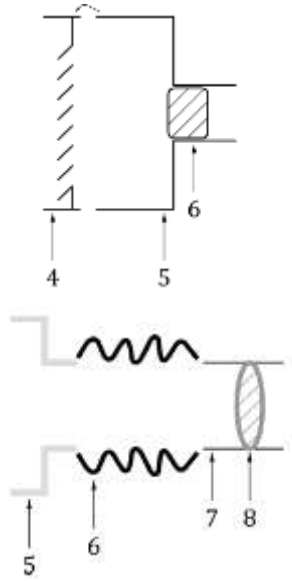
- If known leaky devices are not included => penalties!

Componant			Penalties Correction of measured values
Flexible sleeve	**Climat beam**	**Plenum box**	
Included	Included	Included	x 1
Not Included	Included	Included	x 1,3
Included	Not Included	Included	
Included	Included	Not Included	
Not Included	Not Included	Included	x 1,4
Included	Not Included	Not Included	
Not Included	Included	Not Included	
Not Included	Not Included	Not Included	x 1,5

Included



Not included



National guidance: What is included? ex FD 51- 767

Requirements on the test pressure

- Pressurization/depressurization for Supply/Extract ductwork respectively

Building	Test pressure
Residential Building – Single family houses	± 80 Pa
Residential Building – Multi residential building	± 160 Pa
Non Residential Building	± 250 Pa
Non Residential Building if $\|P_{design}\| > \|$test pressure$\|$+50Pa	P_{design}

Thank you for your attention

Are you interested in ductwork airtightness tests? Join the Tightvent webinar!

Thursday, **April 25th 10:00-12:00 AM** (CET)

10:00	**INTRODUCTION: PLANNED REVISION OF EN 12599 AND DUCTWORK AIRTIGHTNESS TESTS** Frank Bitter, Convenor of WG8, WSPLab, Germany	10:40	**DUCTWORK AIRTIGHTNESS TESTS IN UK: THE DW 143** Peter Rogers, Chaiman of BESA ventilation group technical committee, UK
10:15	**Questions and answers**	10:55	**Questions and answers**
10:20	**DUCTWORK AIRTIGHTNESS TESTS IN FRANCE: THE FD 51-767** Laurent Bonnière, Air-efficience, France	11:00	**DUCTWORK AIRTIGHTNESS TESTS IN SWEDEN: THE VVS & Kyl** Erik Osterlund, Chairman of the national Swedish standardization committee for ventilation, Sweden
10:35	**Questions and answers**	11:15	**Questions and answers**
		11:30	**End of the webinar**