On site ductwork airtightness measurements in standardization
(Revision of EN 12599)

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TightVent Europe Webinar

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Standard EN 12599

- EN 12599: Test procedures and measurement methods to hand over air conditioning and ventilation systems
  - first published in 2000
  - revised in 2012
  - applied to ventilation systems in non-residential buildings

Intention:
Verify the fitness of purpose of ventilation systems

- Measurements intended to be executed by the installer
- Scope opened to other purposes in 2012 („primarily for handing over“)
- Ductwork leakage (airtightness) introduced in the standard in 2012

EN 12599 – overview on functional measurements

Table 2 — Functional measurements

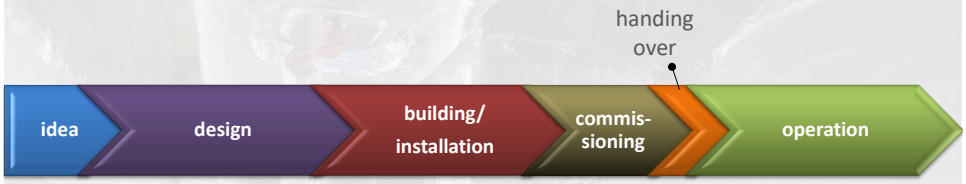
Measurement at		Total System	Central System/Appliance				Duct work	Room					
Parameters Type of Systems/Functions		Additional cleanliness test	Current drawn and power by the motor [D.6]	air flow *) [D.1]	air temperature *) [D.3]	pressure drop across filter [D.7]	**ductwork leakage test [D.8]**	supply air flow [D.1]	exhaust air flow [D.1]	supply air temperature **) and air temperature in the room [D.3]	air humidity [D.4]	sound pressure level [D.5]	Indoor air velocity [D.2]
Ventilation System	(F) Z	2	1	1	0	1	**2**	1	2	0	0	2	0
	(F) H	2	1	1	1	1	**2**	1	2	2	0	2	2
	(F) C	2	1	1	1	1	**2**	1	2	2	2	2	2
	(F) M/D	2	1	1	1	1	**2**	1	2	2	1	2	2
Partial air conditioning system	(F) HC	2	1	1	1	1	**2**	1	2	1	2	2	2
	(F) HM/HD/ CM/CD	2	1	1	1	1	**2**	1	2	1	1	2	2
	(F) MD	2	1	1	1	1	**2**	1	2	2	1	2	2
	(F) HCM/MC D/CHD/H MD	2	1	1	1	1	**2**	1	2	1	1	2	2
Air conditioning system	(F) HCMD	2	1	1	1	1	**2**	1	2	1	1	2	2

*) Outdoor air, supply and exhaust air
**) Depending on control principles, if relevant

EN 12599 – airthightness measurements

- The airtightness class according to EN 1507 and EN 12237 shall be checked
- In large systems the airtightness can only be measured in a part of the system
- The measurements shall be performed while the duct is being installed and accessible
  - Additional tests can be necessary after installation in case of malfunction e.g. excess pressure
- Measurement procedure according to the product standards (laboratory testing)
  - Defined test pressure levels

ductwork airtightness - building process



airtightness	selection	measurements	measurements	inspections
	air tightness class components		**EN 12599**	**EN 16798-17**

Idea of Lars-Åke Mattsson

Ductwork airtightness - System

- Airtightness classes for the system are defined in EN 16798-3

Classification of system air tightness class

Air tightness class		Air leakage limit (f_{max})
Old	**New**	**$m^3\ s^{-1} \bullet m^{-2}$**
	ATC 7	Not classified
	ATC 6	$0{,}067\ 5 \times p_t^{0,65} \times 10^{-3}$
A	ATC 5	$0{,}027 \times p_t^{0,65} \times 10^{-3}$
B	ATC 4	$0{,}009 \times p_t^{0,65} \times 10^{-3}$
C	ATC 3	$0{,}003 \times p_t^{0,65} \times 10^{-3}$
D	ATC 2	$0{,}001 \times p_t^{0,65} \times 10^{-3}$
	ATC 1	$0{,}000\ 33 \times p_t^{0,65} \times 10^{-3}$

Ductwork airtightness - components vs. installed systems

EN 1507 / EN 12237

- Measure the airflow and static pressure
- Surface area at least 10 m^2
- Variety of components and ducts (selection of the product range)
- Different diameters
- L/A ratio 1 - 1,5

EN 12599

- Measure the airflow and static pressure
- sufficiently large section (refers to EN 1507/12237)
- Variety of components and ducts determined by the installation *(„representative selection“)*
- L/A ratio 1 - 1,5

Ductwork airtightness - components vs. installed systems

- Airtightness of the installed ductwork system is a result of the mounting (e.g. joints)
- System can contain different components
- Tightness class of the duct components is rarely reached

Revision on EN 12599

- EN 12599 is currently under revision
- Airtightness is a main subject to be worked on

  - Clarification between the airtightness classes of systems and duct components
  - Measurement method should be applicable also for inspections
  - Take into account requirements of national guidelines

Existing national guidelines for airtightness tests

- Existing guidelines in European countries will be introduced in the 3 following presentations

Presenter	Guideline	Country
Laurent Bonnière	FD 51-767	France
Peter Rogers	DW 143	UK
Erik Osterlund	VVS & Kyl09	Sweden

DUCTWORK AIRTIGHTNESS IN FRENCH REGULATION AND FD E51-767

TIGHT VENT – AIVC – APRIL 2019

OUTLINE

- **DUCTWORK AIRTIGHTNESS IN FRENCH REGULATION**
- **LEAKAGES – EXAMPLE OF A EP CALCULATION**
- **FD E51–767 DUCTWORK TIGHTNESS MEASUREMENTS**

Ductwork Airtightness in French Regulation

In new buildings, the ductwork class is an input data in the Energy Performance calculation (RT2012 : EP Regulation)

→ No minimum requirement

→ Impact on heating loads / cooling loads

If a better value than the default value is used in the EP calculation :

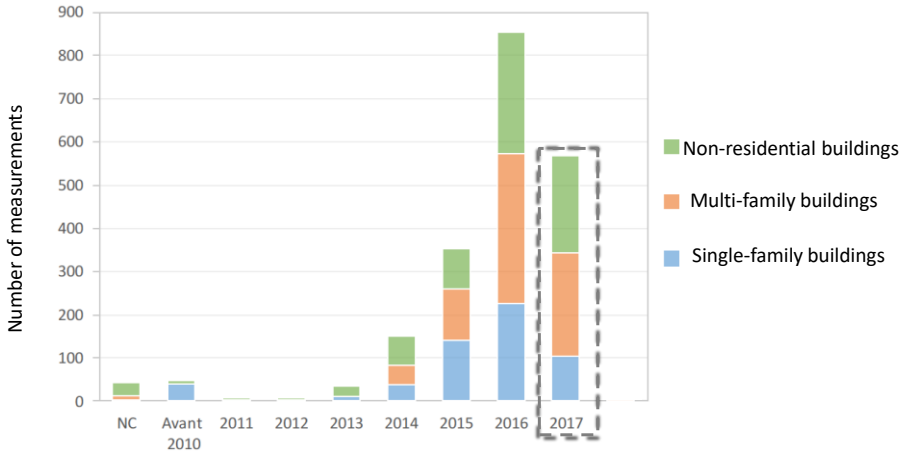
→ a measurement is required to justify Class A, B or C

→ this measurement has to be performed by a qualified idependant technician

Since 2013, Effinergie + label requires Class A

Database overview

Evolution of the number of measurements



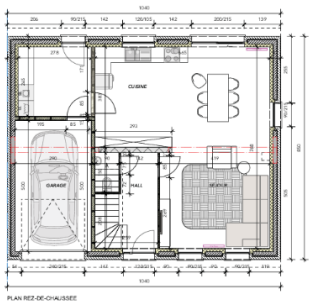
Source – CEREMA Database of ductwork airtightness measurements in France

DUCTWORK LEAKAGES

EXAMPLE OF A EP CALCULATION

Ductwork leakages
Example of a EP calculation

Single family house



CLIMATIC CONDITION :
- Zone H1a

FLOOR AREA :
- 98 m²

TOTAL LOSS AREA :
- 290 m²

Source – OCR (http://ocr-expertise.fr)

Ductwork leakages
Example of a EP calculation

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Characteristics of the house

	Parois	Libellé	Système constructif du bâti	Ep. isolant (cm)	R isolants m².K/W
Building enveloppe					
Ground floor	Plancher bas				
	Sur Vide-Sanitaire	Plancher hourdis isolant	ITR – Polystyrène	-	Up = 0.27
Roof	Plancher haut				
	Rampant	Isolant sous toiture + doublage intérieur	ITR – Laine minérale (λ = 0.040) ITI – Laine minérale (λ = 0.032)	20 + 6	6.9
External Wall	Paroi verticale				
	Mur extérieur	Doublage intérieur sur maçonnerie	ITI – laine minérale (λ = 0.032)	14	4.38
Windows	Paroi vitrée				
		Cadre	Vitrage	Uw (W/m².K)	
	Double vitrage - VR	PVC	4/16/4, PE Argon	1,5	
Technical equipements	Systèmes				
Heating system	Chauffage				
	Chaudière Gaz Condensation	Rdt : 97.8%	Puissance : 24 [kW]		
Hot water	Eau Chaude Sanitaire				
	Ballon thermodynamique – Air extérieur – 250L				
Lighting system	Éclairage				
	Puissance d'éclairage moyenne = 8 [W/m²]				
Ventilation system	Ventilation				
	…				

OCR Source – OCR (http://ocr-expertise.fr)

Ductwork leakages
Example of a EP calculation

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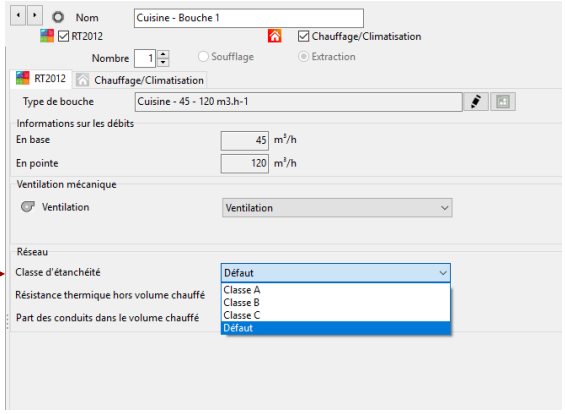
Ductwork airtightness is a input data in EP calculation

Ductwork airtightness class



OCR Source – OCR (http://ocr-expertise.fr)

Ductwork leakages
Example of a EP calculation

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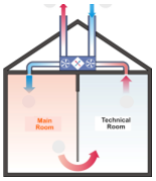
MVHR

- Nominal air Flow : 105 [m³/h] (max 180 [m³/h])
- Exchanger : 82% Heat Recovery Efficiency
- Supply Ductwork and Extract Ductwork :
  25% inside conditioned space
  75% outside conditioned space



Ductwork airtightness Class	Heating [kwhep/m²]	Energy saving	
		[kwhep/m²]	(%)
Default Value	30,6	0	-

Source – OCR (http://ocr-expertise.fr)

Ductwork leakages
Example of a EP calculation

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Ductwork airtightness Class
Default Value
A
B
C

→ Default value : No mandatory test

→ Class A, B or C : Mandatory test

The ductwork airtightness measurement has to be performed :

- ➢ by a qualified idependant technician

(About 100 certified testers according to a national qualification scheme for ductwork testers)

- ➢ according to the FD E51-767

FD E 51-767

Ventilation for buildings – Ductwork tightness measurements

FD E51-767

FD E51-767 -> National guidance to specify how to use test standards :

- On site with various kind of ductwork (different materials, different shapes, …)
- Different use of building (non residential building, residential building…)
- To take into account the usual operating pressure of the ventilation system
- How to sample
- How to take into account specific devices (plenum box, flexible sleeve, …)

FD E51-767

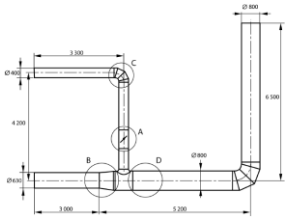
FD E51-767 refers to :

- EN 12 237 : Ventilation for buildings – Ductworks – Strength and leakage of circular sheet metal ducts
- EN 1507 : Ventilation for buildings – Sheet metal air ducts with rectangular section – Requirements for strength and leakage
- EN 13 403 : Ventilation for buildings – Non-metallic ducts – Ductwork made from insulation ductboards
- EN 12 599 : Ventilation for buildings – Test procedures and measurement methods to hand over air conditionning and ventilation systems

FD E51-767

Measurement of ductwork surface area :

- FD E51-767 refers to : EN 14 239 Ventilation for buildings — Ductwork — Measurement of ductwork surface area



Diamètre mm	Aire latérale du conduit [a] par unité de longueur m^2/m	Longueur m	Aire latérale totale du conduit m^2
800	2,51	6,5 + 5,2	2,51 × 11,7 = 29,4
630	1,98	3,0	1,98 × 3,0 = 5,9
400	1,26	4,2 + 3,3	1,26 × 7,5 = 9,5
Total pour l'installation représentée sur la Figure 2			44,8

- Only for individual system (in residential buildings) it's also possible to calculate the surface area with another method :

→ 0,1 x Floor area of the dwelling

FD E51-767

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Test pressure :

Type of ductwork :

- Supply air ducts : Positive pressure
- Exhaust air ducts : Negative pressure

Use of building :

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

FD E51-767

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How to sample :

- Individual system (residential)
  - 100 % of ductwork (Exhaust ductwork and Supply ductwork)

- Collective system (residential) and non residential system
  - All kinds of ducts (size, type of ducts, type of section, type of accessories, …)

AND

  - One of those requirements shall be met :
    - **Case 1 :** L/Aj ≥ 1 and Aj > 10 m2 and Aj > 10 %
    - **Case 2 :** At least one whole floor to the ventilation unit and Aj > 10 m2 and Aj > 20%
    - **Case 3 :** At least one whole column to the ventilation unit and Aj > 10 m2 and Aj > 20%

FD E51-767

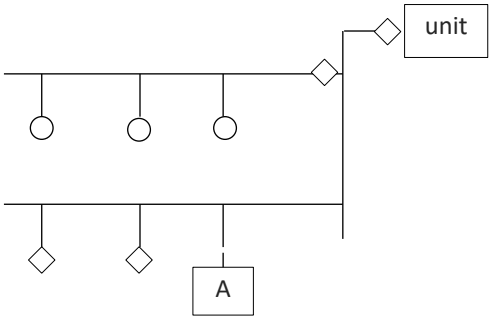
How to sample :

CASE 2 – example

A : equipment for measuring

◯ : exhaust or supply unit

◇ : sealed



FD E51-767

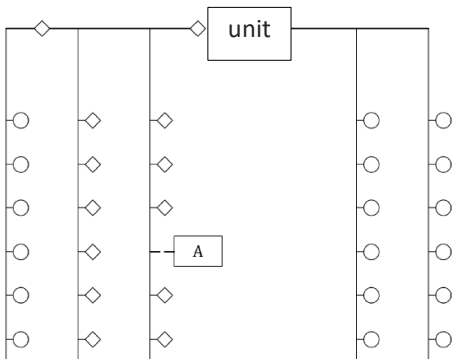
How to sample :

CASE 3 - example

A : equipment for measuring

◯ : exhaust or suppy unit

◇ : sealed



FD E51-767

How to sample :

If there are several ventilation units and air handling units

Method of sample selection :

- If N ≤ 5, each ductwork have to be tested
- If N > 5, number Of ductwork to be tested :

5 + 40% x (N-5)

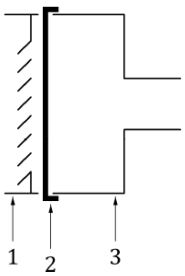
N : number of unit

FD E51-767

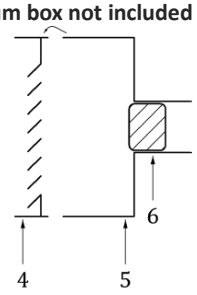
Measuring method – specific devices

- To Give penalties if some parts can't be tested to use it for the EP Calculation
- Method to seal off the diffuser (exhaust units / supply units) or the climate beams

Plenum box included



Plenum box not included



1 - 4 **Exhaust or supply unit or Climate beams**

2 **Sealing instead of unit**

3 – 5 **Plenum box**

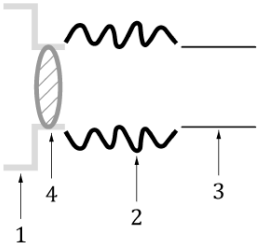
6 **Sealing in the duct**

FD E51-767

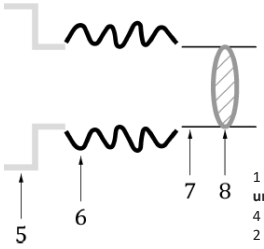
Measuring method – specific devices

Method to seal off the connection to the Ventilation unit

Flexible sleeve included



Flexible sleeve not included



1 – 5 **Ventilation unit (fan, air handling unit…)**
4 – **Sealing in the ventilation unit**
2 – 6 **Flexible sleeve - Connection Ductwork – Ventilation Unit**
3 – 7 **Ductwork**
8 **Sealing in the duct**

FD E51-767

Measuring method – specific devices

Method to seal off – Specific devices – Correction of measured values

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

Thank you for your attention

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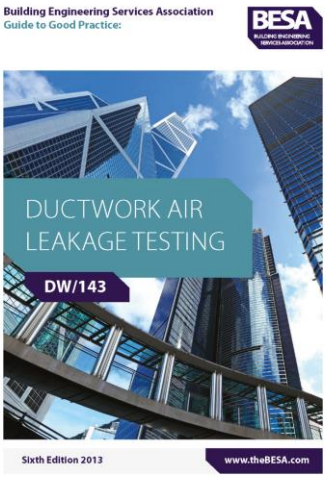
DW/143

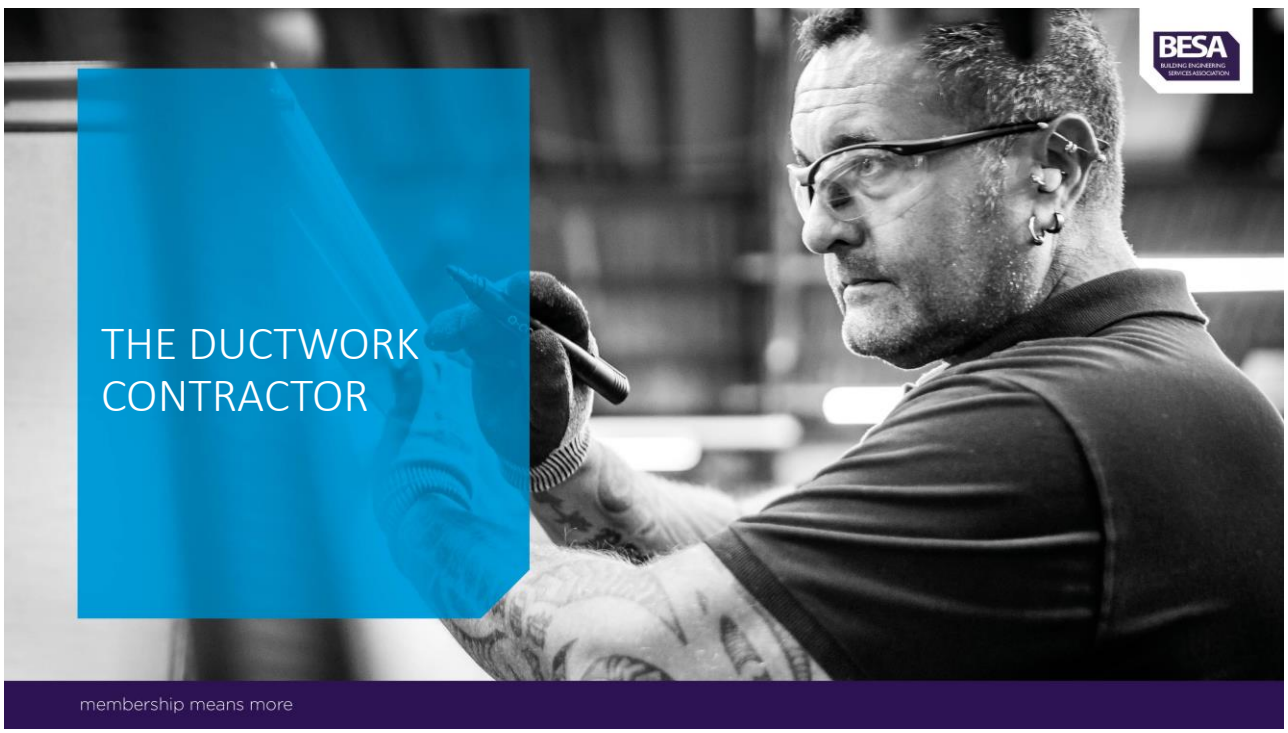
Peter Rogers:

BESA Chairman of Ventilation Group Technical Committee.



GENERAL

- With regard to air leakage, the responsibilities for ensuring the achievement of a satisfactory project are divided between the ductwork contractor, production and the on-site installation team. It is essential that there is full co-operation between them.
- Establish with the system designer, client or representative the class of ductwork called for in the project specification.
- Leakage testing is always done under positive pressure even when the ductwork is to operate under negative pressure.



THE DUCTWORK CONTRACTOR

- Ensure that components have been manufactured and sealed in accordance with the design specification.
- Agree with the system designer the test pressure for each section of the installation
- Decide the best way to isolate the installation into test zones.
- Make sure that test points and blanking devices can be reached with minimum difficulty.
- Prepare test sheets giving the information required for each section being tested.

PRODUCTION

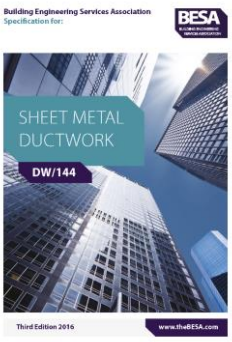
- Manufacture components with a good fit to minimize the use of sealant. A poor fit cannot be remedied by the use of additional sealant.
- Seal all longitudinal seams joints.
- Special care must be taken in the fitting of access doors and panels.
- Ductwork must be handled and delivered with care to avoid the danger of breaking the seals.

ON SITE INSTALLATION TEAM

- Before installation, inspect all duct sections to make sure that factory applied seals have not been damaged during transit.
- Fix blanking plates or other temporary seal in the positions shown by the ductwork contractor.
- Agree with the client a progressive testing programme.
- Carry out a preliminary test and look for any obvious places where there may be leakage.
- Offer the test section to the client for formal acceptance and signature on the test sheet.

CLASSIFICATION, AIR LEAKAGE AND TEST PROCEDURES

- Air leakage testing of low and medium pressure ductwork is not mandatory under BESA DW/144 specification for Sheet Metal Ductwork.
- Air leakage testing of high-pressure ductwork is mandatory under BESA DW/144 specification for sheet metal ductwork.



DUCTWORK CLASSIFICATION AND AIR LEAKAGE LIMITS

Table 1 Ductwork Classification and Air Leakage Limits
(Reproduced from DW/144, Part One, Section 1.1)

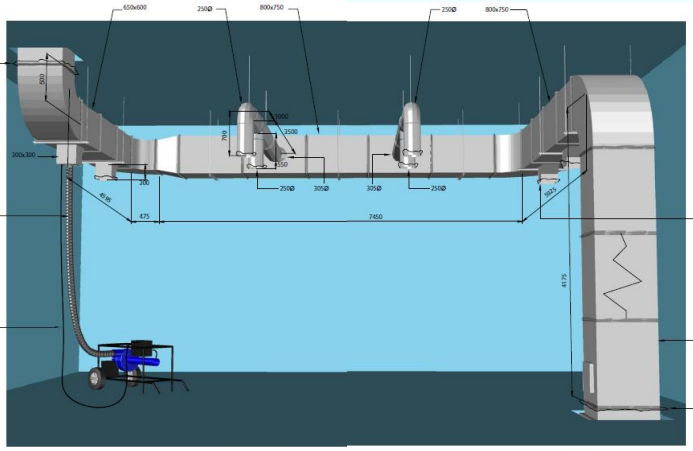
Duct pressure class	Static pressure limit		Maximum air velocity	Air leakage limits litres per second per square metre of duct surface area
	Positive	Negative		
1	*2*	*3*	*4*	*5*
	Pa	Pa	m/s	
Low pressure – Class A	500	500	10	$0.027 \times p^{0.65}$
Medium pressure – Class B	1000	750	20	$0.009 \times p^{0.65}$
High pressure - Class C	2000	750	40	$0.003 \times p^{0.65}$
High pressure - Class D	2000	750	40	$0.001 \times p^{0.65}$

Where p is the differential, pressure in pascals.

AIR LEAKAGE TESTING PROCEDURE

- Determine the extent of ductwork to be tested and the method selected.
- Fit blanking devices in accordance with the system test zones.
- The section of ductwork area to be tested shall have an area large enough to enable the test rig to register a measurable leakage.
- Follow the recommendations of the manufacturer of the test equipment and ensure that it has a calibration certificate.
- Due notice of tests shall be given, so that arrangements for witnessing can be made.
- NOTE Testing shall be completed before any insulation or enclosure of the ductwork.

HINTS ON DUCTWORK LEAKAGE TESTING



SEQUENCE OF TEST

1. Prepare test sheet.
2. Connect and adjust test rig to correct pressure.
3. Read off leakage rate.
4. Reseal if necessary (allow time to cure)
5. Maintain test for 15 minutes.
6. Record details on test sheet and obtain signature.

WARNING

Take care not to over pressurise system under test

HOW TO FIND LEAKS

1. Look	- particular at blanks, access openings and difficult joints
2. Listen	- with test rig running, leaks should be audible
3. Feel	- running your hand (particularly if wet) over joints can help to locate leaks
4. Soap and water	- paint over joints and look for bubbles.
5. Smoke pellet	- placed inside ductwork (obtain permission for use).

EXAMPLE OF COMPLETED TEST SHEET

SECTION 5 **EXAMPLE OF A COMPLETED TEST SHEET**

Based on ductwork illustrated in Fig. 1

Test Certificate No.	24033 / 001	Date	12/12/2013

Project:	New Hospital Project	Building No.	Ward Block 2
Material:	Pre-Galvanised	Location	3rd Floor - Supply
Test Pressure	1500 Pa	Drawing No.	24033 - 012
Leakage Class	Class "C"	Sheet No.	01 of 01

Test Equipment Details

Equipment	Serial No.	Calibration Certificate No.	Expiry Date
Digital Pressure Meter	123456	FM - 123456/001	Dec 1401

Duct Item No(s).								Equipment	
								Type	Ref No.
01	02	03	04	05	06	07	08	Sound Attenuator	S-1098
09	10	11	12	13	14	15			

Surface Area M²

Length (M)	Duct Size (mm)	Periphery (mm)	Surface Area (M²)
17.55	800 x 750	3100	54.40
5.57	600 x 650	2500	13.93
1.20	300 x 300	1200	1.44
7.00	305Ø	958	6.70
4.50	250Ø	785	3.53
		Total:	80.00

Test Particulars

a)	Surface area under test (as above)	80.00	M²
b)	Leakage factor (DW143 Table-22)	0.35	l/s/M²
c)	Maximum permitted leakage (A x B)	28.0	l/s/M²
d)	Duct Static Pressure Reading	1500	Pa
e)	Air Flow Leakage	18.00	l/s/M²
f)	Duration of Test (Minimum 15 minutes)	15	min
g)	Test Result (Pass / Fail)	Pass	

Final Acceptance (Ductwork Contractor)	Signed	Andrew Other	Final Acceptance (Client or their representative)	Signed	A Windsor
	Print	A N OTHER		Print	A WINDSOR
	Date	ABC Ducts Ltd		Date	A B Consultants

BUILDING REGULATIONS

- ADL2A (new buildings) and ADL2B (existing buildings) state that “Ductwork leakage testing should be carried out in accordance with the procedures set out in BESA DW/144” (refers to DW/143) Specification for Sheet Metal Ductwork.

RANDOM TESTING

- If the system designer considers the testing of medium pressure class ductwork to be unavoidable then it is recommended that random tests are identified.

SYSTEM LEAKAGE LOSS

- It is generally accepted that in a typical good quality system the leakage from each class of ductwork under operating conditions will be in the region of:

Class A low pressure	6%
Class B medium pressure	3%
Class C high pressure	2%
Class D high pressure	0.5%

TESTING OF PLANT ITEMS

- Items of in-line plant items will not normally be included in an air leakage test.
- The ductwork contractor may include such items in the test if the plant item has a manufacturers certificate of conformity for the pressure classification for the system under test.

AIR LEAKAGE RATES

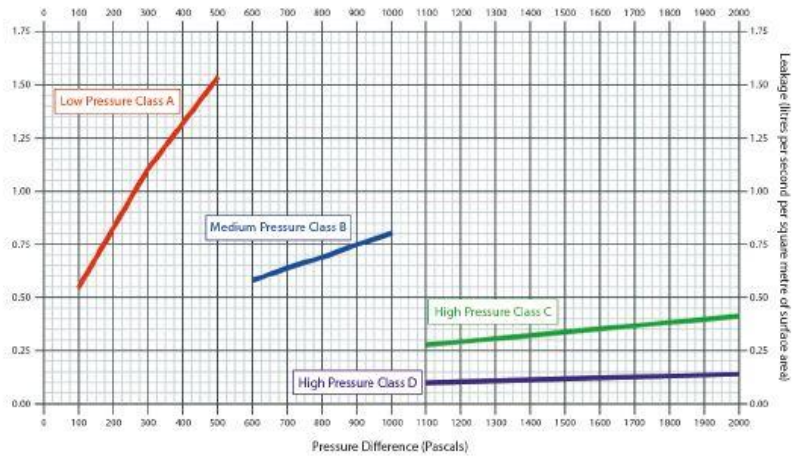
Table 22 Air leakage rates

Note: Recommended 'mean' test pressures are highlighted in **bold** type with the actual selection being left to the test operator.

Static pressure differential	Maximum leakage of duckwork			
	Testing not mandatory		Testing mandatory	
	Low pressure Class A	Medium pressure Class B	High pressure Class C	High pressure Class D
1	2	3	4	5
Pa	Litres per second per square metre of surface area			
100	0.54			
200	0.84			
300	1.10			
400	1.32			
500	1.53			
600		0.58		
700		0.64		
800		0.69		
900		0.75		
1000		0.80		
1100			0.29	0.10
1200			0.30	0.10
1300			0.32	0.11
1400			0.33	0.11
1500			0.35	0.12
1600			0.36	0.12
1700			0.38	0.13
1800			0.39	0.13
1900			0.40	0.14
2000			0.42	0.14

PERMITTED LEAKAGE AT VARIOUS PRESSURES

Permitted leakage at various pressures



OTHER **DUCTWORK–RELATED** PUBLICATIONS

DW/143
A Practical Guide to Ductwork Leakage Testing

DW/145
Guide to Good Practice for the Installation of Fire and Smoke Dampers

DW/154
Specification for Plastic Ductwork

DW/172
Specification for Kitchen Ventilation Systems

DW/191
Guide to Good Practice: Glass Fibre Ductwork

TR/19
Guide to Good Practice: Internal Cleanliness of Ventilation Systems(incorporating DW/TM2 and TR/17)

BESA Working together
Promoting understanding between mechanical services and ductwork contractors

www.theBESA.com

Ductwork Airtightness Tests in Sweden AMA VVS & Kyl

Erik Österlund
Chairman of the national Swedish standardization committee for ventilation

Ductwork Airtightness Standards

Leakage factor q

$1\ m^2$

Leakage per envelope area liters / second and m^2

Class D
Very demanding

q < 0,05 l/s/m² at 400 Pa

3x

Class C
Demanding

q < 0,15 l/s/m² at 400 Pa

3x

Class B
Moderate

q < 0,44 l/s/m² at 400 Pa

3x

Class A
Leaky

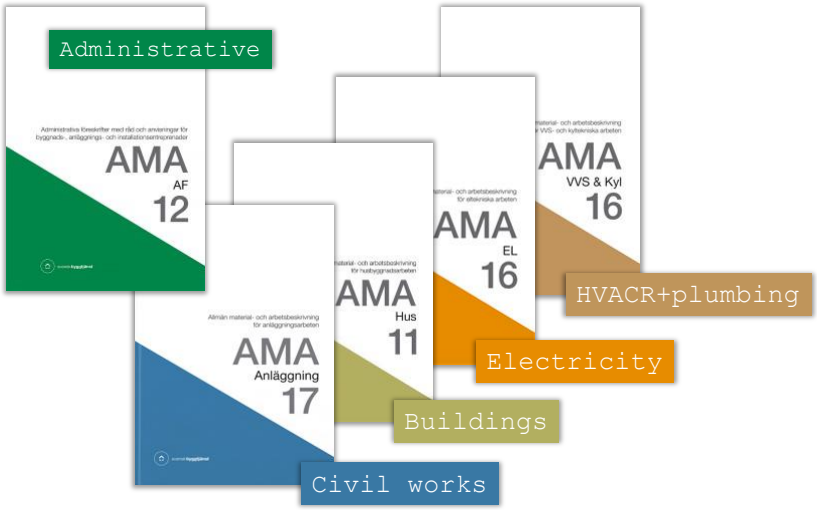
q < 1,33 l/s/m² at 400 Pa

Permitted leakage corresponds to one hole Ø3 mm for each m^2 envelope area.

Svensk Ventilation
Bransch i samverkan

AMA = General Description of Materials and Works

Allmän Material- och Arbetsbeskrivning



RA = Advice and Guidance

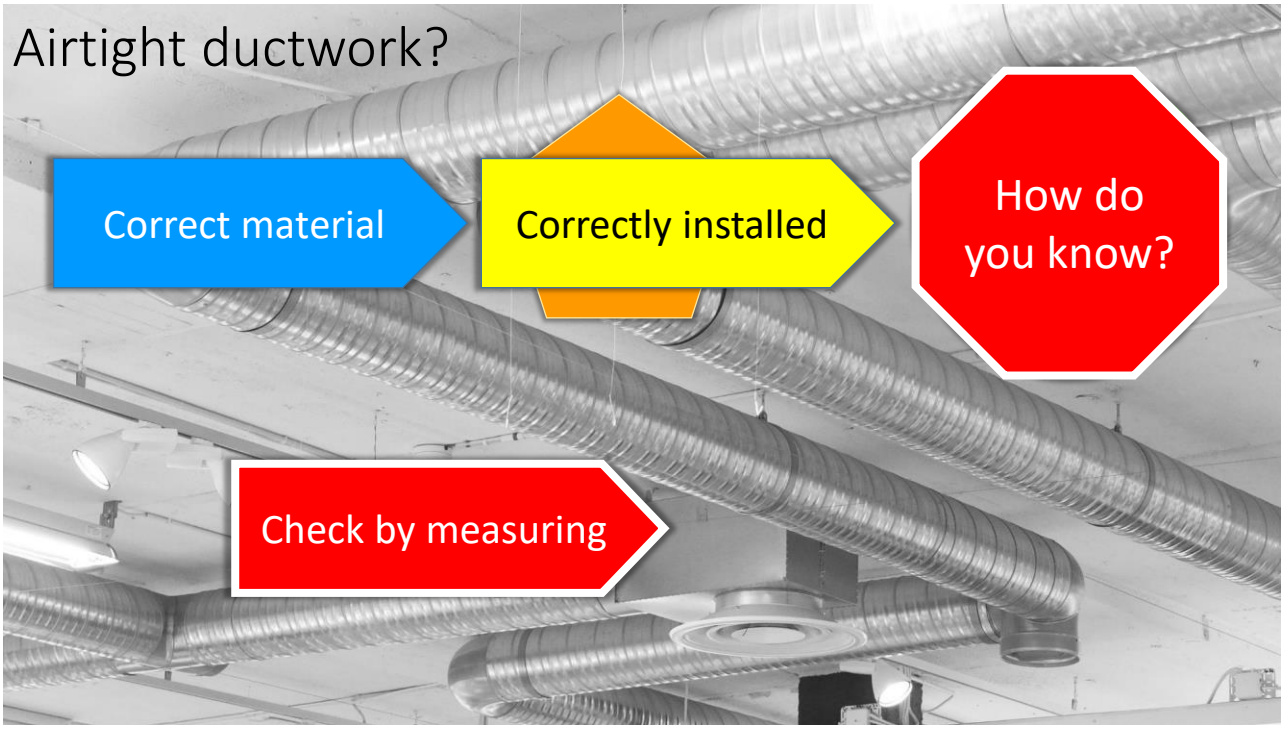
Svensk Ventilation
Bransch i samverkan

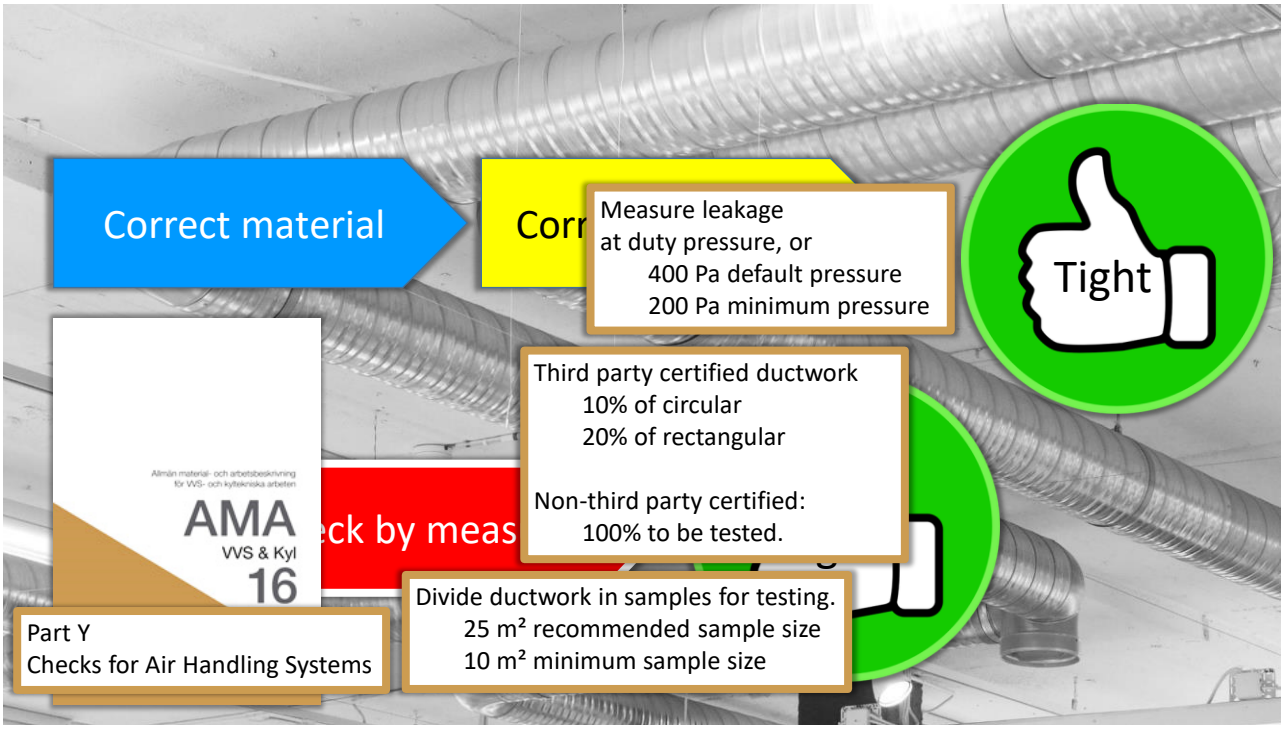
AMA - legal status?

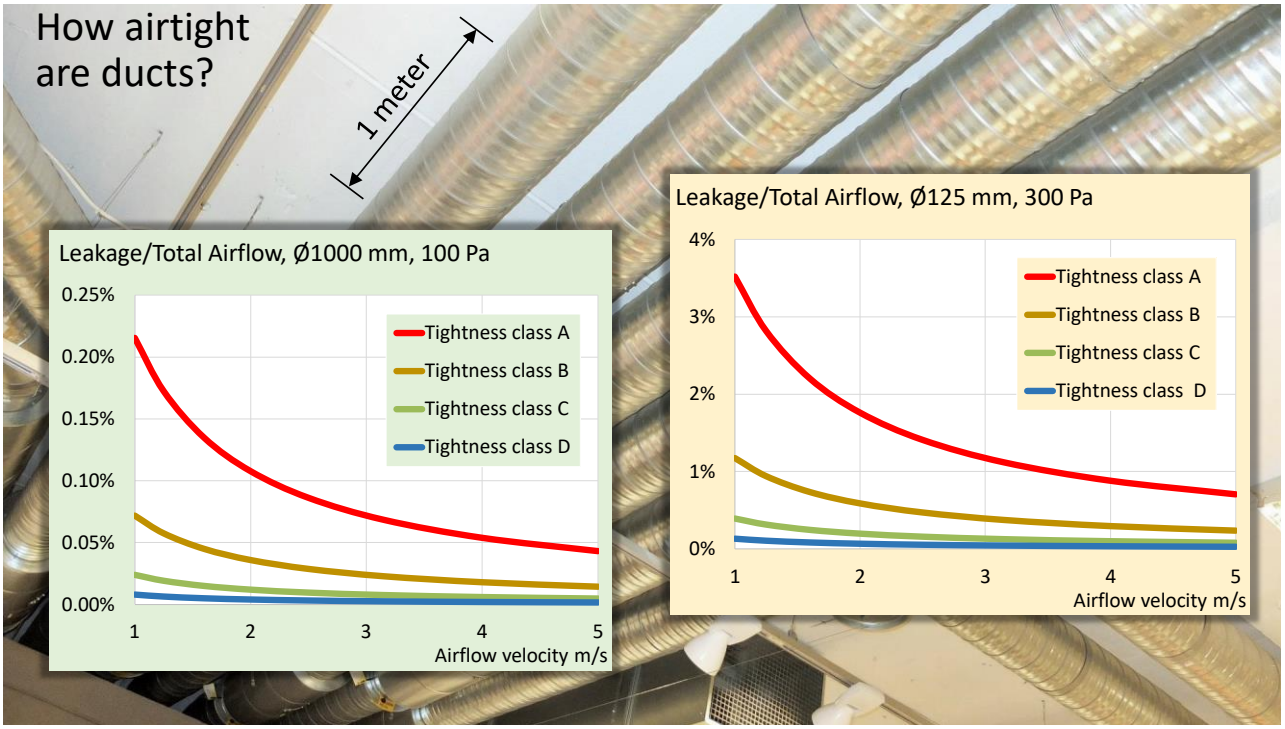
No law!

AMA is voluntary.

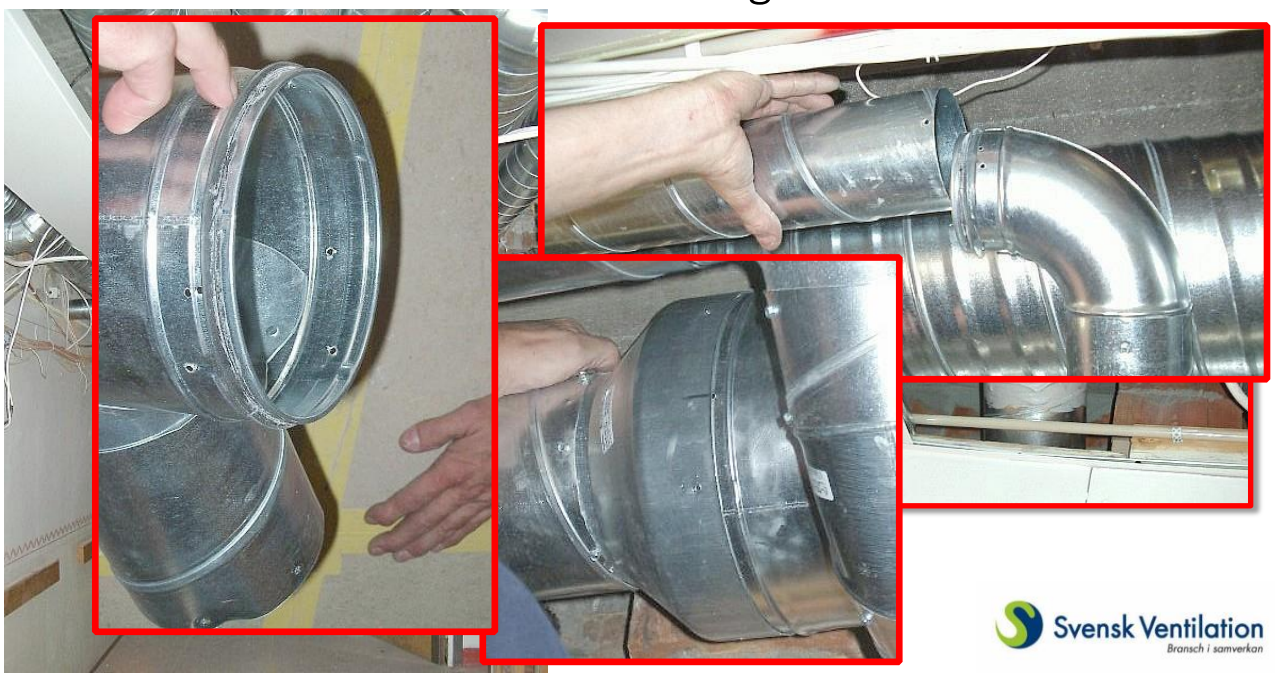
Svensk Ventilation
Bransch i samverkan


Airtight ductwork?
Correct material
Correctly installed
How do you know?
Check by measuring

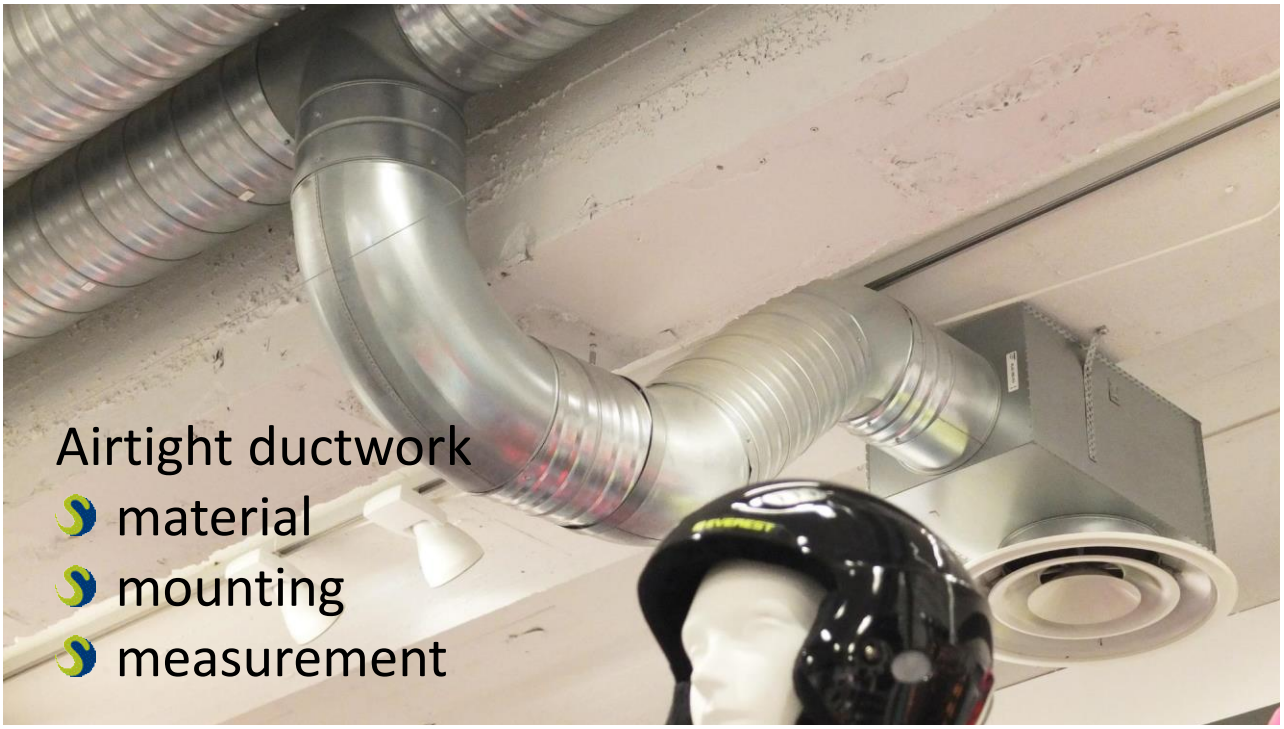

Correct material
Corr
Measure leakage
at duty pressure, or
400 Pa default pressure
200 Pa minimum pressure
Tight
Third party certified ductwork
10% of circular
20% of rectangular
Non-third party certified:
100% to be tested.
AMA
VVS & Kyl
16
Part Y
Checks for Air Handling Systems
Divide ductwork in samples for testing.
25 m² recommended sample size
10 m² minimum sample size



Invisible mistakes can ruin the airtightness class



Svensk Ventilation
Bransch i samverkan


Airtight ductwork
material
mounting
measurement