A review of European standards related to measurement at air terminal devices

Carl Welinder

Swema AB
Pepparvägen 27
123 56 Farsta, Sweden

SUMMARY

Two European standards EN 16211:2015 and EN 12599:2012 describe measurement methods for air flow.
The methods can be used at supply or exhaust air terminal devices, ATDs, or in ducts.
Both standards include the methods air flow hoods, bag and reference pressure method. EN 12599 presents a compensation method with a test chamber and the effective area, Ak-method. EN 16211 also includes two types of air flow hood compensation methods.
In addition to air terminal measurements, the standards also present in duct measurement methods. The methods and some conditions of use are presented.

KEYWORDS

Air flow measurement methods, European standard, EN16211:2015, EN 12599:2012

1 ORIGIN OF EN 16211 AND 12599

In the Nordic countries, Denmark, Finland, Norway and Sweden, there has been a long tradition and need to install, balance and test ventilation systems in buildings. Due to climate, energy tight houses have been built and a tradition of controlled air exchange has been developed. A Nordic guide on how to measure was developed by Professor Anders Svensson, today retired. His work resulted in 2015 in the European standard EN 16211.
EN 12599 originates from Germany and combines how much and what needs to be measured together with how to measure.

2 MEASURING METHODS IN EN 16211:2015 AND EN12599:2012

EN 16211 "Measuring of air flows on site – methods", including 41 pages, covers air flow rates measuring methods and their uncertainties.
EN 12599:2012 "Test procedures and measurement methods to hand over air conditioning and ventilation systems", including 85 pages, covers the extent of checks and measurements, what to measure (electric current, air flow, air temperature, filter pressure drop, ductwork leakage, humidity, sound, air velocity) and special agreed measurements, uncertainty and test reports.
Below follow the different measuring methods in the two standards.

2.1 Air terminal air flow measurement methods in EN 12599 and EN 16211

Figure 1: Flow hood / funnel measurement

Flow hood / funnel air flow measurement method is illustrated by Figure 1. Especially for supply air measurements, large uncertainties can occur due to non-uniform flow, pressure drop and leakage. EN 16211 mentions that the flow direction should be uniform (equalized flow pattern) in the measuring unit. It is assumed that this occurs if the length of the hood is at least three times the largest hydraulic diameter of the hood. If not the measuring method needs to be calibrated / checked with other measuring methods. Such methods can be the reference pressure method (at terminal or in duct), the bag method or any in duct method such as air velocity points measurement in a cross section, pressure drop over fixed devices or tracer gas measurement.
There are compensations methods for the pressure drop: two point measurement with calculation of the unrestricted flow and the zero-pressure drop measurement with a built-in fan in the flow funnel. By covering part of the hood it is noted if the flow is reduced and if there is a need to use a pressure compensation method.

Figure 2: Example of a supply and an exhaust pressure drop air flow measurement

By the pressure drop method the air flow is calculated from a pressure drop over a valve or throttle device. The k-factor is supplied by the supplier of the valve and is multiplied by the square root of the measured differential pressure. Instead of square root another exponent could be used.

Figure 3: The bag method

The bag method uses a bag with a calibrated volume. The flow is the volume of the bag divided by the time it takes to fill it. Two persons are normally needed. The picture does not show the stop watch and a differential pressure meter, both used to measure when the bag is full.

The effective area, Ak-method, is presented in EN 12599 with reference to EN 12238. The air velocity is measured at the air terminal, which works like a nozzle. The air velocity is multiplied by an effective area given by the manufacturer of the air terminal.

EN 12599 also present a “zero” measuring chamber method. A chamber is controlled to zero pressure difference by a fan. Compared to the room the pressure is regulated to zero and the flow from the supply is collected in the chamber. The equipment is equipped with a flow measuring device.

2.2 In duct air flow measurement methods in EN 12599 and EN 16211

Figure 4: Pitot static tube or velocity probe points in duct method.

EN 16211 requires 4 to 8 measurement points that are selected according to a table. It requires also that the velocity in any point is less than 1.4 times the velocity in the center, that no back flow occurs and that the cross-section is in a straight duct at least 5...6 times Dh downstream from a disturbance, such as a bend. The uncertainty of this measurement is 10% (instrument = 5%, method = 8%) with 95% confidence level. The method stipulates that the flow is multiplied by 0.89 for diameters lower than or equal to 160 mm. The calculated air flow is density compensated.

EN 12999 divides the cross-section in equal area annular rings. An uncertainty calculation is made depending of the number of measurement points and distance from disturbance. For circular ducts a multiple of four points is chosen. For a measurement uncertainty of 10%, nine points (but will be 12 points - since a multiple of four points is used) are required for a disturbance minimum $6D_h$ upstream. In section 2.4.2 there are rules regarding minimum air velocity in relation to the diameter of the Pitot static tubes. There is also a formula for reducing the flow depending of the area of the probe in the air stream. For a 9 mm probe in a duct with diameter 100 mm, the reduction factor is 94%.

The difference between EN 16211 and EN12599 could lead to different results and could be investigated by using other measurement methods, such as pressure drop over orifice plates in laboratory conditions. For circular ducts, the reduction factors for EN 16211 have been recommended by "Slutrapport, Nordtest Prosj. 1463-99 from Norges Byggforskningsinstitut Rev 2001.05.23."

Figure 5: Tracer gas method

The tracer gas method inserts tracer gas in the air flow and calculates the flow. It is important that a good mixing takes place.

3 UNCERTAINTY OF MEASUREMENT

Both standards stipulate the measurement uncertainty to be stated with probability coverage of approximately 95%. EN 16211 calls this the expanded measurement uncertainty, being twice the standard measurement uncertainty. EN 16211 divides the standard measurement uncertainty into standard instrument uncertainty, standard method uncertainty and standard reading uncertainty.

4 FUTURE DEVELOPMENT OF EN 12599 AND EN 16211

When revising the standards one idea is to present all the measurement methods in EN 16211 and refer to these methods from EN 12599 and from other standards, such as prEN 14134:2017 "Ventilation for buildings - Performance measurement and checks for residential ventilation systems". Another idea is that a revised EN 16211 will require further and more detailed air flow hoods / funnel conditions. EN 16211 may also be extended by including some more measuring methods such as the effective area method and the in duct cross-section equal area points measurement method.

5 ACKNOWLEDGEMENTS

A. Svensson – measuring methods in EN 16211
J. Kjeldgård – measurement technician
U. Rosendahl – measurement technician
J. Rosendahl – measurement technician
T. Masaki – tracer gas equipment picture

6 REFERENCES

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

EN 16211:2015 - Ventilation for buildings - Measurement of air flows on site - methods.

prEN 14134:2017 - Ventilation for buildings - Performance measurement and checks for residential ventilation systems.

Hestad, Trygve (2001). *Slutrapport, Nordtest Prosj. 1463-99. Rev 2001.05.23* Oslo: Norges Byggforskningsinstitut.