Determination of air permeability of buildings according to ISO 9972 or EN 13829 – Proposal for clarifications

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ABSTRACT

Building airtightness is an important parameter that can be measured according to the International Standard ISO 9972 *"Thermal performance of buildings — Determination of air permeability of buildings — Fan pressurization method"*.

Since 2006, there is a second edition of the standard that cancels and replaces the first edition (ISO 9972:1996). A modified version of ISO 9972:1996 has been published by the European Committee for Standardization (CEN) as European standard (EN 13829:2000).

The standard provides good guidance for the measurement of building airtightness but some aspects should be clarified for the need of national regulations and in order to improve the comparability of the results. These aspects are mainly related to the measurement methods and to the calculation of the air change rate at reference pressure difference.

Depending on the chosen method, intentional opening in the building envelope are open, closed or sealed during the measurement. Based on the general guidance of the standard, this paper gives a practical table with common intentional openings and their status for each of the 3 methods.

The air change rate, n_{50}, at 50 Pa pressure difference, is calculated by dividing the mean air leakage rate at 50 Pa by the internal volume. While a precise guidance is given for the measurement of the mean air leakage rate, the standard refers to national regulations for the calculation of the internal volume. It means that the widely used n_{50} value is not directly comparable from country to country. Therefore the authors propose a practical common method for the calculation of the net floor area and the internal volume.

Another consequence of the existence of different measurement methods is that the models that have been developed for the estimation of annual infiltration rates in buildings from the airtightness should be used with care.

1. INTRODUCTION

In the framework of the European Directive of 16 December 2002 on the Energy Performance of Buildings (EPBD), the three Regions of Belgium have adapted their building regulation. One of the new things is that the regulations take the airtightness of buildings into account in the calculation of the energy performance.

The reference for the optional measurement of the airtightness is the European standard EN 13829:2000 "Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified)". Some clarifications are however necessary in order to integrate the standard in a strict regulation.

2. AIRTIGHTNESS IN THE REGULATION

2.1 The new regulations in Belgium

Belgium is a federal state made up of three Regions (the Flemish Region, the Brussels-Capital Region and the Walloon Region) which have competence in the energy policy. The European Directive on the Energy Performance of Buildings has therefore been implemented at regional level. Although the three regulations are not exactly the same, the calculation method of the energy performance and the main annexe requirements (ventilation, maximum U-values (thermal transmittance), thermal bridges) are almost identical.

For new buildings, the theoretical consumption level of primary energy must be

below a determined value. It includes the following elements:
(a) thermal characteristics of the building (*including airtightness*);
(b) heating installation and hot water supply;
(c) air-conditioning installation;
(d) ventilation;
(e) built-in lighting installation (for the non-residential sector);
(f) position and orientation of buildings, including outdoor climate;
(g) passive solar systems and solar protection;
(h) indoor climatic conditions.

A first rough calculation is generally made before the construction of the building while a precise calculation is made after the construction. Administrative penalties (i.e. no need to go to court) must be paid in case of infraction.

The measurement of the building airtightness is not obligatory. However if there is no measurement, an unfavourable default value is taken into account in the calculation. On the other hand, a good airtightness shown by a measurement can reduce the calculated consumption level of primary energy of the building. This can help to avoid a fine and/or to obtain a better energy performance certificate.

2.2 Other examples of regulation or requirement

In England, the new regulations introduced in 2006 specifies that all building types (commercial, industrial and dwellings, whatever the size) must be tested for airtightness and achieve the minimum standard of 10 $m^3/h.m^2$ at 50 Pa (Kolokotroni, 2008).

In different countries like Germany, Belgium or France for example the "Passive house" private label imposes a n_{50} value below 0.6 h^{-1}. Very high financial incentives are given for this kind of building in Belgium.

3. MEASUREMENT PROCEDURE

3.1 Different methods

Building airtightness can be measured according to the International Standard ISO 9972 "Thermal performance of buildings — Determination of air permeability of buildings — Fan pressurization method".
Since 2006, there is a second edition of the standard that cancels and replaces the first edition (ISO 9972:1996). A modified version of ISO 9972:1996 has been published by the European Committee for Standardization (CEN) as European standard (EN 13829:2000).

Three different measurement methods[1] of the building airtightness are proposed in ISO 9972:2006:
- Method A (test of a building in use): The condition of the building envelope should represent its condition during the season in which heating or cooling systems are used.
- Method B (test of the building envelope): Any intentional opening in the building envelope is closed or sealed.
- Method C (test of the building in use): Automatically regulating, externally mounted air transfer devices are sealed, other openings are handled in the same way as for method A.

Table 1 gives an overview of the way the most common openings must be treated for the three methods. The table is based on the specifications of ISO 9972:2006 with some interpretation and comments when necessary (Delmotte, 2007).

The air leakage rate at 50 Pa (q_{50})[2] of a building can of course be very different depending on the chosen method. Therefore one could consider mentioning the measurement method in the expression of the results, e.g.:
- $q_{50,A}$ instead of q_{50}
- $n_{50,C}$ instead of n_{50}
- $C_{L,A}$ instead of C_L

[1] Note that only the first two methods (i.e. A and B) are proposed in EN 13829:2000

[2] The symbol used for the air leakage rate is $\dot{V}_{50}$ in EN 13829:2000.

Table 1: Status of common intentional openings for the 3 different measurement methods

Component	Method A	Method B	Method C
Exterior door	Closed (preferably locked)	Closed (preferably locked)	Closed (preferably locked)
Exterior window	Closed	Closed	Closed
Interior door towards a space outside of the part of the building to be tested (e.g. cellar, garage...)	Closed	Closed	Closed
Trap door towards a space outside of the part of the building to be tested (e.g. attic, crawl space...)	Closed	Closed	Closed
Interconnecting door in the part of the building to be tested	Open (1)	Open (1)	Open (1)
Air terminal device of mechanical ventilation or air conditioning systems	Sealed (2)	Sealed (2)	Sealed (2)
Air terminal device of natural ventilation	Closed if manually adjustable, but not sealed	Sealed (2)	Closed if manually adjustable, but not sealed
Externally mounted air transfer device - automatically regulating	Closed if manually adjustable, but not sealed	Sealed	Sealed
Externally mounted air transfer device - manually adjustable	Closed	Sealed	Closed
Externally mounted air transfer device - fixed	Not sealed	Sealed	Not sealed
Louvre (e.g. for the exhaust of a tumble dryer or a cooker hood)	Closed if manually adjustable, but not sealed (3) (4)	Sealed	Closed if manually adjustable, but not sealed (3) (4)
Letter box integrated in the building envelope	Closed (4)	Closed (4)	Closed (4)
Cat flap	Closed (4)	Closed (4)	Closed (4)
Chimney (e.g. for fireplace, boiler, stove...)	Closed if closing device available, but not sealed (3)(5)	Sealed (5)	Closed if closing device available, but not sealed (3)(5)
Water traps in plumbing systems	Filled or sealed	Filled or sealed	Filled or sealed
Venting of the discharge (drainage) system	Not sealed	Not sealed	Not sealed

(1) Except for cupboards and closets, which should be closed.
(2) Alternatively one can remove the device and seal the duct with a balloon.
(3) If available, one should close the device connected to the louvre or the chimney.
(4) Mobile part(s) of the opening should not move during the test. If necessary one should take appropriate measures to avoid any movement. (not mentioned in the standard).
(5) Appliances connected to the chimney must be turned off before closing or sealing the chimney.

3.2 Pressurization or depressurization

Besides the proposed different methods, the standard also gives the choice to carry out the measurements by pressurization or depressurization of the building. However, the difference between the two results reaches usually more than 3 % in most of the buildings we have tested, and can even be higher than 20 % in some cases. This difference can be probably mainly explained by the physical asymmetry of the leakage orifices in the envelope, but other sources of error could also be involved.

Given the important of the difference between pressurization and depressurization, the following recommendations would be very useful:

- always mentioning the used procedure with the result of the test (i.e. only pressurization, only depressurization, or the average);
- as often as possible, systematically carrying out both procedures and using the average in the result.

4. EXPRESSION OF RESULTS

4.1 Reference values

The air leakage rate at 50 Pa (q_{50}) obtained from the test depends on the area of the building envelope, through which the leakages occur, and must be normalized to be used in comparison with other results or with the regulation requirements. The standard ISO 9972 proposes the calculation of different derived quantities, based on reference values:

- internal volume (V)
- total envelope area (A_E)
- wall and roof envelope area (-)
- net floor area (A_F)

However even if some guidance is given for the calculation of these values, the standard mainly refers to national regulations for the net floor area and consequently for the internal volume. As a consequence the air change rate ($n_{50} = q_{50}$ / V) and the specific leakage rate ($w_{50} = q_{50} / A_F$) are hardly comparable from country to country.

In Belgium, for example, there is no regulation for the calculation of the net floor area. May be it could be done according to the Belgian standard NBN B 06-002:1983 (but it is no regulation). In this standard the net floor area does not include the surface occupied by the internal partitions but includes the doorways larger than 0.5 m². In practice in Belgium it is not done like that because it takes a not insignificant time and is therefore too expensive in the framework of an airtightness test.

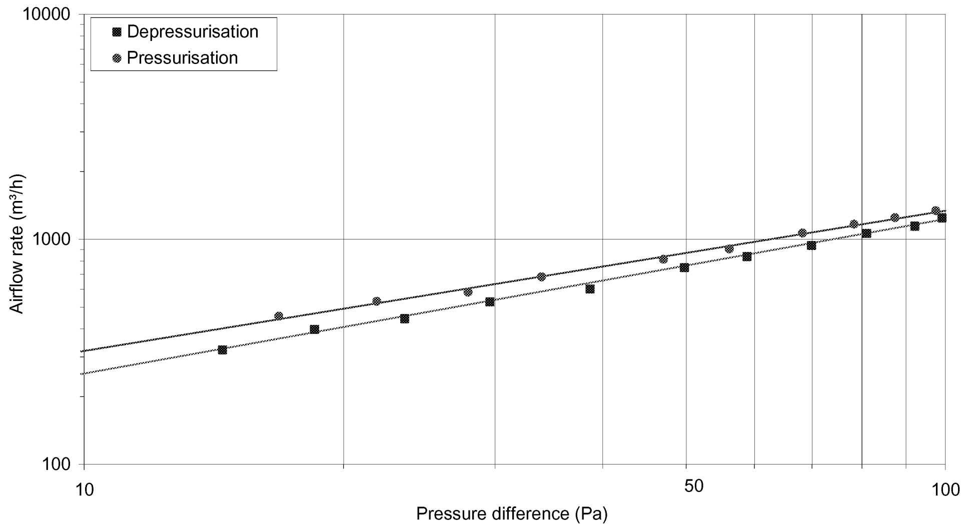

Figure 1. Example of an air leakage graph

4.2 Proposal for common conventions

In order to come to an harmonisation of the airtightness metrics and to be able to compare them at international level, the ISO 9972 (and EN 13829) standard should give a common calculation method for the net floor area and the internal volume.

Our proposal is:

- It should consider the overall internal dimensions as for the envelope area (Figure 2);
- There should be no deduction for the internal partitions and floors (a surface difference of internal partition within two identical buildings cannot be the unique cause for a difference in the derived quantities like n_{50} or w_{50});
- There should be no addition for the openings (e.g. doors or windows) in the buildings envelope (they are generally small surfaces or volumes which can make the calculation much longer) (Figure 3);
- The volume could be directly calculated by splitting it up into simple sub-volumes, rather than by multiplying the net floor area with the (generally unknown) mean height as required by ISO 9972.

A more precise calculation method would probably have the following disadvantages:

- more details and information about the building necessary;
- more complicated;
- more time consuming, more expansive;
- more risks of error, less repeatability.

4.3 Derived quantities

The choice of the derived quantity used depends on the aim of the measurement.

The air change rate, n_{50}, is very useful for comparison of different buildings because it is widely used for a long time and numerous data are available. Nevertheless, the n_{50} is just a normalised result which has no physical signification and which depends on the building compactness (ratio between volume/envelope area).

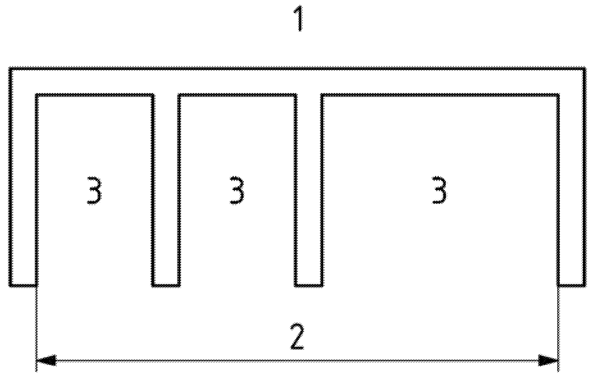

Figure 2. Building dimensions – 1. Outside – 2. Overall internal dimensions – 3 Inside

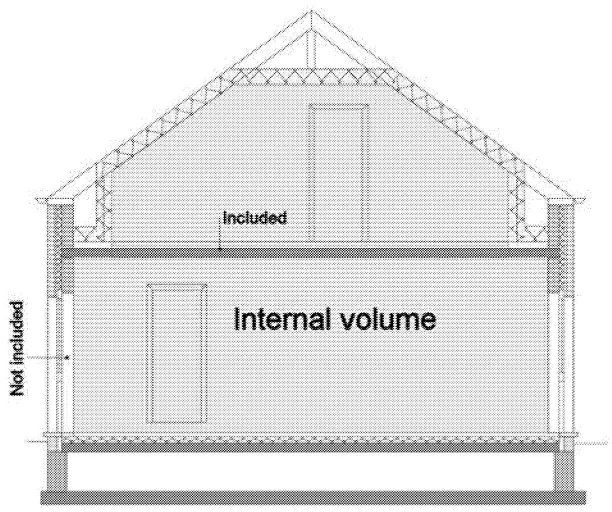

Figure 3. Illustration of internal volume

To compare strictly the envelope airtightness of different buildings in different countries or with different construction techniques, the air permeability, q_{a50}, would be more rigorously appropriate. The result is normalised with the building envelope area which is physically responsible for the air leakage. Nevertheless, this requires the time consuming determination of the total envelope area (A_E) which cannot be obligatory.

In the context of the energy performance of buildings (EPB) regulation, other indicators are sometimes defined at national or regional level, such as the I_4 in France or the $\dot{v}_{50}$ in Belgium. This $\dot{v}_{50}$ is equal to the air leakage rate at 50 Pa (q_{50}) divided by the building envelope area involved in thermal losses, i.e. excluding the area of the partitions in contact with other heated spaces. The area is based on external dimensions. It is nevertheless proposed that those who measure the airtightness are not obliged to also calculate the $\dot{v}_{50}$ which is preferably included in the more general calculation of the energy performance of the building (done by the architect or the EPB responsible).

5. CONSEQUENCES OF THE CHOICE

The choice of the measurement method and the rules for calculation of the surfaces and volume can lead to different results for the same building. Any requirement should therefore come together with information on these method and rules. The required level of performance should also be chosen accordingly.

The choice of the measurement procedure has also an impact on the cost and the result. Method A is normally cheaper than method B which requires the sealing of many openings. On the other hand, method A can give a higher leakage rate than method B.

Another consequence of the choice is that the different models that have been developed for the estimation of annual infiltration rates in buildings should be used with care. The K-P model for example says that a good estimate of annual infiltration rate can be achieved by dividing the n_{50} value by 20 (Sherman, 1987). However the model has probably been developed considering well defined measurement method and definition of volume and it probably can not be applied to other assumptions.

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