



**ISO 9972: Position paper for propositions of revision
Brainstorming document**

Provisional version, September 2009

Samuel Caillou, Dirk Van Orshoven

Division Climate, Installations and Energy Performance
**Belgian Building Research Institute
CSTC - WTCB**

Version of 29 Sep. 2009

**IMPORTANT NOTE: This is a working document which is still under discussion.
Future versions will be made available on the project website www.asiepi.eu**

Table of contents

1	CONTEXT	3
2	HARMONY WITH EN 13829	4
3	MANY POSSIBLE PURPOSES OF AIRTIGHTNESS	4
4	METHODS AND TREATMENT OF THE INTENTIONAL OPENINGS	5
4.1	Current problems	5
4.2	Description of the methods	6
4.3	Definition of "to close" and "to seal"	6
4.4	Examples of proposed methods	7
4.4.1	Proposed method: "close all, seal none"	7
4.4.2	Proposed method: "close all and seal all the remaining intentional openings"	8
4.4.3	Proposed method: "all intentional openings can (or must?) be sealed"	8
4.4.4	Proposed method: variants	9
5	EXPRESSION OF THE RESULTS	9
5.1	Mention of the method used	9
5.2	Choice of the derived quantities	9
5.3	Calculation of volumes and the areas	10
5.4	Uncertainty calculations.....	11

6	MEASURED EXTENT AND SAMPLING OF BUILDINGS	11
7	OTHER POINTS RELATED TO THE MEASUREMENT	12
7.1	Pressure difference to achieve	12
7.2	Pressurisation and/or depressurization.....	13
7.3	Measurement by means of the HVAC system.....	13
8	OTHER POINTS RELATED TO THE BUILDING PREPARATION	13
8.1	Switching off of all devices taking or rejecting air.....	13
8.2	Position of the pressurization equipment.....	13
8.3	Treatment of the openings inside the building.....	14
9	EDITORIAL MODIFICATIONS.....	14
	CONTRIBUTIONS BY OTHER PERSONS TO THIS PAPER.....	14
	REFERENCES.....	14

1 Context

The airtightness of the building envelope is an important parameter, for different fields such as the energy performance of buildings, fire safety, safety against chemical pollution (industrial risk), etc.

In Europe for example, the result of an airtightness measurement can be used in the national regulations on the energy performance of buildings (EPB) to quantify heat losses by in/exfiltrations. The impact of airtightness on the EPB-calculations can be high, e.g. up to around 15% of the EP-requirement in the EPB-calculation method in Belgium. In other countries, such as in the United Kingdom, or for certain labels, such as for Passive Houses, there are also minimum airtightness requirements that must be achieved.

Consequently, the way of measuring and the EPB-calculation method should be coherent among each other. The choice of the method (A, B or C in the current standard) and the treatment of the intentional openings (open, closed or sealed) are highly critical. However, the standard ISO 9972:2006 is unclear for some of these points and different ways of measurements are in use in the European countries [1]. Moreover, some documents with additional specifications to the standard in the context of national EPB regulations have been developed in certain countries, among other in Belgium [2] and in France [3] (not yet published). In other countries, there are also some guidelines with some additional elements compared to the standard, such as for example the FLIB document in Germany [3].

In its meeting of 4 May 2009 in Zürich, the working group ISO/TC163/SC1/WG10 has decided to launch the revision process of the ISO 9972:2006. It was also decided that the revision work should be conducted in the harmony with related standards, i.e. the EN 13829 (working group CEN/TC89), which is currently based on the ISO 9972:1996 with modifications. This revision of ISO 9972 is surely the opportunity to improve the airtightness measurement method, benefitting from all the experiences accumulated at national level.

To ambition a harmonized standard in coherence with all the EPB-calculation methods in European countries is however a big challenge. The coherence with the national EPB-calculation methods is highly relevant because the final aim is to increase the energy savings by building as airtight as possible; aim for which the EPB-regulations are a key driving force.

The aim of this paper is to identify a number of major discussion points related to the revision of ISO 9972 in the context of EPB-regulations, and to propose some alternatives to be discussed with all involved people at international level. These discussion points are presented in the order of relevance in this paper, but reference is made to the structure of the standard if necessary.

2 Harmony with EN 13829

First of all, it is highly desirable that the revision of the ISO 9972 is conducted in coherence with the revision of EN 13829, in order to achieve a single common text.

3 Many possible purposes of airtightness

There may be several different reasons for aiming to achieve a certain level of airtightness of the building envelope, in many different applications and contexts:¹

- "chemical safety"
- clean rooms
- fire protection
- avoiding comfort problems (cold draughts, ...)
- proper operation of the ventilation system under any climatic condition
- energy savings, e.g. as formalised in the context of national EPB-regulations
- etc. (to be further elaborated in the standard)

It would seem good to mention and elaborate this in sufficient detail in the introduction.

Depending on the purpose, different requirements on the air tightness may apply. For instance: it may be important that certain openings are not leaky in closed position if the passage of hazardous gases in emergency circumstances must be avoided. In that case, these closing devices should not be sealed during the test, in order to be able to detect any remaining, unacceptable leakage.

A measurement of the air tightness may thus have to serve many different objectives, depending on the specific context of each individual measurement. It is therefore desirable that the measurement standard acknowledges this possible variety of applications, and allows for sufficient flexibility to be able to deal with each and all of these situations. The standard could thus constitute a solid foundation that is universally applicable to any measurement, without the need for deviations from the standard in specific measurements. In writing the standard, a clear distinction should thus be made between what is essential and identical for all measurements and what can be specific for an individual measurement.

For this reason, the standard should maybe not be too rigid and commanding in certain prescriptions, but rather try to guide the reader to make informed choices for all aspects of his/her particular application. Notably on the issue of intentional openings (seal them, close them, or leave them untouched), it seems useful to draw up a list as extensive as possible of different possible intentional openings, and to discuss in depth the different considerations on how to treat them, depending on the purpose (see partial list above).

A few standardised methods can then be defined (as is presently the case), to cover many of the common applications, but explicit allowance should be foreseen that on an

¹ Historic note: reportedly, the very first version of this standard would have been established specifically for clean rooms?

individual project basis, or on national level, etc. different specifications can be defined. The thorough discussion of all potential points of attention can help guarantee that these specific prescriptions are then complete and well-thought. This idea is further elaborated in the following chapter.

4 Methods and treatment of the intentional openings

This is surely the most important and challenging point, because it is highly related to the aim of the measurement, such as the use of the airtightness result in the EPB-calculation methods, chemical safety, etc.

4.1 Current problems

For the moment, there are several inconsistencies between the ISO 9972 and the EPB-calculation methods, for example in Belgium and France where additional specifications to the standard are published (or in preparation). Some examples of such discussion points, occurring in the EPB-context in Belgium or France are:

- Certain mechanical ventilation systems are not permanent and the corresponding opening(s) will contribute to in/exfiltrations when the system is switched off. However, even the current method A requires the sealing of such intentional openings.
- Some intentional openings can open during the pressurization test, for example cat doors, the flap of a letter box, etc. The question is how to handle such intentional openings in method A.
- In Belgium, certain exhaust openings for the natural ventilation systems can be equipped with a non-permanent fan. To close or to seal?
- Natural ventilation openings for which the ventilation flow rate is taken into account in the EPB-calculation, causing no additional infiltration flow. They could be sealed while in the current method A, they can only be closed.
- Exhaust systems of certain combustion appliances, in common use in France, for which the flow rate is already taken into account in the EPB-calculation, and causing no additional infiltration flow. They could also be sealed while in the current method A, they cannot be sealed.
- Etc.

Moreover, the current standard can sometimes be interpreted differently in different countries. The ventilation requirements and the definition of ventilation components, for instance, can be very different from one country to another, leading to a different interpretation for the treatment of the ventilation openings. For example, a non permanent fan associated with a ventilation opening could be seen in certain countries as a mechanical ventilation system (and thus sealed with method A and B), and in other countries, as a natural ventilation opening (and thus closed with method A and sealed with method B).

4.2 Description of the methods

Being probably impossible to define, in the standard, methods adapted for each application in each country, it is thus proposed, as explained above, that the standard:

- explains the different possible applications of the measurement;
- mentions a list as complete as possible of all the points of attention (see for example, the Table 1 of the Belgian EPB specification document [2], and also the FLIB document in Germany [3], or a first international brainstorming proposal in Table 1 here below);
- defines 2 or 3 standardised methods, clearly stating the purpose of the method and detailing and the treatment of all the openings.
- and finally, leave the possibility to adapt the methods, country by country and case by case, for specific applications.

For example, in the context of the EPB-calculations, the standard should define at least one method for which the aim is related to the energy performance of buildings. Each national EPB-regulation could then deviate to some extent from this standard method (specific treatment of certain intentional openings), on the condition that these deviations are explicitly mentioned in the national prescriptions and referred to in the test report. In the long term, if a unified international EPB-calculation method would be established and would also be used without changes in all countries, then single method for the airtightness testing for EPB-purposes might become conceivable. But it is still unclear whether it will ever be possible to establish such unified EPB-method. In addition, divergences in national rules for ventilation systems could complicate matters. In the mean time, reaching a harmonized measurement method for EPB-purposes adapted to each specific situation of the widely varying national EPB-calculation methods is probably very difficult, or even impossible to achieve.

4.3 Definition of "to close" and "to seal"

In any case, and surely useful for all methods, clear definition of "to close" and "to seal" should be included in the standard. A proposition of definition could be (as used in Belgium):

- "To seal" means: to make hermetic by any appropriate means (adhesive, inflatable balloon, stopper, etc) ;
- "To close" means: to use the closing device present on the considered opening without additionally increasing the airtightness of the opening when in the closed position.

In some cases, certain intentional openings could also be kept closed (mechanically with a mass or with a punctual adhesive), to allow the measurement to be carried out (but without the intention of increasing the airtightness in closed position). Example: cat flaps.

4.4 Examples of proposed methods

Based on the reflexions and discussion in the context of EPB-regulation in Belgium and France, different measurement methods and the related treatment of the intentional openings are presented hereafter.

The aim of these examples is to show the different possibilities with their advantages and disadvantages.

However, the final revised ISO9972 should contain a limited number of different methods, for instance 2 or 3, which could be one of the following examples or a combination/modification.

The treatment of the intentional openings, corresponding to these proposed methods and the current methods A, B and C is illustrated in Table 1 for a number of openings (non-exhaustive).

4.4.1 Proposed method: “close all, seal none”

A first proposition of method is to simply close all intentional openings in the building envelope that are equipped with a closing device: windows, doors, ventilation openings with a closing device, but also openings for mechanical ventilation or kitchen hoods equipped with a closing device. All other openings must be let open.

- Advantages:

- This method could be appropriate in the context of energy performance (EPB-calculations), because it evaluates all the leaks in the envelope that the occupant cannot close during the heating season, and which can contribute to in/exfiltrations.
- Moreover, this method could be a base for additional national specifications in the context of EPB-calculations, which would specify which additional openings to seal, because they are already taken explicitly into account in the national EPB-calculation (example: openings for ventilation according to the national ventilation requirements).
- This is a simple and general rule, without any exception.
- Compared to the current method A, this proposed method 1 has the advantage of also stimulating the installation of closing devices on mechanical ventilation systems (one general closing device on the air inlet and/or one on the air outlet). In certain cases, some mechanical ventilation openings can contribute to in/exfiltrations. For example: a non-permanent extraction in a garage or an atelier will contribute to in/exfiltrations when it is switched off; or a demand ventilation system can also contribute to in/exfiltrations when there is no demand.

- Disadvantages:

- In some cases, the leaks could be overestimated. For example, a mechanical ventilation system (without closing device) will probably not significantly contribute to the in/exfiltrations when the system is in use.
- In certain countries, fixed natural ventilation openings (without closing device) are authorized or required. The air flow through these openings is

- maybe already taken into account in the corresponding EPB-calculation method.
- Maybe not directly compatible with certain EPB-regulations and EPB-calculation methods.

4.4.2 Proposed method: “close all and seal all the remaining intentional openings”

This proposed method is probably very similar to the current method B in the present standard. If a closing device is present on the intentional opening, it must be closed; otherwise, the openings must be sealed. Note that this method is probably not appropriate in the context of energy performance.

- Advantages
 - This is a simple and general rule, without any exception.
 - This method could be in some cases appropriate to test the building envelope only, as defined in the present standard.
- Disadvantages:
 - For an intentional opening without any closing device, it can be a significant advantage to be sealed compared to another but similar opening having a bad and leaky closing device. However, in reality, the fixed opening (without closing device) will contribute more to the leakages.

It is however not very clear for what purposes this method would be relevant.

4.4.3 Proposed method: “all intentional openings can (or must?) be sealed”

This proposed method is a theoretical complement to the current method B, presented here mainly to stimulate the discussion. The aim of this method could be to evaluate only the leakages through the different parts of the building envelope and due to the joints between elements (between window frames and walls for example); but neglecting all the leaks associated with the intentional openings themselves (gaskets of a windows for example).

- Advantages:
 - This method could allow comparing precisely different construction methods and details, for example between different countries, without the influence of the intentional openings.
- Disadvantages:
 - The sealing of all windows and doors and any other intentional opening can be time consuming, expensive and hazardous (risks of deterioration of the painting of the window frame for example). That is why the rule for this method could alternatively be: all intentional openings can (in place of “must”) be sealed. In practice, for example, the sealing of windows could be carried out only if leakages are detected, in order to avoid unnecessary and expensive work.

4.4.4 Proposed method: variants

Depending on the specific purpose of the measurement ("chemical safety", fire concerns, national EPB-regulations, etc.), deviations from any of the basic international methods may be appropriate, e.g. in order to include or exclude the leakage of certain intentional openings. Any deviation should be clearly defined and documented, both in the specifications and the test report.

Table 1: Illustration of the treatment of the intentional openings for the current methods (A, B and C) and the proposed methods in this paper: seal = 3 (yellow), close = 2 (green) and leave open (if no closing device) = 1 (blue).

Intentional openings in the building envelope	Current methods			Proposed new methods			Other ideas ?	Adapted case to case
	A	C	B	Close all Seal none	Close all + seal remaining	Seal all		
Windows, doors and trapdoors to the outside (or space outside of the measured extent)	2	2	2	2	2	3		
Mechanical ventilation (permanent, centralized)	3	3	3	2	2 or 3	3		
Opening with a non-permanent fan (WC, kitchen, etc)	?	?	3	2	2 or 3	3		
Natural ventilation opening (supply or evacuation)	2	2	3	2	2 or 3	3		
Automatically regulating natural ventilation openings ^a	2	3	3	2	2 or 3	3		
"Natural" ventilation opening (evacuation) with a non-permanent fan ^b	?	?	3	2	2 or 3	3		
Kitchen hood (connected to the outside)	2	2	2 or 3	2	2 or 3	3		
Kitchen hood (connected to a ventilation system)	?	?	?	2	2 or 3	3		
Air outlet for tumble-dryer, dehumidifier	2	2	2 or 3	2	2 or 3	3		
Openings with flaps (eg, letter slots, cat flaps, vacuum cleaners) ^c	2	2	3	2	?	3		
Chimney with closing device (open fireplace, boiler, stove, etc) ^d	2	2	2	2	2	3		
Chimney without closing device (open fireplace, boiler, stove, etc) ^d	1	1	3	1	3	3		
Fixed opening (without closing device) for ventilation, for air supply for combustion appliances, in elevator shafts, in gasmeter rooms, etc	1	1	3	1	3	3		
Other openings with a closing device	2	2	3	2	2	3		
Other openings without closing device e.g. lock, opening for the belts of the shutters, etc	1	1	3	1	3	3		
Opening waiting for the installation of a device (kitchen hood, stove, boiler, etc)	?	?	3	2	3	3		

5 Expression of the results

5.1 Mention of the method used

The symbol for the derived quantities should include the method used (A or B, pressurization, depressurization, or average), to avoid that non-comparable values are represented by the same symbol. For example: $n_{50,A,P+}$ in stead of n_{50} , etc.

5.2 Choice of the derived quantities

The current standard requires calculating and reporting the n_{50} value, while other parameters are sometimes used at national level, for example v_{50} (flow rate per area of thermal envelope) in Belgium or q_4 in France (flow rate per area of thermal envelope² at 4 Pa).

² Note that the definitions and conventions with respect to thermal envelope differ between France and Belgium, notably on the inclusion or not of floor slabs on ground.

For the daily airtightness measurements in the context of EPB-regulations, the calculation of n_{50} , which requires the calculation of the internal volume, can be time consuming and expensive. For large buildings, the experience accumulated in some countries [5] shows that the permeability (q_{50} value for example) could be more appropriate to evaluate such large buildings for which the volume/envelope area ratio can be very high. For comparing a small and a large building with the same construction methods and details, the permeability values could be close while the n_{50} value will be much smaller for the large building compared to the small one.

One proposition could be to define clearly several derived parameters (and corresponding calculation method, including areas or volumes, cf. 5.3), but without the obligation to mention any one of them (currently n_{50}) in the report.

The list of these derived quantities could be completed to include the values currently in use in different countries (e.g. in an informative annex). Note however that, for the derived quantities calculated per envelope surface area the definition of the thermal envelope area can be different in different countries, including or not the floor surface for example.

5.3 Calculation of volumes and the areas

The calculation of the volumes and areas is unclear in the current standard for some points. Ch. Delmotte et al. [6] previously made the following proposition:

- For the internal volume 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 areas or volumes which can make the calculation much more time consuming) (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 expensive;
- more risks of error, less repeatability.

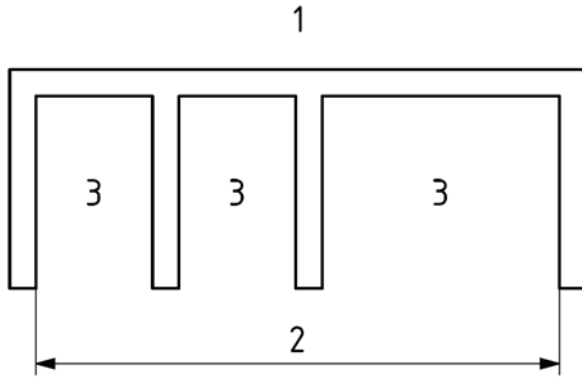


Figure 2. Building dimensions – 1. Outside – 2. Overall internal dimensions – 3 Inside

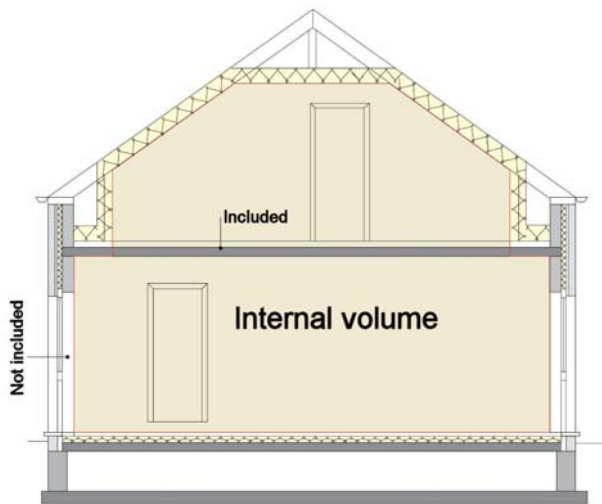


Figure 3. Illustration of the proposed internal volume

5.4 Uncertainty calculations

The current standard does not treat in detail the measurement uncertainties. Annex C gives the method for estimating the variability of the regression of the data; the § 8 requires to calculate the overall uncertainty of the result, but no method is mentioned. The ISO 9972 should be improved to explain how to calculate the uncertainty of the measurement results, including how to take into account for the uncertainties on the calculated volumes and areas.

6 Measured extent and sampling of buildings

The choice of the measured extent is related to the aim of the test, the choice of the method (A, B,...) and then also to national regulations or individual purposes/prescriptions.

The § 5.1.2 could then be restructured more logically:

- First refer to national regulations or individual prescriptions and to the aim of the test to determine the measured extent.

- Then, in absence of national regulation or individual prescriptions, define the measured extent as including all deliberately conditioned rooms for example.
- Finally, let the possibility open to define the measured extent in other way for special cases.

Moreover, the question of the sampling arises also in some countries: measurement of only a part of a building, or only a sample of houses among identical/similar houses. It could be proposed to include a method of sampling in the ISO 9972. However, it could be better that this point is regulated at national level for the following reasons:

- The global approach of airtightness measurement in the context of EPB-regulation can be completely different from one country to another: obligatory test in certain countries, voluntary in other, etc.
- It could be difficult to reach a compromise for the method of sampling at international level.
- The sampling is actually not related to the actual measurement, but constitutes a preliminary step by itself. For this reason, it would be better to deal with it in a separate document, which may rather be on a national level for the abovementioned reasons.

7 Other points related to the measurement

7.1 Pressure difference to achieve

The minimum highest pressure to be achieved for large buildings is currently 25 Pa while for small buildings 50Pa is required and even 100 Pa recommended.

However, the most important point is to have a sufficiently large range of pressure differences to limit the uncertainties and above all to allow significant extrapolation of the result to very low pressure differences (it is often the final aim to calculate in/exfiltration in normal conditions).

On the other hand, too high pressure differences can cause damage to the building (air barrier membrane, etc) in some cases (among other when the measurement is carried out during construction phase).

One proposition could be to require a minimum range of pressure differences rather than a requirement on the highest pressure.

Example

For a minimum range of 25 Pa (for example), the test is carried out:

- from 10 Pa to 35 Pa if the zero-flow pressure difference is sufficiently low;
- from 25 to 50 Pa if the average zero-flow pressure difference is 5 Pa (this is the maximum accepted value for this zero-flow pressure difference in the current standard)

Calculations of the measurement uncertainties could help to define this pressure range such that it is just enough to have significant results.

7.2 Pressurisation and/or depressurization

The question to require both measurements (pressurization and depressurization) arises often. The idea of this requirement is to avoid that the best result of both measurements is chosen to comply with a requirement (e.g. n_{50} of 0.6 for passive houses) or to obtain a better EPB-calculation result for example.

However, it seems that depressurization can sometimes cause some practical problems of damage: for example to certain ceiling composed of plastic foil, or to the air barrier membrane during the construction phase.

7.3 Measurement by means of the HVAC system

The current annex of the standard mentions the possibility to measure the airtightness by using the fans of the HVAC system of the building. Several issues could be clarified or explained in more detailed:

- homogeneity of the pressure in the measured extent if the flow is distributed via the ductworks in each room;
- minimum requirements on the flow measuring devices (e.g. built-in venturi): calibration, etc.
- In some cases, it can be difficult to achieve both pressurization and depressurization;
- etc

8 Other points related to the building preparation

8.1 Switching off of all devices taking or rejecting air

The standard should require the switching off of all devices taking or rejecting air to the outside, such as heating and ventilation systems, but also kitchen hoods and tumble-dryer outlets (not yet mentioned in the current § 5.2.3).

8.2 Position of the pressurization equipment

To avoid that the pressurization equipment is placed in a leaky door, thus masking these leaks in the result, the standard could include the following recommendations:

In the case of pressurisation equipment that is fitted into an external opening (door or window), an opening that is safely accessible and that presents a priori the highest airtightness should be chosen for the equipment placement. As a general rule, the measurement operator should choose, in order of preference:

1. a French window (“window-door”) or a window with a sealing joint along its entire perimeter
2. a door equipped with a sealing device on its lower part (fitted or brush plinth, for example)
3. a door that is not equipped with a sealing device on its lower part.

The positioning of the equipment must be specified in the test report.

8.3 Treatment of the openings inside the building

In the current standard, the doors of toilets and cupboards must be closed. However, the treatment of the openings inside the buildings requires also some clarifications:

- In certain cases, some leaky technical shafts for example could contribute to significant losses of energy by in/exfiltrations inside the shaft, and then transmissions losses through the shaft partition. The question is then: should it be required to open such technical shafts.
- For safety reasons, some openings could be let closed, such as doors of lift shafts.

9 Editorial modifications

The current title of the standard (“thermal performance of buildings”) is maybe not always appropriate, because the standard can be used for other applications than only in the energy context, for example for fire protection, clean rooms, etc.

Contributions by other persons to this paper

The present version of the paper includes ideas expressed during brainstorming discussions with the following experts in the field: Rémi Carrié (CETE, France), Peter Schild (SINTEF, Norway) and Bernd Rosenthal (EUZ, Germany).

Due to a lack of time for a thorough review of this draft version by these persons, maybe not all views mentioned in this paper are fully supported by all of them. Their discussion input is already greatly appreciated, though.

References

1. Caillou S. and Van Orshoven D. (2009) Report on the building airtightness measurement method in European countries. Sub-report of WP-5 of the ASIEPI project. Available on <http://www.asiepi.eu/wp-5-airtightness/related-information-and-first-results.html>.
2. Additional specifications on building airtightness measurement within the context of EPB regulations in Belgium (2008). Available on <http://www.epbd.be/go/airtightness-measurement>
3. Normalisation française. Performance thermique des bâtiments. Guide d’application de la norme NF 13829 :2001. Not yet published.
4. Fachverband Luftdichtheit im Bauwesen e.V. Beiblatt zur DIN EN 13829. FLIB, Allemagne, 2002.
5. Experience with Air Tightness Tests of Large Buildings. BlowerDoor GmbH. Available on <http://www.blowerdoor.de/en/service/reports.html>.

6. Delmotte C., Caillou S., Van den Bossche P. and Wouters P. (2008) Determination of air permeability of buildings according to ISO 9972 or EN 13829 – Proposal for clarifications. 29th Conference of the AIVC (14-16 October 2008, Kyoto, Japan)

Draft version