BELGIAN FRAMEWORK FOR RELIABLE FAN PRESSURIZATION TESTS FOR BUILDINGS

Xavier Loncour[1], Christophe Delmotte[1*], Clarisse Mees[1] and Maarten De Strycker[2]

1 Belgian Building Research Institute (BBRI)
Av. Pierre Holoffe, 21
B-1342 Limelette
Belgium
www.bbri.be

2 Belgian Construction Certification Association (BCCA)
Rue d'Arlon, 53
B-1040 Bruxelles
Belgium
www.bcca.be

*Corresponding author: *cde@bbri.be*

ABSTRACT

This paper presents the new framework for the realization of reliable pressurization tests in Belgium and the provisions taken to widen the number of buildings where a valid pressurization test can be realized.
The pressurization test is described in standards. In Belgium, the measured airtightness performance can be used in the regional Energy Performance (EP) regulations in order to improve the calculated performance. A few years ago, supplementary specifications to the test standard (NBN EN 13829) describing detailed specific elements of the test, were added to the regulations. Testing is not required by the regulations but a relatively unfavourable default value for the airtightness has to be used if no test is carried out. With the progressive strengthening of the energy standards included in the regulations, the airtightness performance has become more and more important. Measuring the airtightness is a common practice nowadays. In some Regions, over 50% of the buildings is now tested. Up to 2014, in Belgium, requirements have not been imposed on the testers. Everyone in possession of the test equipment could realize a pressurization test and could use the test result in the EP regulation. Moreover, several years of experience with the regulations show specific situations where the strict respect of the test standard is not always possible (e.g. in high buildings).

KEYWORDS

Airtightness of buildings, Fan pressurization test, Quality, Large building, Competent tester

1 INTRODUCTION

Since 2006 in Belgium, the airtightness of buildings determined by fan pressurization tests can be used on a voluntary basis as input data in the Energy Performance (EP) regulations for new residential buildings, offices and schools. Even though the rules for these tests are well defined, some questions are still open. Considering the increasing number of tests and evidences that some of them are not performed as good as they should be, updated rules including also the possibility of a quality framework imposing a competent tester scheme have been developed.

2 SITUATION REGARDING THE PRESSURIZATION TESTS IN BELGIUM

2.1 Energy performance regulations and use of the results of pressurization tests

The regional EP regulations[1] require the introduction of a final declaration at the end of the works taking into account the actual characteristics of the buildings in order to prove the compliance with the requirements. The result of a pressurization test can be used as input data for new buildings (residential buildings, offices and schools). It has to be mentioned that in these buildings, the installation of a ventilation system is mandatory.

At present, there is no requirement regarding the airtightness performance of new buildings. Making a pressurization test is also not mandatory and no requirements are set on testers. The Brussels Region however has announced the introduction of an explicit requirement on the airtightness performance of new buildings from 2018 ($n_{50} \leq 0.6\ h^{-1}$). A similar evolution is not planned in Flanders and in the Walloon Region.

If a test is not realized, the energy consumption for heating and cooling is calculated with quite unfavourable $\dot{v}_{50}$ air permeability default values[2]. These values are equal to 12 m³/(h m²) for heating calculations and 0 m³/(h m²) for the risk of overheating and cooling calculations.

The airtightness has an important impact on the calculated energy performance of buildings. When the first EP requirement was set in 2006, this impact was about 5% to 15% for residential buildings. However, according to the definition of Nearly Zero Energy Buildings (NZEB), it could increase up to about 30% and make it nearly impossible to comply with regulation using the air permeability default value. Even if a pressurization test is not required by the regulations, it is becoming indispensable in practice.

2.2 Increasing number of pressurization tests in new buildings

EP regulation taking into account the airtightness of buildings has been introduced in 2006 in the Flemish Region and in 2010 in the Walloon Region. Both regions have developed databases with data included in the final EP declarations and they are able to produce statistics regarding airtightness of buildings (VEA, 2013).

In the Walloon Region, 22% of the final declarations include measured air permeability (information from early 2014). The average air permeability ($\dot{v}_{50}$) is 2.9 m³/h m².

In the Flemish Region, more than 14 700 final declarations include measured air permeability (information from June 2014). The average air permeability ($\dot{v}_{50}$) is 3.7 m³/h m². The percentage of final declarations including measured air permeability is increasing every year (see Figure 1)[3].

---

[1] Belgium consists of three regions which are independently responsible for the rational use of energy in buildings on their territory. The three regions are: the Flemish Region, the Walloon Region and the Brussels-Capital Region.

[2] The air permeability ($\dot{v}_{50}$) is equal to the mean air leakage at 50 Pa ($\dot{V}_{50}$) divided by the envelope area of the building based on external dimensions. The energy performance regulations define the exact way of calculating it.

[3] These figures are changing with the number of final declarations introduced. The statistics of the last year presented (2012) are based on a limited number of final declarations (3000).

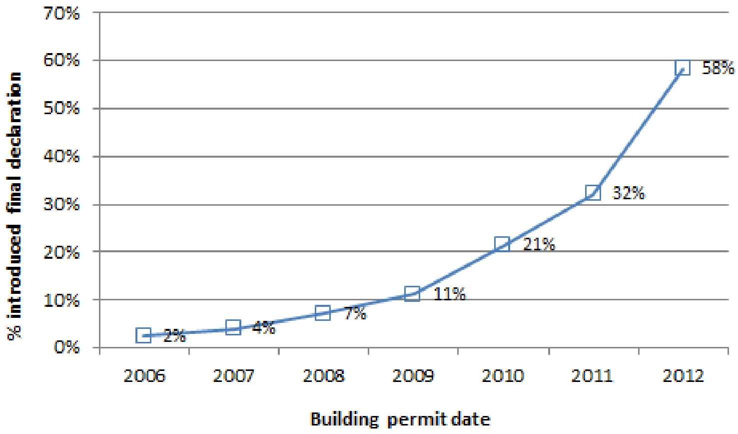

Figure 1: In the Flemish Region, the percentage of final EP declaration including measured air permeability of buildings is increasing since 2006

2.3 Rules for the realization of the pressurization test

The pressurization test has to be performed according to NBN EN 13829 (2001). Clarifications needed in the context of the EP regulations were published by the regions in 2008. These clarifications include, for example, the preparation of the buildings in coherence with the EP calculation procedure, the type of test (type A), specific requirements regarding the testing material or the content of the test report. Updates published in 2010 and 2013 include clarifications about closing or opening of internal doors and prohibition of simultaneous pressurization of adjacent spaces not included in the test volume.

When analysing reports, it appears that some tests are not performed with sufficient quality. Though a detailed study has not been carried out, different explanations can be presented:

- Modern measuring equipment's have automatic testing options which make it very easy to obtain results without specific knowledge of the test procedure;
- Many small companies propose pressurization tests just as a secondary service;
- There are no requirements on the tester.

2.4 Example of problematic situations with pressurization tests

The tester measures leakage airflow. The client is generally more interested in specific airtightness indicators, as the n_{50} or the $\dot{v}_{50}$-values, than in the air leakage flow on itself. The calculations of these indicators require knowledge of the parameters such as the volumes or areas related to the tested building. The conventions to calculate these parameters are well defined. However, the responsibility to determine these values was up to now not really well defined. The common practice was that this information, communicated by the client, was integrated into the test report and used to calculate the airtightness indicators. In the past, some testers have been asked to update their test reports and modifying the surfaces or volumes earlier communicated by the client.

In case of measurements in high buildings, it is not always evident to strictly follow the requirements of the test standard mainly regarding the zero-flow pressure difference criteria. The stack effect caused by temperature differences limit in a very substantial way the acceptable conditions the realization of a pressurization test in accordance with the rules of the measuring standard. In large buildings, the highest pressure difference to reach may also require many fans, potentially installed in all available external doors. The test standard is ambiguous on the acceptable conditions related to this highest pressure difference.

In Belgium, the EP-regulations require the tests to be made in the two measuring modes (overpressure and underpressure). This is more restricting than NBN EN 13829 and is sometimes not evident or even impossible. For example, it can be very difficult in presence of non-accessible valves that progressively open with increasing overpressure. This kind of valve can be present in exhaust ducts connected to cooker hoods. Measurements in the two modes can also be difficult with measurement devices like large fans fixed on a trailer.

2.5 Belgian Technical Specifications

The supplementary specifications for the pressurization tests were updated in early 2014 to take into account the development of the new STS-P 71-3.

The STS documents[4] are published by the Federal Public Service Economy in Belgium[5]. The main objective of a STS is to help clients or architects to establish the technical specifications for a specific construction project. The STS documents describe how a specific product or construction technique has to be specified, installed and controlled. They are developed in collaboration with all interested parties of the construction sector and are based on a consensus. They are applicable if reference is made to them for a specific construction project and are mandatory if this reference is made by a regulation. In case of optional elements within the STS as recommendations or informative annexes, specific reference to these particular elements has to be made to make them applicable.

[4] STS stands for « Spécifications techniques unifiées – Eengemaakte technische specificaties » which means « unified technical specifications »

[5] Website : http://economie.fgov.be/en

3 UPDATED RULES FOR PRESSURIZATION TESTS IN BELGIUM – STS-P 71-3

The STS-P 71-3 developed in 2014 considers specifically pressurization tests. The schematic content of this document is shown in Figure 2. An informative annex describes general requirements regarding the organization of a quality framework. The complete scheme including this informative annex will be applicable in the Flemish Region for every airtightness measurement realized from January 2015.
The STS clearly indicates which part of the process is the responsibility of the tester. Some elements within this process are the responsibility of the client.

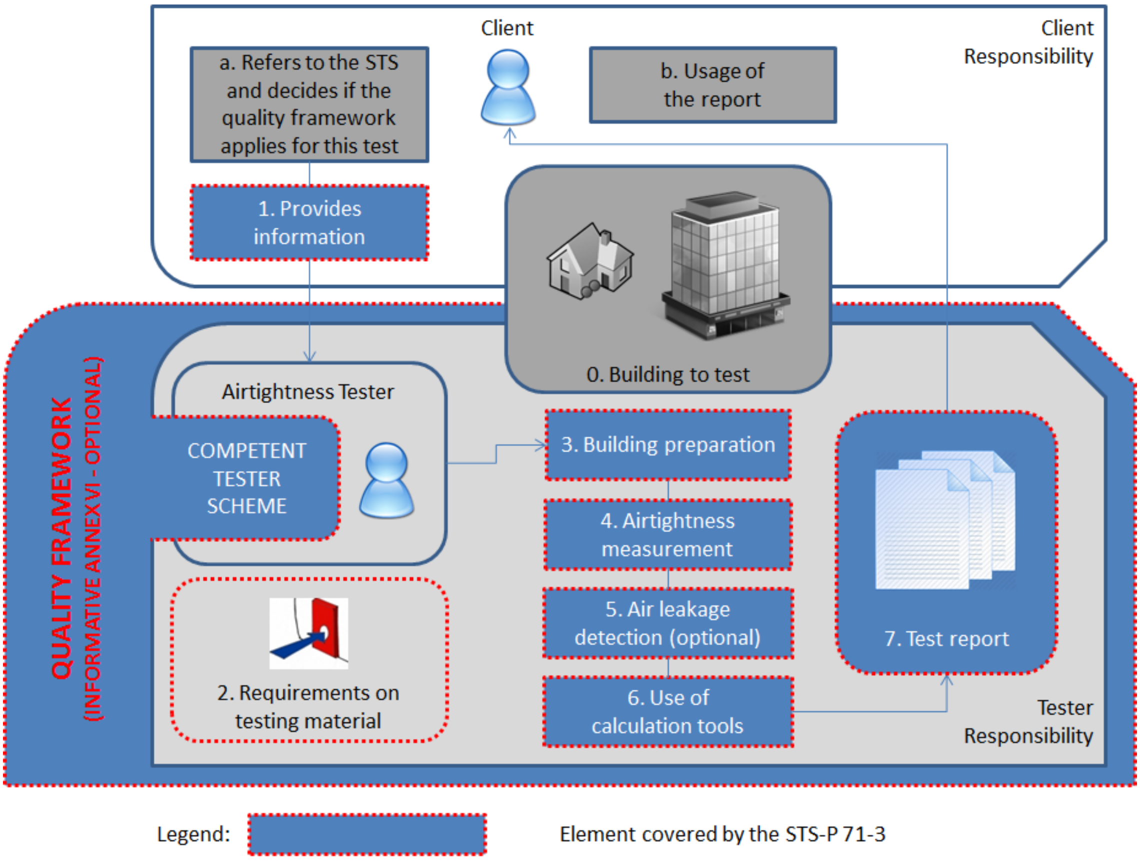

Figure 2: Steps of a pressurization test and elements covered by the STS-P 71-3

3.1 Responsibilities of the client

If not mandatory by the regulation, the client has first to decide to make the STS applicable by making a reference to it (step a. - Figure 2).
According to the objective of the test, different requirements are imposed on the state of the building (step 0 - Figure 2) for the realization of the pressurization test (Figure 3). In the context of the EP regulation, a “standard” test has to be realized. This test can only be carried out if the building is totally closed (all windows and doors installed). No temporary closing system is allowed. It is however recommended to wait until the end of the construction works to perform the test.
When ordering a pressurization test, the client has to provide the tester with information relative to the building (step 1 - Figure 2). The client has to define the tested zone in accordance with all applicable specifications. The test report has to contain one of the following parameters relative to the tested zone: total area of the walls around the tested zone (information used for the determination of the $\dot{v}_{50}$-value) or internal volume (information used for the determination of n_{50}-value). The client is responsible for providing the information and for its correctness.

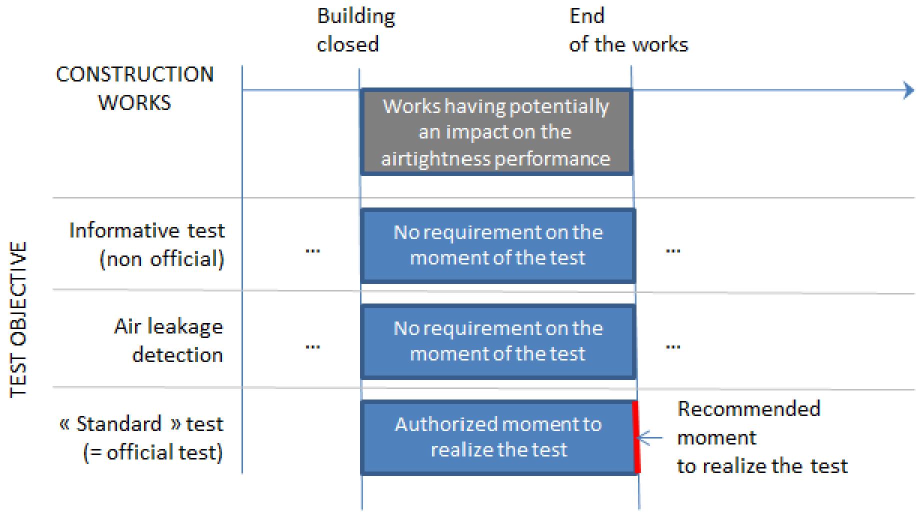

Figure 3: Specifications relative to the state of the building to realize the test according the test objective

In some cases, the person in charge of the building preparation has to be defined (step 3 - Figure 2). In small buildings, it is by default the responsibility of the tester. In large building, it may require a significant effort and it is not part of the usual occupation of the tester. The client has also to decide whether air leakage detection has to be realized (step 5 - Figure 2).
Finally, the client is responsible for the use of the test report (e.g. in the context of the EP regulation) (step b. - Figure 2).

3.2 Responsibilities of the tester

Based on the information communicated by the client, the tester is responsible for the realization of the steps necessary to deliver the test report. Specific steps e.g. the building preparation in case of large buildings, can be delegated to third parties.

3.2.1 Requirements on the testing material

Requirements on the testing material going beyond the requirements of the test standard have been introduced (step 2 - Figure 2). These requirements are mainly related to calibration aspects. The verification of the calibration of measuring devices[6] has to be realized with a frequency of two years. This frequency is imposed on manometers and thermometers. If the verification of the calibration shows unacceptable results, the measuring devices have to be effectively calibrated.
In the absence of evidence that regular calibration of hardware e.g. a blower door is necessary, a specific requirement is not imposed on the frequency of calibration of such equipment.

3.2.2 Building preparation for the test

The building preparations for tests A and B are described in the STS (step 3 - Figure 2). In the case of a “standard test”, the building preparation requirements are closely related to the conventions presented in the EP regulation, in order to consistently take into account the energy losses related to infiltration and ventilation. A summary of the requirements for the method A is given in Table 1.
In large buildings, the building preparation can be delegated to third parties. The tester has anyway the responsibility to check that the building preparation complies with the applicable specifications.

[6] Definition given in [JCGM 200]

Table 1: Overview of the treatment of intentional openings (method A)

Component	Status	Example
Opening **inside** the measured zone		
Doors, windows, stairs and other intentional openings (except special dispensation)	Opened	Door to a technical room, a boiler room, etc. Stair, greater than 1 m², to a room, accessible for purposes of technical maintenance of installations. Etc.
Opening **in the envelope** of the measured zone		
Mechanical ventilation openings	Sealed	Inside air terminal devices or ducts or outside air terminal devices
Natural ventilation system opening **with** closing device	Closing required Sealing allowed (1)	Adjustable supply or extract air terminal device (for natural ventilation only)
Other opening **with** closing device	Closed (2)	Exterior doors and windows Doors to a space outside of the measured zone: to a basement, garage, an attic, a crawl space Letter slot, cat-flap Evacuation of used water (3) Air outlet with closing device for tumble-dryer, kitchen hood (4) Chimney with closing device (open fire place, boiler, stove, etc.) (4) (5)
Other opening **without** closing device	Open	Unsealable air inlet for an open combustion appliance, etc. Aeration of waste water discharges Lock, openings for the belts of the shutters Other air outlets and chimneys without closing device (4) (5) Etc.

(1) Sealing is allowed (but not mandatory) in order to be consistent with the calculation of the infiltration and ventilation losses in the EP regulation.
(2) By using the closing device(s) present in the opening, but no sealing.
(3) Filling of the siphon = closing.
(4) If there is no closing device in the opening itself but an apparatus is connected to the opening, the apparatus must be closed (example: valve of a kitchen hood, door of a dryer, door of a stove, etc.).
(5) All the combustion appliances concerned must imperatively be stopped before any intervention. Note that it is not necessary to take sealing measures for appliances.

3.2.3 Requirements regarding the pressurization test

The STS-P 71-3 introduces adapted requirements regarding the pressurization test (step 4 - Figure 2).

3.2.3.1 Criteria to realize a measurement in accordance with the test standard in large buildings

Among all the criteria to realize a measurement in accordance with the test standard, specific requirements on the following three criteria are imposed:

- the pressure differences at zero-flow (ΔP0),
- the pressure difference for the first measurement point
- the highest pressure difference to realize.

Figure 4 presents the measurements conditions in accordance with the test standard. These conditions have been unchanged for measurement realized in small buildings.

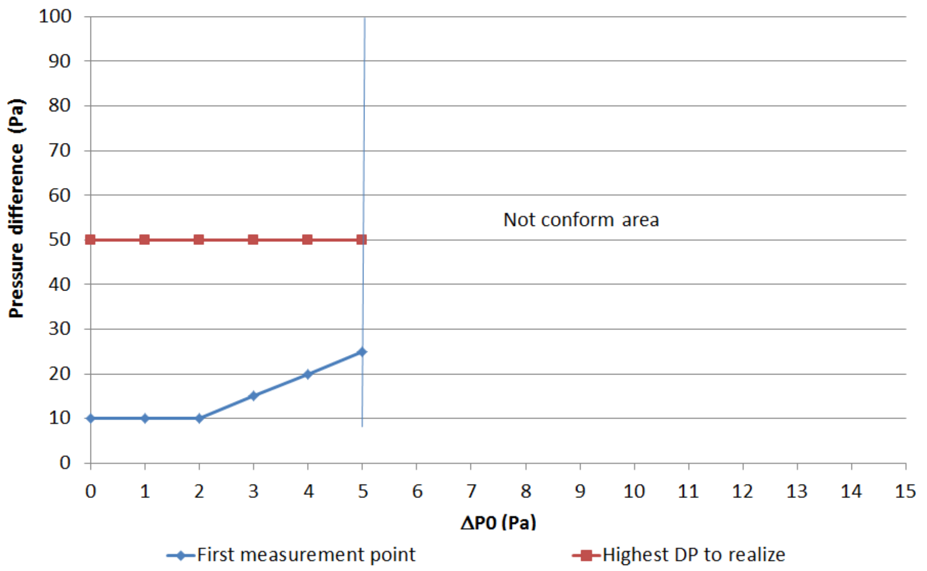

Figure 4: Conditions for a measurement in accordance with the NBN EN 13829 – criteria of the STS-P71-3 for small buildings

It is not always possible to realize a pressurization test fully in accordance with the test standard, especially in high buildings. In particular, the criteria on maximal pressure difference at zero-flow ($|\Delta P0| \leq$ 5Pa) can be problematic. This pressure difference is influenced by the wind conditions and the stack-effect. In low-rise buildings, respecting the criteria is generally not an issue. In high-rise buildings, even small temperature differences between inside and outside can make the measurement not conform to the test standard. Figure 5 presents the maximal allowed temperature difference between inside and outside according to the height of the building. In building higher than 45m, only 5K temperature difference can cause problems for the test.

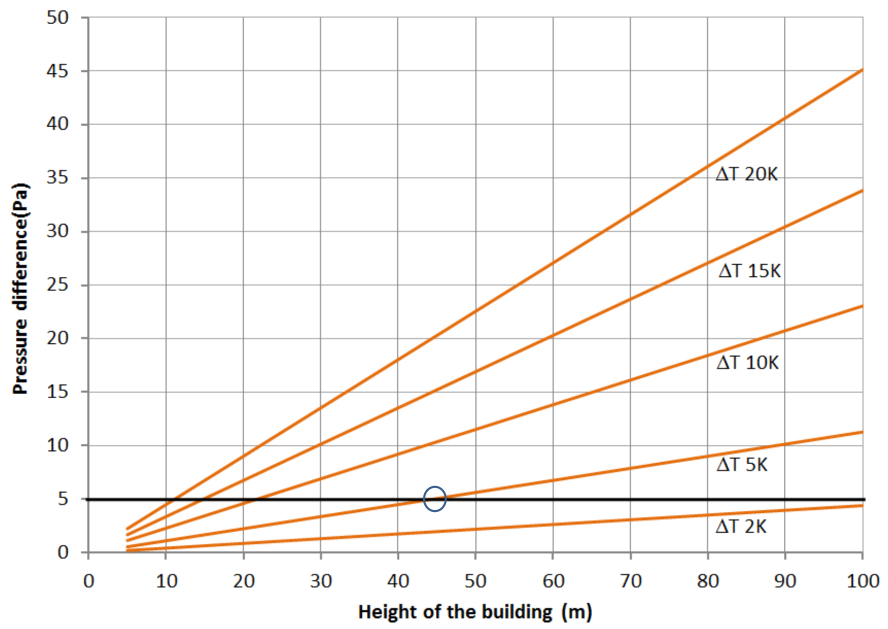

Figure 5: Maximal allowed temperature difference according to the building height to fulfil the maximal pressure difference at zero flow criteria (ΔP0 < 5Pa)

In high-rise buildings, the existing criterion on ΔP0 limits the possibilities to realize conformable measurements during periods of time where the temperature difference inside-outside is very limited.

In large buildings, in some cases, the availability of a sufficient number of openings where blower doors can be installed can also be an issue.
In order to enlarge the number of conformable pressurization tests, adaptations to the allowed combinations of the above mentioned three criteria have been introduced for large buildings. Small and large buildings are defined according to the building volume (threshold of 4000m³). Adaptations to these criteria have been proposed while keeping a sufficient accuracy of the measurements. The following elements have been considered:

- The pressure difference at zero flow (ΔP0) should not be higher than 20% of the lowest test pressure,
- A minimal range of 25Pa should be obtained between the lowest and the highest test pressure (= minimal criteria accepted by the test standard).
- The highest pressure difference should not exceed 100Pa,
- Extrapolate of the values at 50Pa is not recommended, especially if high pressure differences at zero flow are measured,
- Based on the above mentioned conditions, the measuring conditions could be relaxed when exceeding 85.000m³/h (corresponding to about 10 to 15 blower doors).

These considerations resulted in the definition of a new set of criteria presented in Figure 6.

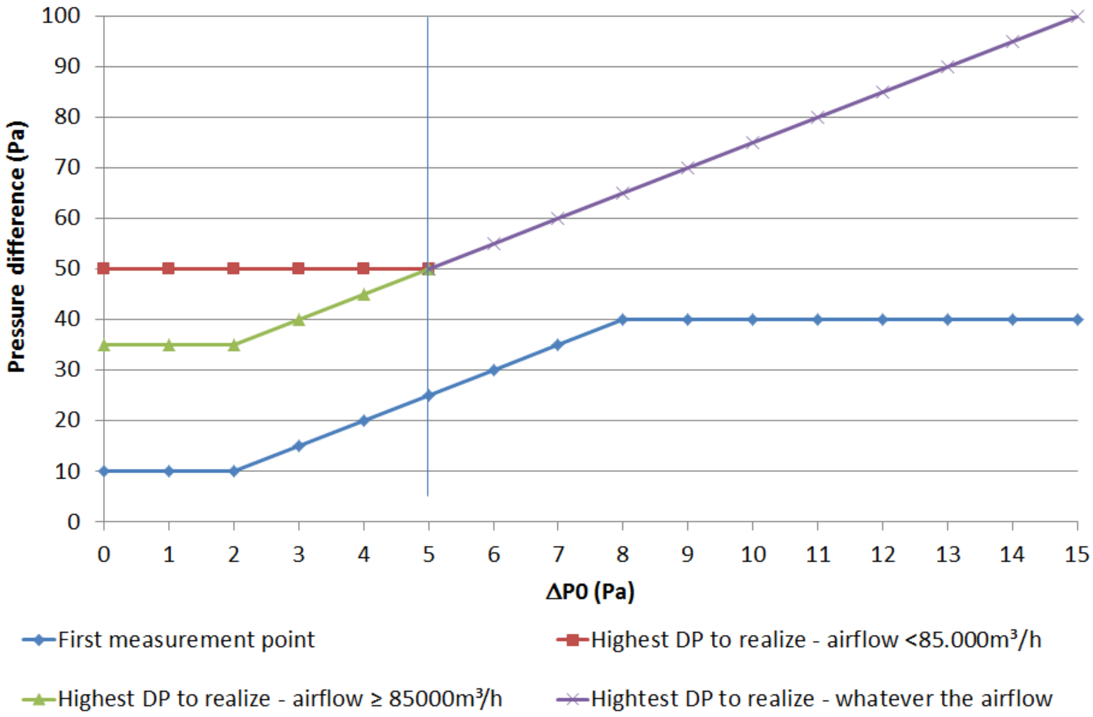

Figure 6: Conditions for a conform measurement in large buildings – adaptation of the criteria of the test standard

3.2.3.2 Measurements in the two modes

In the context of the EP regulations, it is required to realize the pressurization test in the two modes (pressurization and depressurization). The average performance has to be used for the calculation. However, in specific cases, it may happen that the measurement in one of the two modes is problematic or even impossible. The new STS-P 71-3 still requires realizing the measurement in the two modes. Though, if only a measurement in one mode should give conformable results, the average performance to consider is the result of this conformable measurement increased by 20%. Given the fact that differences of 40% between the two modes hardly occur; this approach is considered to be at the safe side to effectively stimulate the realization of the measurement in the two modes.

3.2.4 Air leakage detection

The air leakage detection (step 5 - Figure 2) is not mandatory. Discussions about the opportunity to systematically realize this detection took place with sets of arguments in favour of the two options. The main arguments against the mandatory air leakage detection were:

- This detection has an impact on the cost of the test. In many cases, the clients are not interested in this detection. They should in this case not have to pay for it.
- It is difficult to describe what precisely an air leakage detection is and which level of detail would be required. This part of the test cannot be controlled.
- The air leakage detection raises questions related to responsibilities of the actors – who is responsible for the leakage and is it necessary to fix (or reduce) it.
- Even in airtight buildings build by experienced building contractors, very limited air leakages always exist. What is the sense of this detection is such cases?

The tester can realize this air leakage detection. He is not responsible for the identification of the cause of the leakages and is also not responsible to fix them.
A standardised list of air leakage sites has been added as an informative annex to this STS. This list was developed and tested in the scope of a national research project.

3.2.5 Use of calculation tool

Specific requirements have been introduced regarding the correctness of calculation tools (step 6 - Figure 2). A specific annex to the STS contains a set of input data: indoor and outdoor temperature, pressure difference at zero flow as well as the airflows corresponding to different pressure differences. This annex also contains the main calculation and indicators calculated with these input data. The calculation tools must have been tested according to this annex and produce the correct calculation results.

3.2.6 Content of the report

In addition to the requirements on the report of the test standard, supplementary requirements have been introduced into the STS (step 7 - Figure 2). The following elements have been introduced:

- Attestation of conformity of the test with the requirements of the STS-P 71-3
- Presence of pictures of the installed blower door: one picture taken from inside the building as well as one picture taken from outside has to be included in the report. The tested building has to be recognizable. This element guarantees that a test has effectively been realized. It can also be helpful to easily identify the building (or a specific apartment inside a building).
- To respond to an identified existing problem (see §2.4), the report has to contain the surface of the tested zone or the internal volume. The origin of this information has to be mentioned. It is generally communicated by the client. The tester can on a voluntary basis add to the report the derived quantities ($\dot{v}_{50}$, n_{50}) based on these values.

3.3 A new quality framework

The STS-P 71-3 contains an informative annex describing in general terms the requirements regarding a quality framework for the realization of pressurization tests. A certification organization may organize a system allowing to show the compliance with the STS and this particular annex.

Quality systems demonstrating the compliance with the STS should contain a competent tester scheme as well as a control system of all the steps of the pressurization tests described in Figure 2. Central databases of the test reports will be developed.
From January 2015, in the context of the EP regulation, the Flemish region imposes the respect of the STS including the annex related to the quality framework for every new pressurization test. Systems for demonstrating the compliance to the STS are operational by this date.

4 CONCLUSIONS

The result of a pressurization test is an input value in the context of the Energy Performance regulations for new buildings in Belgium. The impact of this parameter is growing with the strengthening of the EP requirements. Testing is not mandatory. Since the introduction of the first EP regulation in 2006 in Belgium, measuring the airtightness has become a common practice and more than half of the new buildings are nowadays tested in the Flemish Region.
Although the rules to realize these tests are already well defined; specific problems regarding the tests exist and quality problems of the test have also been identified. To solve these problems, updated rules for the realization of the test have been defined in the STS-P 71-3. Specific rules have i.a. been defined for large buildings in order to widen the number of situations where a test in accordance with the standard can be realized. The steps of the test the tester is responsible for have been defined. The STS introduces also the possibility of a quality framework imposing a competent tester scheme.
In the Flemish region, the rules of the STS including the quality framework will become applicable in the scope of the EP regulation for every new test in 2015. Operational systems enabling the conformity demonstration to this STS are developed.

5 ACKNOWLEDGEMENTS

The STS-P 71-3 described in this paper benefits from the results of the research project ETANCH'AIR supported by the Walloon Region in Belgium.
This paper has been written in the scope of the IEE project QUALICHECK (IEE/13/610/SI 2.675574) funded by the European Union.
The sole responsibility of the content of this paper lies with the author. The Executive Agency for Small and Medium-sized Enterprises (EASME) is not responsible for any use that may be made of the information contained therein

6 REFERENCES

VEA. (2013). Cijferrapport energieprestatieregelgeving, Procedures, resultaten en energetische karakteristieken van het Vlaamse gebouwenbestand - periode 2006 – 2012, – available on www.energiesparen.be

FPS economy. (2014). STS-P 71-3 – Airtightness of Buildings – pressurization tests – (Not published yet)

NBN EN 13829 (2001) – Thermal performance of buildings — Determination of air permeability of buildings — Fan pressurization method (ISO 9972:1996, modified)

JCGM 200:2012 - International vocabulary of metrology – Basic and general concepts and associated terms (VIM), Joint Committee for Guides in Metrology (JCGM)