Quality framework for residential ventilation systems in Flemish Region in Belgium – feedback after three years' experience

Maarten De Strycker[*1], Liesje Van Gelder[1], Martyna Andrzejewicz[1] and Valérie Leprince[2]

1 BCCA
Aarlenstraat 53
BE-1040 Brussels, Belgium
**Corresponding author: m.de_strycker@bcca.be*

2 PLEIAQ
84 C Av. de la Libération
69330 Meyzieu, France

ABSTRACT

A ventilation performance report is mandatory for every new residential building in Flanders, for building permits issued since January, 1st 2016. This means that the features of the ventilation system as installed in the dwelling must be reported and that, in the EPB-report of the dwelling, these data must be used to justify the energy performance of the ventilation system.

To enhance the properly functioning of the ventilation systems, a ventilation preliminary design has to be made before the physical building process is started.

The EPB-regulation in Flanders defines sine 2006 minimal ventilation requirements per type of room. In 2015, a new regulation, which refers to STS-P73-1, was published. The STS-P 73-1 describes performance criteria for residential ventilation systems and how to report them.

Similar to the reporting of the airtightness of the building, the reporting of performance of the ventilation system is guarded by a quality framework. The quality framework requires that the preliminary design and the report after commissioning are made by a qualified reporter and that audits, both desktop and on-site, are performed by auditors from the organiser of the quality framework. This article also describes requirements for quality framework organisers as defined by the authorities in Flanders.

This article describes the quality framework and its output. Desktop and on-site controls represent both 10% of ventilation performance reports. They are done by 12 qualified auditors all around Flanders. The inspector has to inform BCCA of every inspection at least the day before and to send a message when the measurement actually starts and ends. The inspector is informed within 5 minutes after the end of the inspection whether he will be audited or not.

The article discusses some results of the quality framework: the effectiveness of the audits, the outcome of the audits on preliminary designs, the challenges in measuring ventilation flows on-site, the energy use of the fans and the conformity of ventilation systems with the regulatory requirements.

The article concludes that it is possible to set up an effective and efficient quality framework for inspections on ventilation systems. An intermediate step to fill the gap between the non-binding preliminary design of the ventilation system and the commissioning of the system 21 months later is presented. The situation for ventilation systems is not dramatic, but there is still room for improvement of the quality of ventilation systems in residential applications and on-site measurements require some guidance.

KEYWORDS

Ventilation system inspection, quality framework, database

1 INTRODUCTION

Indoor air quality and the well-performance of residential ventilation systems is a concern in many countries and the inspection of residential ventilation systems comes gradually into force in European countries (Bailly Mélois & Mouradian, 2018) (Bourdin, 2019) (EPBD19, 2019)

This is also the case in Flanders, Belgium, where the energy performance calculation of the building also ensures that a healthy and comfortable indoor climate is provided to the occupants. As with stricter energy performance requirements, buildings become more airtight and controlled ventilation is becoming more and more important. Minimal air flows for different rooms are determined (Vlaams Energieagentschap, 2019).
During last years stakeholders (architects, installers, producers and distributors of ventilation products, EPB-reporters, …) and the authorities have been concerned about the properly functioning of ventilation systems and the accuracy and reliability of the reported air flowrates in the EPB-reporting. This concern is justified by the fact that 80% of the non-compliance fees in EPB-regulation are related to the ventilation systems (Vlaams Energiesagentschap, 2019)

Therefore, a quality framework for the inspection of ventilation systems in residential buildings was launched on January 1st, 2016.

The objectives of this article are to:

- Describe the Flemish quality framework for the inspection of residential ventilation systems,
- Explain the efficient audit process to improve the reliability of results,
- Give output and lessons learned from the quality framework.

2 METHOD

2.1 STS-P 73-1 : the key document

The STS are "Unified technical specifications". They are edited by the Belgian Federal Public Service for Economy to optimise and standardise construction quality. Various STS exist on the construction field, STS-P 73-1 is for ventilation systems in residential buildings (SFP Economie, 2015).

In the STS-P, the criteria for ventilation systems that could be prescribed and could be reported are listed.
The STS-P does not prescribe requirements for the ventilation system, but lists possible evaluation criteria for ventilation systems and how to prescribe, determine and the performance of the ventilation system for each the criteria. For example, the STS-P does not impose or advice a certain specific fan power of the system (SFP_{system}), but it defines the formula for calculating the SFP_{system}, the classes, and the method for measuring the power consumption of the ventilation system. It is then up to the builder to define which class of SFP_{system} should be reached and to the ventilation inspector to determine the actual class of SFP_{system}.
Different levels of requirements may apply to a ventilation system, e.g. the EPB-regulation sets only minimal ventilation flows, but a builder could require better IAQ, so higher ventilation flows. Therefore the output of the ventilation inspection is not a conformity declaration to a requirement, but a report (the ventilation performance report VPR) with

objective data and figures about the performance of the ventilation system such as (neither exhaustive, nor applicable to all):

- per room the measured air flow, nominal air flow of air inlets,
- the efficiency of the heat recovery unit,
- the power consumption of the fan,
- the description of the demand controlled ventilation system,
- etc.

2.2 The Flemish regulation

The Ministerial Decision that enforced the quality framework for inspections of ventilation systems was published in November 2015. It defines the rules that apply to residential ventilation systems in dwellings with a building permit from January 1st 2016 on (VLAAMSE CODEX, 2015). The two main requirements in this regulation are

(i) a ventilation preliminary design is mandatory before the building works start and

(ii) a ventilation performance report is required to justify the values related to the ventilation system in the EPB-reporting. A ventilation performance report can be seen as an inspection by a qualified inspector, according to the STS-P 73-1 on the ventilation system after commissioning.

The quality framework for inspections on ventilation systems is managed by an *organiser of a quality framework*.

In December 2017, the Flemish government has tightened the requirements on the organisers of the quality framework for the inspection of residential ventilation systems:

- The organiser of a quality framework must have a qualification procedure for ventilation inspectors, which includes at least
  - an optional training,
  - a mandatory theoretical and practical exam.
- The organiser of a quality framework must guarantee the reliability of the ventilation reporting by running desktop and on-site audits combined with effective enforcement.
  - Minimal random annual desk and on-site audits is 10% each.
  - Random checks are supplemented by targeted checks so that 90% of the active inspectors are checked at least once a year.
- The organiser of a quality framework shall develop a database gathering all measurement data that can be consulted by the authorities.
- The organiser of a quality framework is impartial: he should not have any members or directors who also carry out ventilation reporting in the context of the regulation.
- The organiser of a quality framework must have an accreditation in accordance with NBN EN ISO 17065 (certification of products and services).

The organiser of the quality framework has to be approved by the Flemish authorities.

The inspector shall be qualified and its company recognised by an approved organiser of the quality framework to perform a task in this context.
The quality framework for the inspection of residential ventilation systems of BCCA (Belgian Construction Certification Association) has been approved by the Flemish authorities since the new requirements on qualification bodies.

2.3 The BCCA quality framework

The purpose of the quality framework is to guarantee the correct reporting on the performance of the ventilation system. The reporting on the performance of the ventilation systems is done by *inspectors*. An inspector is a person that is qualified by the organiser of the quality

framework and is audited by the quality organisation by desktop and on-site audits. The surveillance on the inspectors is done by BCCA *auditors*.

Qualification
BCCA provides a complete quality framework for a company which includes the qualification procedure for the inspector.
The qualification procedure for the inspectors includes:

- Optional theoretical training (1 day)
- Theoretical exam for each component of the ventilation system (online multiple choice questionnaire)
- Practical exam: measuring the flow at 10 vents with their own measuring device. Different flows between 25 and 90m³/h, both extraction and pulsion.

Web application and database
To facilitate the process of inspection, reporting and auditing, a web application has been set up. Only qualified inspectors and auditors of BCCA have active access to this application. A builder has passive access to the database, which means that the access is limited to consult documents validated by the inspectors.

Auditing processes
BCCA has 12 auditors active to manage the quality framework. Not all auditors are working full-time on this quality framework, and the auditors are regionally distributed over the area of Flanders to limit travelling time to audited buildings. Auditors have at least the same qualification as inspectors plus a specific training for audits. Furthermore, auditors are regularly checked on-site by their manager and internal meetings are set up.

The **on-site audit** is either performed:

- Option 1: During the measurement
- Option 2: After the communication of the measurement result with a check on this result by a second (partial) measurement (at least half of on-site inspections are performed in Option 2).

To allow this inspection, at least one day before the measurement is performed, the inspector shall provide some information to BCCA by the online platform, such as the address of the building, the timing of the measurement, and the person that will do the inspection. When on-site, the inspector has to send an SMS, or indicate in the web application that the measurement has started. After the measurement, the inspector has to communicate the measurement results by SMS or in the web application.

During the audit, the auditor checks

- the qualification of the inspector and the company,
- the equipment (calibration, settings and correct use),
- the building preparation,
- the fixed components of the ventilation system,
- the compliance of the measurements of air flowrates and fans power with the STS-P 73-1. The inspector has to remeasure a random set of vents under supervision of the auditor. This result is compared to the reported ones to check the reliability.

The **desktop audit** is performed when preliminary designs or performance reports are uploaded in the database. If a desktop audit is done, the auditor will check at least the following:

- The report is complete and made according to the STS-P 73-1,
- The timing is correct (lodgement of information, etc.),
- Text messages have been sent according to the schedule ,
- The information in the report is consistent (e.g. type of ventilation system corresponds to the components reported).

Non-conformities and sanctions
An essential part, besides doing audits, is following up output audits. The system of enforcement classifies non-conformities into 4 categories:

- **Unacceptable non-conformities (ONC)**: such as deliberate manipulation of results in the reported flowrate, repeated "major non-conformities" with no correction,
- **Major non-conformities (GNC)**: anomalies with regard to the STS-P 73-1 with an important impact on the measurement result, repeated "minor non-conformities",
- **Minor non-conformities (KNC):** anomalies with regard to the STS-P 73-1 that have a small impact on the result, repeated remarks,
- **Remarks (REM).**

For a minor non-conformity, the frequency of desktop or on-site inspection is increased.
For a major non-conformity, also the performance report and/or the measurement shall be redone.
In case of major non-conformity, due to calibration validity, the recognition may be temporarily withdrawn. These sanctions are clearly communicated to the inspectors in the rules of the BCCA quality framework (BCCA, 2019).

Cost
Every report has a cost of 71.5EUR. This cost is split between the registration of the ventilation preliminary design and making up the ventilation performance report. An additional cost of 10.21EUR is added when different companies are working on the same report and a reduction is foreseen for dossiers containing more than 10 dwellings.
Yearly fee for use of the digital platform is 255.36EUR, with an additional cost of 51.07EUR per extra qualified user in the company.
The optional 1-day training costs 355EUR.
The online theoretical exam costs 51.07EUR per module, for the package with all modules this amounts to 177.73EUR.
The practical exam costs 178.75EUR.

3 RESULTS

3.1 Qualified inspectors
In June 2019, 560 qualified inspectors were active in 470 companies in the BCCA quality framework.

3.2 Measurement lodging
There is a substantial time between the building permit date and the measurement of the ventilation flowrates. Although all dwellings with a building permit date after 1/1/2016 fall under the application of the quality framework, in 2016 only 1 measurement was registered in the database. Fig.1 shows the number of measurements registered in the BCCA database on a monthly base for 2017. It is clear that the measurement of ventilation flows took off only from September 2017 on which is 21 months after the first building permits falling under this regulation.

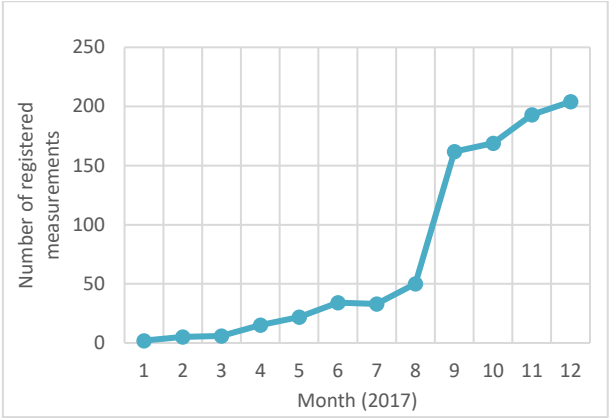


Fig. 1 Number of measurements on monthly base registered in the BCCA database

This shows one of the issues with the quality of a ventilation system in a building: ventilation should be taken into account from the building design (e.g. space for the unit and the ducting, effect of trickle vents on windows), but the effectiveness of the system is only controllable several months later: after installing all components and commissioning of the ventilation system.

3.3 Inspections on preliminary designs

The preliminary design of the ventilation system comprises a plan with some essential elements on it, e.g. the position of the ventilation unit, the position and the indicative diameter of the ductwork, for each room the function, the surface, … Details can be found in a separate document (Werkgroep A VVO, 2017).

A preliminary design is not binding, especially because of the timing: it should be made before the construction works start. In most cases, the builder has, at that moment, no idea of the details of ventilation system that will be chosen, and the installer is not yet known. In most cases, there should be an estimation about the required performance of the ventilation system to reach the energy performance of the dwelling.

The inspections on the preliminary designs are thus limited to checking if the required elements are present. The findings from these inspections are:

- That some are very comprehensive and some are very limited.
- In most cases, the condensate drain is missing, which can be an issue when the heat recovery unit is located far away from the drainage system.
- The position of the operating console of the unit, which may require wiring when the console is not put on the unit or the console is not functioning wireless.
- The position of the air inlet and outlet (facade or roof) is not specified, which may induce issues with the dilution factor and recirculating air.
- Attenuators are not specified, while they need a substantial place and the lack of attenuators may induce acoustical issues.

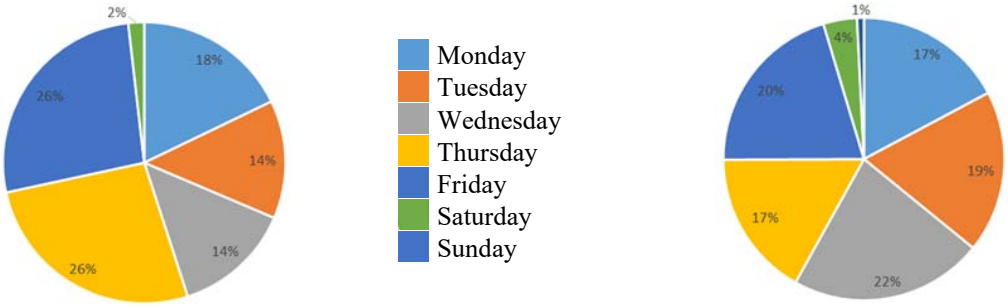
3.4 On-site audits

More than 10% of installations for which an inspection has been carried out in 2018 have undergone a desktop audit and more than 10% have undergone an on-site audit. In Fig. 2 the regional distribution of the inspections registered in the database and the audits done by BCCA auditors is presented. From these density plots is clear that both have a similar distribution.

Audits performed in 2018 Inspections performed in 2018

Figure 2: Geographical distribution of the inspections and inspections registered with BCCA in 2018

Fig. 3 shows that the same repartition of the day of the week is observed in audited inspections and in all inspections performed (even during the weekend).



Audit days Inspection days

Figure 3: Repartition of the day of the measurement for audits and for all inspections in 2018

From Fig. 2 and Fig. 3 can be concluded that the auditing process is representative for the actual distribution (both in time and geographical) of the inspections in Flanders.

3.5 Measurement of power consumption

In 60% of the inspections the power consumption of the fans was measured, see Fig. 4.

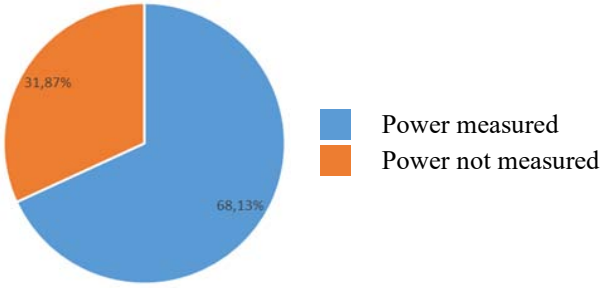
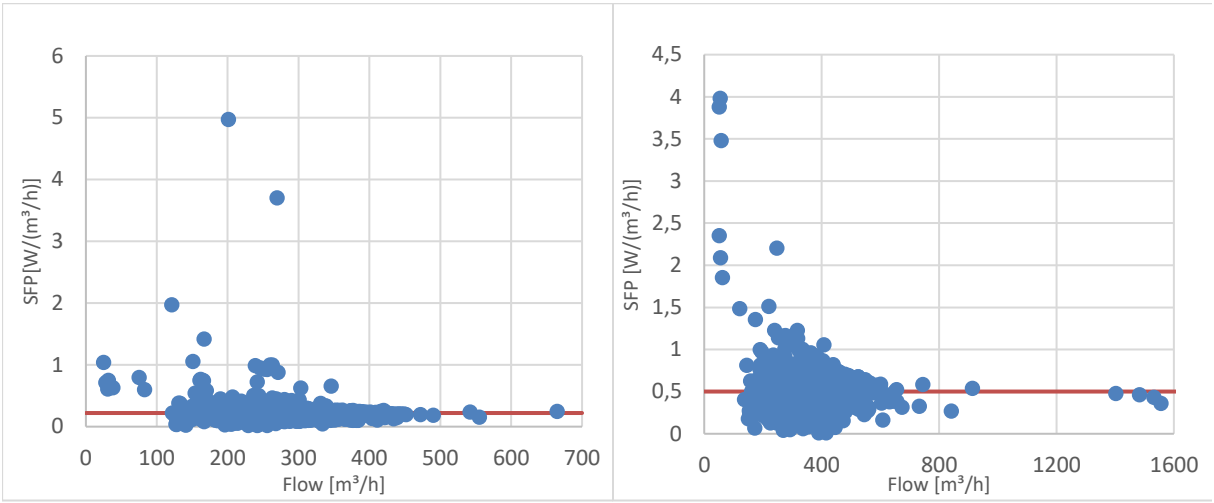


Figure 4: Ratio of installations with the power consumption measured

SFP_{system} recorded in the database are shown in Fig. 5. The average SFP_{system} for ventilation systems with only mechanical exhaust is 0.22 W/(m³/h), which corresponds to SFP_{system} class 3 in the STS-P. Average SFP_{system} for a ventilation system with mechanical ventilation and heat recovery is 0.50 W/(m³/h), which corresponds to SFP_{system} class 4 in the STS-P. Although the average value of the SFP_{system} is reasonable, there is quite some spread on the power consumption of the systems. The high SFP_{system}-values for a large part of the inspected ventilation systems, indicate that there is room for improvement in the design and installation of ventilation systems in dwellings.



Mechanical exhaust | Mechanical ventilation with heat recovery

Figure 5: SFP_{system} distribution for different systems

3.6 Conformity of the inspected ventilation systems with EPB-regulation

Based on the registered flows in the database, some superficial conclusions on the conformity of the inspected ventilation systems with the EPB-regulation can be drawn. In the regulation, the minimum flowrate for a room is 25m³/h (extracted air), which is required for a WC. Fig. 6 shows the minimal exhaust flow per registered inspection in the database.

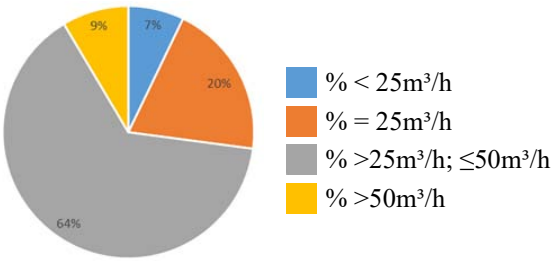


Figure 6: SFP distribution for different systems

In 7% of the registered measurements the lowest airflow rate is lower than 25m³/h, which means that at least 7% of the ventilation systems does not reach the minimum requirements as set in the EPB-regulation for at least one room. Probably a higher share of systems does not meet the requirements:

- as only the room with the lowest flow can be evaluated from these data. It would require a detailed analysis of the registered flows per room to evaluate the real number of non-complying installations.
- as probably not all inspectors are reporting what was actually measured.

On the other hand, it shows to some extent that inspectors do correctly report what was measured, which shows the effectiveness of the quality framework.

3.7 Challenges in measuring flows on-site

Although measuring flows in ventilation systems seems at first sight quite simple and several techniques are documented in literature (CEN EN 12599, 2012) (CEN EN16211, 2015; ISO 16956, 2015), in practice some challenging situations exist. Within the quality framework, almost all measurements are performed with flow hoods on the vents. For 1.72% of the systems with mechanical exhaust, there are vents with a reported flowrate of 0m³/h, which means that it was not possible to measure the airflow rate for at least one vent, see Fig 7.

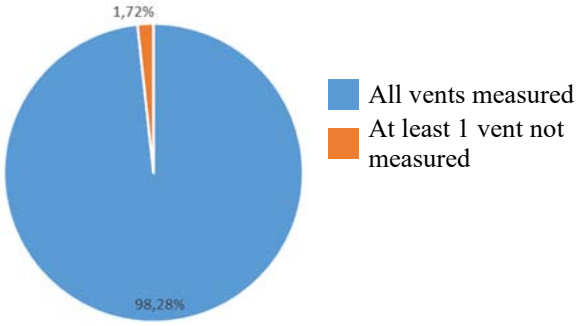


Figure 7: SFP distribution for different systems

1.5 year of inspections has shown that not all vents are measurable on-site. Some ventilation inspectors stay on the safe side, while others act quite creatively to still measure and report a flow. Therefore, in collaboration with the stakeholders, a practical guideline was elaborated to help inspectors in measuring flows (BCCA, Praktische uitdagingen bij het opmeten van ventilatiedebieten, versie 1.0, 2019).
The figure below shows an example taken from this document: the situation on-site is described, the wrong measuring method is shown, and the acceptable solution is shown.

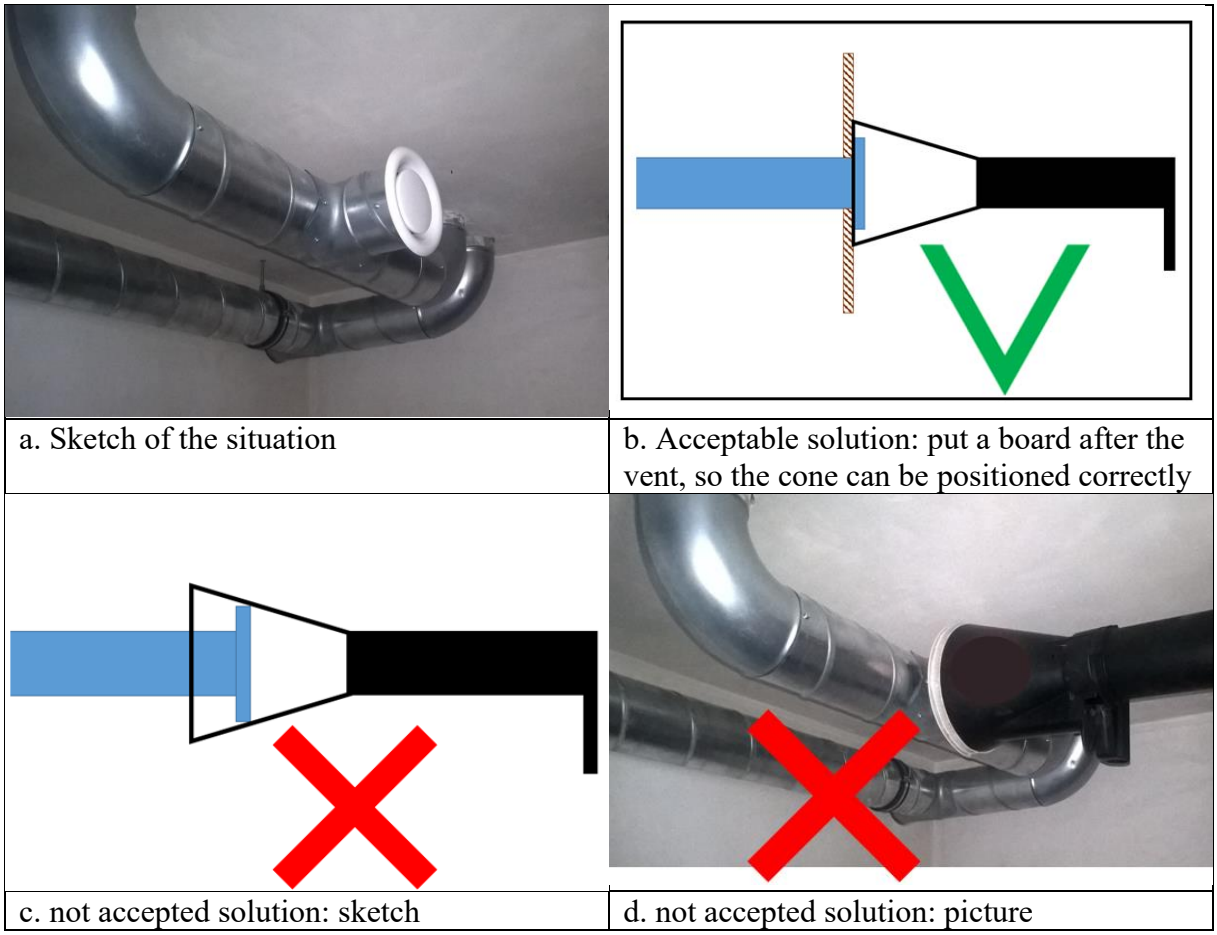


Figure 8: example from the guideline for measuring ventilation flows

This is also a necessary document for auditors when they have to accept or decline certain measurements. This document may also help other building partners (architects, contractors, builders) to create measurable situations.

4 DISCUSSION

4.1 On-going improvements

In the quality framework of BCCA ventilation design requirements have been introduced in May 2019. The objective is to fill the gap between the preliminary design which is

- not binding,
- made far before the ventilation system is ordered by the installer

and the ventilation performance report which gives the final performance of the ventilation system.
The effect of this additional requirements will probably be only visible within the coming months or years.

Measurements of the air velocity in the ductwork are more and more performed. However, this technique requires some specific precautions (straightness of the ductwork around the measured point, accuracy of the probe, calculation of the flow from the velocity,…). A guidance document is foreseen to detail the conditions for these measurements in addition to EN 16211.

4.2 Future work

It would be interesting to perform a detailed analysis of the performance reports registered in the database and check whether flowrates are complying with the requirements set in the EPB-regulation.

5 CONCLUSION

Since January 1st 2016, a quality framework for the inspection of ventilation systems in new and thoroughly renovated dwellings is mandatory by law in Flanders, Belgium. Besides requirements for the inspection scheme itself, there are also requirements for the organiser of the quality framework. The article gives an overview of the concept of the quality framework and references to documents were details can be found.

This quality framework includes a qualification procedure for inspectors. Only qualified inspectors can make a non-binding ventilation preliminary design. After commissioning, a report of the performance of the ventilation system should be made by a qualified inspector. This report is needed to justify the proper functioning of the ventilation system in the EPB-reporting of the dwelling. The inspectors, who are not collaborators of BCCA, are audited by BCCA auditors through desktop and on-site audits that both represent 10% of the performed inspections.

For the quality framework a web application was developed and the reports are stored in a database. A first analysis of the results in the database shows that the quality of the installations is not dramatic, but that there is still room for improvement.
On average, it takes 21 months between the registration of the preliminary design and the measurement of the ventilation flowrates on-site.

It has been shown that, for Flanders, it is possible to set up a system of on-site unannounced audits of the inspectors. These on-site audits have stressed the need for guidance to perform measurement of ventilation flowrates on-site in challenging situations.

Future work is to fill the gap between the preliminary design and the ventilation performance report and to develop further help for inspectors in measuring flows on-site.

6 ACKNOWLEDGEMENTS

The authors would like to thank the colleagues at BCCA involved in the development and operational activities of the quality frameworks.

7 REFERENCES

Bailly Mélois, A., & Mouradian, L. (2018). Applications of the Promevent protocol for ventilation systems inspection in French regulation and certification programs. *39th AIVC Conference "Smart Ventilation for Buildings",*, (p. 7). Antibes Juan-Les-Pins, France, 18-19 September 2018.

BCCA. (2019). *Beschrijving van het kwaliteitskader Ventilatie van BCCA vzw, Versie 2.0 van 06/05/2019.*

BCCA. (2019). *Praktische uitdagingen bij het opmeten van ventilatiedebieten, versie 1.0.*

Bourdin, E. (2019). The context in Ireland - Changes to Irish regulations and inspection of ventilation systems. *AIVC Workshop: Quality ventilation is the key to achieving low energy healthy buildings*, (p. 22). Dublin, Ireland.

CEN EN 12599. (2012). Ventilation for buildings. Test procedures and measurement methods to hand over air conditioning and ventilation systems.

CEN EN16211. (2015). Ventilation for buildings. Measurement of air flows on site. Methods.

EPBD19. (2019). Récupéré sur https://www.epbd19a.eu/

ISO 16956. (2015). Thermal performance in the built environment — Determination of air flow rate in building applications by field measuring methods.

SFP Economie. (2015). *Spécifications techniques unifiées , STS P-73-1, Systèmes pour la ventilation de base dans les applications résidentielles.*

Vlaams Energieagentschap. (2019). Récupéré sur Energiesparen: https://www.energiesparen.be/bouwen-en-verbouwen/epb-pedia/technieken/ventilatie

Vlaams Energieagentschap. (2019). *EPB-CIJFERRAPPORT Procedures, resultaten en energetischekarakteristieken van het Vlaamse gebouwenbestand - periode 2006 – 2018.* https://www.energiesparen.be/sites/default/files/atoms/files/uitgebreidcijferrapport_2019.pdf.

VLAAMSE CODEX. (2015). *Ministerieel besluit houdende wijziging van het ministerieel besluit van 13 januari 2006 betreffende de vorm en inhoud van de startverklaring en het ministerieel besluit van 2 april 2007 betreffende de vastlegging van de vorm en de inhoud van de EPB-aangi.*

Werkgroep A VVO. (2017). *Werkgroepdocument A, Ventilatievoorontwerp (VVO), Aanvulling op STS-P 73-1: Systemen voor basisventilatie in residentiële toepassingen.* Récupéré sur https://www.ikventileerverstandig.be/wp-content/uploads/2017/02/STS-P-73-1-Ventilatie-Werkgroepdocument-A-ventilatievoorontwerp-201702095.pdf