Commission and performance contracting of ventilation systems in practice. Determination, analyses and consequences for practitioners and contractors

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ABSTRACT

Traditionally ventilation systems in the Netherlands are installed in new or retrofitted buildings by an installation fitter under the responsibility of a contractor. In some cases but certainly not all cases, it is checked by a consultant if the ventilation system performs according to the design. Studies in the Netherlands show that ventilation systems of dwellings often don't meet the designated Standards. Deviations are found in airflow rates, noise from the ventilation system and malfunctioning due to lacking air tightness of the building envelope. Other European countries are struggling with similar quality issues.
In offices and apartment buildings there are several initiatives to improve the performance of ventilation systems. For example by the use of Energy Performance Contracts. In these projects there is an increased attention for quality control in the installation and operational phases. Since a couple of years there are initiatives with performance contracts also in dwellings. An example is the energy efficient retrofitting of dwellings repaid via the energy bill in "Stroomversnelling". As a result of this driver of performance contracting, several initiatives have sprung up to support quality control of ventilation systems in dwellings, through new test instruments, ICT solutions and training. In the SecureVent project easy to handle methods for installation fitters are being developed to check the performance of a ventilation system regarding air flow distribution, noise and airtightness with good accuracy. Instruments which will soon be on the market are presented. Within the Energy leap "Stroomversnelling" program an API (Application Programming Interface) has been developed allowing standardized communication between on the one hand an external database and on the other hand sensors and installation in a dwelling. This allows an easy check on performance of the Indoor Environmental Quality (IEQ) and Energy use, both for housing corporations and occupants. In the Horizon2020 Sphere project this kind of interfaces will be used to build a digital representation (Digital Twin) of a dwelling based on monitoring data. It will be used to check the performance on IEQ and Energy use during the lifespan of a dwelling. It is important that the craftsmen installing the ventilation system have ample knowledge and skills to check its performance during construction and commissioning. To this end, in the Newcom project a European training program is being developed to help the craftsmen involved to acquire the required skills to obtain better performing ventilation systems.

KEYWORDS
Energy performance contracting, ventilation testing, commissioning

1 INTRODUCTION

Studies in the Netherlands show that ventilation systems of dwellings don't comply with building regulations. The main shortcoming is insufficient ventilation. This applies to both the house as a whole as to individual rooms. Ventilation systems produce too much noise, for example due to the lack of adequate silencers, the location of the ventilation unit and the dimensions of the air ducts. Because ventilation systems make so much noise when operating at high flow, the ventilation is often only set to the lowest speed (van Dijken, 2011). Because the houses are often not sufficiently airtight, the designed ventilation flows are not achieved especially for houses with natural supply and centralized mechanical extract ventilation. Other European countries are struggling with similar quality issues. In France, an analysis of 1,287 houses showed that 68% of single-family homes were found to be non-compliant with regard to ventilation regulations. Many of these malfunctions could be avoided through the implementation of quality management tools. These tools should be available at different stages of the construction process, and should be efficient and effective. (Jobert, 2013). Performance contracts can be an important driver for quality management and to focus on performance rather than the placement of components. Simplified tools should make it possible during the construction process to simply and effectively measure the most important aspects affecting the overall performance of the ventilation system: noise from the ventilation system, volume flow and airtightness of the building envelope.

2 CURRENT COMMISIONING

2.1 Current commissioning in the Netherlands

Traditionally ventilation systems are installed in new or retrofitted buildings by an installation fitter under the responsibility of a contractor. In some cases, the performance of the ventilation system and the airtightness of the building envelope are measured by a consultant. In these cases, the first dwelling of the project is tested, after which adjustments may be made. In exceptional cases, all the houses in the project are tested individually. In offices and apartment buildings there are several initiatives to apply energy performance contracts (EPC). In these contracts there is a shift from installing and supplying products and systems towards supplying good indoor environmental quality and low energy use. In these projects there is an increased attention for quality control in the installation and operational phases. Quality standards are very important. In essence, they are a natural part of the EPC; because the contractor (ESCO) gives a guarantee regarding energy savings. Renovations are done at a level that offers the savings and all the guarantees are fulfilled (Augustins, 2018).

2.2 Energy performance contracts and commissioning for Nearly Zero Energy dwellings in the Netherlands

Since 2016 there is legislation in the Netherlands for energy performance contracts for nearly zero energy dwellings initiated by the "Stroomversnelling". Landlords and housing associations that renovate their homes to a (nearly) energy-neutral are entitled to ask their tenants for an energy performance fee, "Energie Prestatie Vergoeding" (EPV). The landlord supplies energy to the tenant for his own use by financing the photovoltaic systems and retrofitting of their dwelling. The landlord may charge an energy performance fee for this in order to recoup his investments. Whereas the tenant previously paid rent to the landlord and the energy bill to the energy company, the tenant will pay an energy performance fee to the landlord in addition to the rent after the renovation. The aim is that the total housing costs for the tenant do not increase compared to the 'old' situation. The first condition for an energy performance fee is a very good insulation of the house. How well the house is insulated must be determined by an approved company. Such a company assesses, among other things, the floor and roof insulation, and what type of glass the windows have. If the heat demand is less than 50 kWh per square metre per year, the landlord or housing corporation may request an EPV. The amount of energy generated in the house must be recorded. The landlord or housing corporation, must provide an overview of the energy generated in the dwelling in the past year before 1 July each year. Because the energy savings and energy productions are well measured, therefore there is a strong driver for the contractor to deliver high quality installations and an airtight building envelope. It is also possible to get a quality label for this type of energy efficient dwelling.

2.3 NOM Certificate for dwellings

In the Netherlands, the “Stroomversnelling” has taken the initiative to achieve the NOM label. Houses that meet the NOM standard can more easily meet the regulations needed for the energy performance fee. Builders who offer dwellings with a NOM label, offer proven and tested retrofitting solutions and give at least ten years warranty on the performance after delivery. The NOM certification starts with a review of the concept, from the technical design, quality control plan to performance conditions and residents' manual. When renovating, it is checked whether the legal requirements are met in order to obtain the energy performance fee. During construction and at commissioning, a sample dwelling is taken to measure the performance of the dwelling, for example air flow measurements and airtightness testing. During the use phase, the monitoring data is presented to an audit team together with a report on the experiences of the users. The user survey takes place before, during and one after year of renovation.

2.4 Open Source API and model based data analytics

In order to make it easier to monitor the data of homes with a NOM label or an energy performance fee, an interface has been created by the "Stroomversnelling". This API (Application Program Interface) makes it easy to exchange data from different monitoring systems. The open source API developed jointly by market parties and Stroomversnelling makes it possible for different software providers to develop monitoring products that can communicate with each other. This makes it easier for housing associations, to collect the performances of different monitor systems and compare them with each other. This contributes to the delivery of good quality.

In the Horizon2020 project Sphere, such data will be used to calibrate physical models in order to make a digital representation (Digital Twin) of dwellings in the field of indoor air quality and energy. The houses in this project will be 100% checked for airtightness, ventilation and noise during delivery, but also the performance in the field of indoor air quality and energy will be tested during the use phase with such a Digital Twin.

3 SIMPLIFIED MEASURING TECHNIQUES FOR VENTILATION

3.1 Current measurement techniques

To obtain a good indoor climate, the ventilation flows from the ventilation system for each room in a dwelling needs to meet the demands given by standards which are based upon pollution by persons, moisture production, production of fine particles and so on. Often, due to incorrect adjustment of the mechanical ventilation system, the flows for the whole dwelling or for the different rooms in the dwelling do not meet the standards. These adjustments concern the tuning of the fan itself plus the valves and grids in the system. A proper control of the actual realised ventilation flows from the ventilation system is required but often not performed. For airflow measurements a pressure compensating airflow meter should be used. Such a meter consists of a controllable fan and a differential pressure meter. Although it is in fact the only way to measure (supply) flows properly it is not used in all cases, as it is not affordable for all craftsmen.

Especially in case of a centralized mechanical extract ventilation system in combination with grids in the façade, the airtightness of a dwelling also influences the ventilation. Besides the fact that a low airtightness results in higher energy use, it also reduces the ability of the ventilation system to achieve the desired ventilation flows. In other words, the ventilation system does not succeed in achieving the desired pressure difference across the ventilation grids for sufficient ventilation flow, especially on the leeward side of the house. Opening of a grid does not lead to air intake because the air enters via the gaps and cracks at other places. Checking the airtightness is therefore needed. Nowadays the airtightness of a dwelling is measured by a so-called “blowerdoor” test. In case of a blowerdoor test, a dummy door is installed in the door of the dwelling in which a controllable fan is incorporated. A lot of equipment is needed for a blowerdoor test, e.g. the dummy door, and installation takes time.

Another problem is that in practice often too high noise levels are produced by the ventilation system especially at higher fan flows. Due to this, occupants do not use the ventilation system at the appropriate flow. Means to measure the noise levels and to indicate possible adjustments are needed. The current measurement of noise in homes according to the Dutch Standard is complex and requires specialist equipment and knowledge. In particular this applies to reverberation time measurements. It requires a speaker to produce sound and a dedicated sound meter, including software to calculate the reverberation time.

To improve the indoor climate on the above-mentioned aspects, easy to use and affordable measuring techniques are needed. In the Dutch TKI project SecureVent this is done for the measurement of airflows, airtightness and noisy production.

3.2 Simplified measurement of airtightness

In case of a blowerdoor test different over- or under pressures in the dwelling are set by adjusting the fan speed in the blowerdoor, while at the same time the supplied or extracted airflow is measured. Based upon the relation between airflows and pressure differences, the airtightness of the dwelling is determined.

A simplified measuring technique is developed in which the ventilation system in the dwelling is used to maintain a pressure difference over the façade. By switching the ventilation system from off/low to on/high position an under- or overpressure, in case of respectively extract or supply, can be obtained. The pressure difference is measured using a reference vessel. The pressure in this vessel serves as the reference to the pressure changes in the dwelling due to switching the fan. A connection to the outside is therefore not needed. In combination with the airflow maintained by the ventilation system, the airtightness can be derived.

The simplified airtightness measurement can easily be performed by placing the equipment (see figure 1) in either one of the rooms. The equipment consists of the reference vessel and a

differential pressure meter. The dimensions are roughly 15 by 30 cm, so easily portable. The measurement is performed using a tablet which is connected via WIFI to the equipment. After setting the airflow in the tablet, the measurement can be performed by switching the fan a couple of times. The pressure difference is indicated to monitor the measurement (see figure 2) and finally the airtightness is calculated automatically (Lanooy, 2019).
Measurements have been performed in 82 dwelling in which both a blower door test and a simplified airtightness measurement are performed. The results show a good comparison (see figure 3).

Figure 1: Equipment simplified airtightness measurement (prototype)

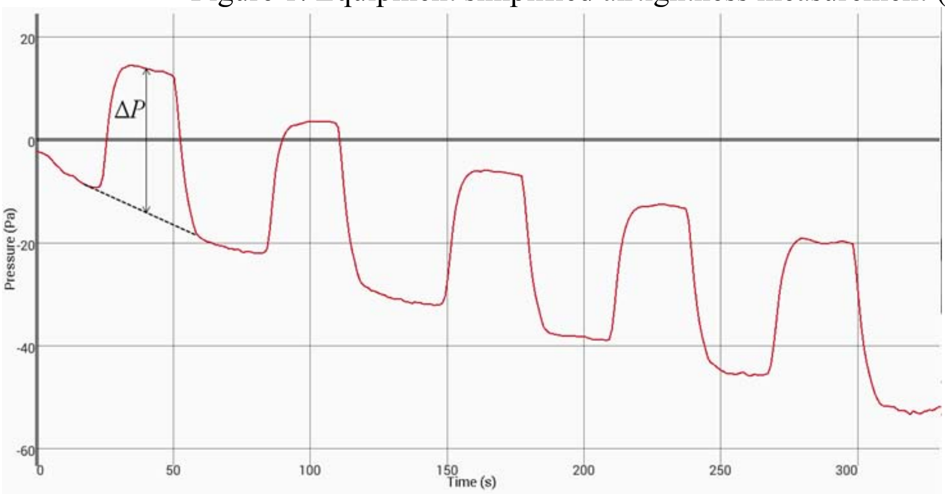

Figure 2: Typical measured pressure difference

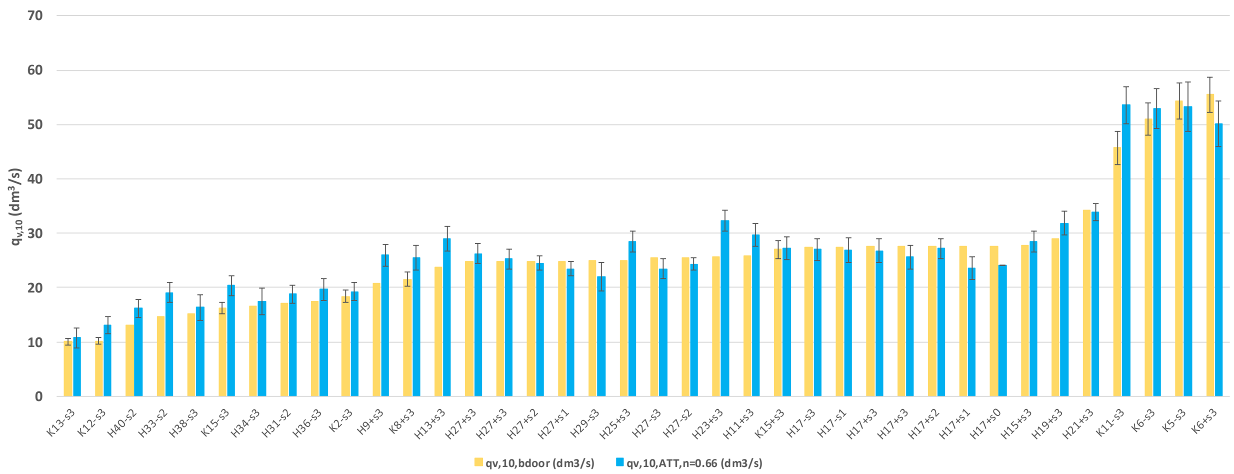

Figure 3: Comparison of blowerdoor measurement ($q_{v,10,bdoor}$) with the simplified airtightness measurement ($q_{v,10,ATT}$)

3.3 Simplified air flow measurement

At first, the possibilities for the development of a simplified version of a pressure compensating airflow meter were investigated. However it was hard to improve on the existing instruments against a lower price while maintaining the same accuracy and measuring range. The next option was to find an alternative method by relaxing the level of accuracy and decreasing the measuring range. The main challenge was to design an airflow meter which can handle supply flows. Especially an inducing supply valve with a covered sector can cause inaccuracies due to turbulence and a variable velocity field. The pressure compensating instruments have a high resistance and, while compensating this resistance, they also 'destroy' the unwanted turbulence and smooth the velocity field. At lower airflows, from standard grids, pressure compensation is less important but smoothing the velocity field is important. It was found that an existing passive propeller airflow meter could be improved using a flow hood with a special flow straightener to do just this. The design of the hood and the flow straightener are optimized to limit the pressure drop and to obtain a correct measurement of the airflow. Supply and extract flows can be measured up to 100 m^3/h with a maximum deviation of about 10% for most occurring ventilation grids (see figure 5) .

Figure 4: Passive flowmeter (prototype)

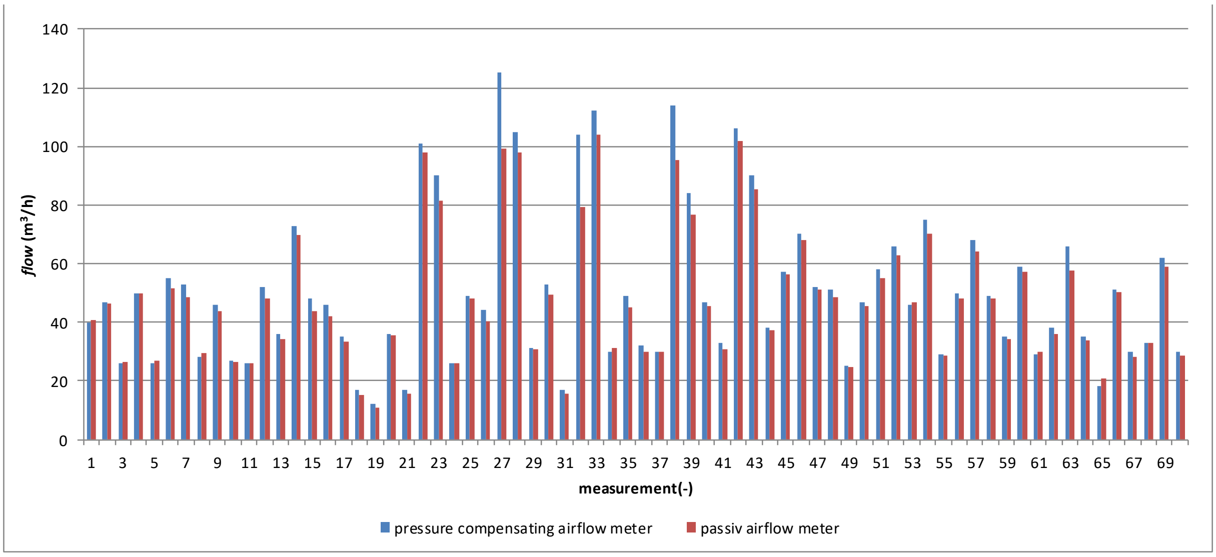

Figure 5: Comparison pressure compensating and passiv airflow meter

3.4 Simplified noise measurement of ventilation systems

The noise production of a ventilation system in a room can be considered to depend upon the following aspects:

a) the pressure drop over the ventilation ducts,
b) the noise level nearby the ventilation unit,
c) the electrical power consumption by the ventilator
d) the number of bends, reducers, tees, flexible hoses and so on in a duct system.

A simplified approach to verify the possibility for too high noise levels can be done by measurement of the above-mentioned aspects a) to c) and perform a visual inspection of the duct system. In this way actual noise measurements don't have to be performed (such measurements can be difficult, due to background noise and require dedicated instruments). The pressure drop over the ventilation ducts can sometimes be read from the ventilation unit display, depending on the type of ventilation unit, or can be measured with either a pitot tube or the installation of a hose through the outer layer of a flexible hose. The noise level close to the ventilation unit can be measured with a class 2 sound level meter, while the electrical power can be measured with any appropriate power meter. For the visual inspection, a checklist has been made with, among other things, the permissible length of the dampers, installation space of the ventilation unit (in a separate room / acoustic cupboard / cupboard / outside), number of bends, etc.
This simplified method has been investigated by actual measurements, together with noise measurements according to standards. In this case the BRL 8010 (method 1) (KvINL 2012) and NEN 5077 are applied. The investigation showed that only in a very limited number of cases the noise level met the requirements, i.e. 30 dBA in living and sleeping rooms. This immediately indicates the seriousness of the noise problems. It also turned out that in the houses in which the noise did meet the requirements, the simplified approach could score poorly (indicating risk of noise problems). The other way around also occurred, because some houses that did not comply with the noise limit, scored well according to the simplified approach. In order to be able to better assess the simplified approach, more measurements still are needed in dwellings in which the noise complies with the limit.
The best alternative to the simplified approach is considered to be method 1 according to the BRL 8010. According to this method the noise measurements should be carried out in the critical reception areas, such as living room and master bedroom. With this method, reverberation is not measured but determined according to tables. This method corresponds

well with NEN 5077, where the actual reverberation time is measured. This is shown in figure 6.

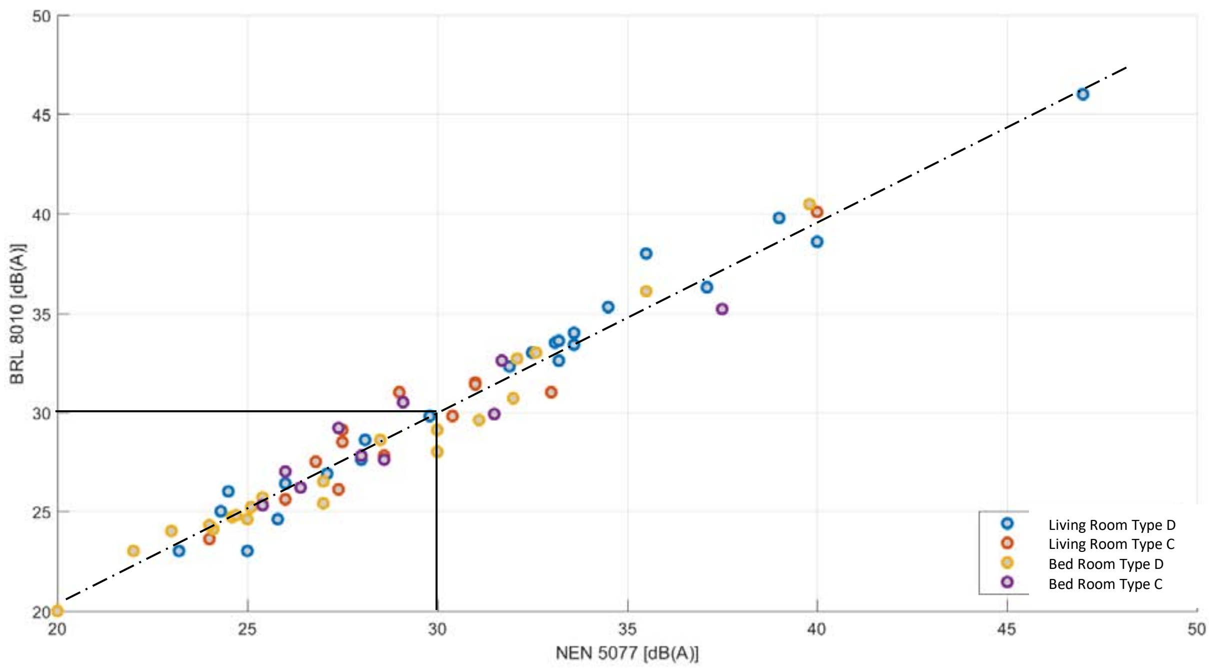

Figure 6: Comparison simplified measurement BRL 8010 with the measurement according to Dutch Standard NEN 5077

3.5 Training of ventilation installation fitter

Energy performance contracts such as the energy performance fee will impose additional requirements on the knowledge and experience of installation fitters and contractors. They will need to be better able to measure the performance of the systems they deliver during construction and delivery as well as in the use phase

In the European Newcom project, European training programs are being set up for fitters of ventilation systems for highly energy-efficient homes. The use of the simplified measurement methods described above is part of this. Input for the training program has been written. The first training courses will soon be set up and will be evaluated in 2020.

4 CONCLUSIONS

There are various initiatives for a label and energy performance contracts for highly energy-efficient homes. Under this label and energy performance contracts, thousands of homes are now being built in the Netherlands. The future will show whether this will actually lead to better performance.

An open source API for monitoring makes it easier to perform analyses on data from homes of energy and indoor air quality and makes the link to model based data analytics as for example Digital Twins easier. This initiative from the Netherlands may also be interesting for use in other countries.

The simplified measurement methods as described here will soon be available on the market. They will lower the threshold for the measurement of the performance of indoor climate systems by professionals.

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