Rationale and pros and cons of various approaches for setting building airtightness requirements

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ABSTRACT

This paper analyses approaches for setting airtightness requirements whether in voluntary or regulatory schemes. We have classified approaches for upper limits into two major types: default values and minimum requirement. Lessons learnt from existing schemes where minimum requirements have been enforced show that the scheme to justify a given airtightness level is one fundamental ingredient in terms of market impact. In France and in the UK where justifications are based on testing and additional quality measures if performed on samples, a market transformation is clearly underway and building professionals gradually revisit their methods to meet airtightness requirements. This trend does not appear to be nearly as strong in countries that have not given a clear signal to justify airtightness levels claimed.

KEYWORDS

Airtightness, requirements, air leakage test.

INTRODUCTION

With the implementation of the Energy Performance of Buildings Directive (2002) and its recast [1], a number of European countries have introduced airtightness in their energy performance calculation methods [2][3].

The energy impact of envelope airtightness depends on various parameters including climate, building usage, ventilation system type, usage of air conditioning system; however, the general consensus that can be drawn is that this aspect merits attention in low-energy buildings. In parallel, concerns for indoor air quality and building damage have resulted in some cases in specific rules besides standard ventilation requirements.

The approaches to tackle these problems are still young, however, it is possible to analyse the types of requirements and related concerns, as well as the consequences in terms of air leakage testing.

ACCOUNTING FOR BUILDING AIRTIGHTNESS IN REGULATIONS

Origin of approaches

There are a number of bodies that can include encouragements or requirements for lower or upper permeability levels. Regulations imply that the rules apply to all buildings defined within the scope, whereas standards or guidelines apply on a voluntary basis unless referred to in a regulation. For instance, the Effinergie, Minergie-P or Passivhaus labels include minimum airtightness requirements for those who apply for these labels. The US Army Corps of Engineers has minimum airtightness requirements for all new and renovated US army buildings. On the other hand, the regulations in the UK (since 2002) and France (since 2012) include minimum requirements for selected buildings. The origin of the approach is important because it has implications on social acceptance as well as on the number of buildings concerned.

Purpose

Building regulations or other technical specifications (standards, guidelines, etc.) may take into account airtightness to answer two major concerns:

- A limitation of envelope leakage is desirable because of the energy impacts. This position is often further backed up with indoor air quality and building damage issues that can be due to poor airtightness. Implicitly, this approach calls for ensuring proper ventilation airflow rates. The underlying philosophy may be condensed by the mantra "*build tight, ventilate right*".

- The benefits for *very low* leakage levels may be small or even counter-productive in terms of indoor air quality and cost. This position mostly stems from problems when dealing with renovated building with no ventilation system (whether natural, hybrid or mechanical) or from insufficient air supplied to unvented combustion appliances inside the conditioned space. This concern may be summarized by "*how tight is too tight*".

These two aspects are treated separately herebelow.

Upper permeability level

The objective is to encourage building professionals to build airtight. For this, we can identify two main approaches:
- Approach 1: Define a default airtightness value (i.e., which can be used in the calculation without testing) but give a credit to better airtightness if proven;
- Approach 2: Impose a minimum requirement, i.e., a maximum level of acceptable leakage for the building envelope. This approach may or may *not* be linked to mandatory testing.

Lower permeability level - Provisions for air renewal (beyond standard ventilation requirements)

The objective is to avoid indoor air quality problems due to a combination of airtightness and inadequate air renewal provisions. The specifications or recommendations are generally expressed in terms of a minimum air leakage level for specific systems. For instance, in the Netherlands, NEN 2687 requires $n_{50} \geq 2\ h^{-1}$ for buildings with mechanical ventilation systems with natural supply. A similar concept has been developed in the USA with the Building Tightness Limit (BTL), which is a tightness limit that determines when a mechanical ventilation system is necessary.

CONCERNS FOR COMBUSTION APPLIANCES, RENOVATION, SYSTEM FAULTS

Typical examples of concerns that have lead to setting lower permeability levels include:

- tightening of existing buildings that relied on leakage for air renewal prior to retrofitting or without prior treatment of liquid water penetrations (e.g., by capillarity);
- provisions for air supply for unvented combustion appliances inside the conditioned space;
- provisions for air renewal in case of ventilation system fault.

While these concerns are obviously legitimate, it is not clear to the authors that recommending a lower airtightness limit addresses correctly the issues raised. Of course, besides the energy penalty, one question remains whether infiltration can provide the necessary airflows both in terms of quantity and quality. Several shortcomings can be mentioned:

- It is very difficult (if not impossible) to target a minimum leakage level. This is often caricatured with the expression “make it just bad enough”, which is challenging to implement in reality both in terms of technology and management;
- Although the overall renewal may be sufficient, rooms may be short-circuited, yielding IAQ problems locally.

With regard to the unvented combustion appliances, an alternative has been developed in France with a minimum opening size to provide air to the appliance. The reader may argue that it is the same as requiring a minimum leakage level, but the fact that it is an identified opening makes a fundamental difference. Namely, it overcomes the two shortcomings mentioned in the previous paragraph. Still, one major drawback of this method remains that users may be tempted to seal the opening. Maybe the only satisfactory solution is to gradually phase out these types of appliances.

MARKET IMPACTS OF COMPLIANCE JUSTIFICATION IN THE UK AND IN FRANCE

The relevance of one scheme versus another can be discussed at length based on intuition and concrete examples, however it is useful to recall some facts for decision-making. It is a fact that the airtightness market has drastically changed in the UK since mandatory testing has been introduced gradually starting in 2002.

The market is also clearly changing in France since the introduction of mandatory requirements for residences in the popular BBC-Effinergie label (as of 2012, over 22 000 dwellings certified, requests for over 250 000 dwellings in process, see www.observatoirebbc.org). Note that there was already a significant bonus for better airtightness in the 2000 and 2005 regulations, but alone, it had not been sufficient to induce a major change in the market.

Credits for state-approved quality management schemes [4], namely to allow the use of a better value than the default value without systematic testing has also been a significant push as soon as some pioneers engaged in the scheme.

In any event, the common underlying message in these successful approaches in terms of market transformation is:

Check the building performance on site!

A building performance should not be assessed uniquely through calculations on paper, but also through checks. Air tightness testing, whether systematic or on a sample, is a first step in this overall philosophy.

IMPLICATIONS FOR AIR LEAKAGE TESTING

Training of testers

The testing philosophy implies that the tests are reliable. However, anyone who has performed a leakage test will confirm that finding out which openings should be sealed or closed during a pressurisation test or how to interpret measurement data is not a trivial task. Performing such measurements require some background on the EP regulation and HVAC systems, as well as experience with data analyses and field constraints.

To our knowledge, in Europe, such schemes are operational only in the UK (www.bindt.org), in Germany (www.flib.eu/certifications.html), in Finland (www.rateko.fi) and in France (www.qualibat.fr). Note that Japan has developed a successful certification framework since the early 1990s: in 2011, over 3 000 testers were registered.

The qualification procedure may imply an examination of several test reports produced by the candidate and examination in real testing conditions. It may be reduced to certain building or ventilation system types that require less experience and knowledge.

The testing philosophy also implies that there are enough trained testers to perform the tests. Based on 100 as a rough estimate of the average number of tests performed per year per tester, 1 000 trained testers would be necessary to perform 100 000 tests per year. In the French context, the objective is to have in turn 3 000 qualified testers; as of March 2012, over 320 testers have been qualified.

Intermediate voluntary site controls

It is well-known that it is very risky to wait until the end of the construction to find out if airtightness has been correctly dealt with. In fact, once finished, it is usually much more difficult to correct defects than during the construction phase. For this, it is advised to perform envelope pressurisation tests during the construction to seal what can be sealed. This practice becomes fairly common for envelope airtightness for building professionals aiming at low-energy targets. Also, experience shows that such tests are very instructional for designers and workers as they better realize the weak points and ways for improvements in their contribution. Such tests can be encouraged for instance through pilot projects supported at national or regional level.

Towards quality management approaches

Intermediate and final testing make a first step into quality management. Checking and Acting (corrections applied) will in turn lead professionals to better Plan and Do. To deepen this concept, schemes are operational in Japan (since about 1992) and in France (since 2006 and both for envelope and ductwork in that country starting in 2011) to give credit to approved quality management approaches by introducing the possibility to claim for a better value than the default airtightness value in the EP-calculation, without performing systematically a test. In France, based on third-party testing results, this scheme gives good results. To gain better confidence in this statement, an evaluation (with controls performed by state technicians on houses that benefit from this measure) is underway.

CONCLUSION

We have identified and analysed approaches for setting airtightness requirements whether in voluntary or regulatory schemes. The feedback on existing schemes shows that the framework developed to justify for a given airtightness level is one fundamental ingredient for an effective market transformation. This justification *should* require some testing, whether tests are performed systematically or on samples. This will strongly encourage building professionals to gradually revisit their methods to meet airtightness requirements. This approach, since it implies checks and remedial actions, can be seen as a first step in quality management.

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