Quality Management Approach to Improve Buildings Airtightness

Requirements and Verification

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ABSTRACT

In France, starting on January 1st, 2013, a minimum airtightness value for all residential building will be required by the energy performance regulation (RT 2012). It will be compulsory to justify for any new residential building that its airtightness is below 0.6m^3/h.m^2 at 4 Pa (Q_{4Pa_surf}) for single-family houses and 1 m^3/h.m^2 for multi-family buildings.

The new regulation specifies two ways to prove the building airtightness compliance: either a State certified technician measures the building airtightness at commissioning, or the builder implements an approved quality management approach.

Firstly, this paper discusses the requirements for approved quality management approaches. Then, since this process started in 2008, results obtained by companies who implemented this quality management have been analysed.

Secondly, in order to check if the airtightness of constructions built by those companies is in line with expectations, State technicians perform controls. Each company quality management approach is evaluated through measurements and files analysis. This paper describes the process of these controls, and gives a preliminary analysis of the verifications performed.

The key result is that measurements ordered by the builders show significant improvement in envelope airtightness. This trend merits to be confirmed with evaluations by state technicians that are underway, but whose preliminary results already show the relevance of state control namely to avoid competition distortion.

KEYWORDS

Airtightness, Quality management, Control, Thermal regulation

INTRODUCTION

Building airtightness became a key subject in the nineties for low-energy buildings labels such as Passivhaus and Minergie. In the 2000's, airtightness is confirmed as a prerequisite to design low-energy buildings.

The 2005 version of the French energy performance regulation (RT2005) included the possible adoption of an approved quality management approach to justify the airtightness level. However, justifying airtightness treatment was compulsory only for the low-energy building label "BBC-Effinergie" [3].

In the 2012 version of the French energy performance regulation (RT2012), which imposes the low-energy level to all new construction, a minimum requirement for the envelope air tightness of residential buildings is included, with two options to justify its treatment: a) measurement at commissioning or b) adoption of an approved quality management approach.

On January 1st 2013, when the RT2012 will come in force for residential building, the quality management will become a key approach to justify airtightness level.
This paper describes first the requirements to obtain an approved quality management approach. Then, since the first companies were approved in October 2008, the impact of measures taken by those companies on airtightness performance can be analysed and compared to conventional buildings airtightness.
Finally, the paper describes the control process set by State technicians to check on randomly selected buildings the correct application of the quality management and performance.

REQUIREMENTS TO SET AN APPROVED QUALITY MANAGEMENT

Procedure to file a quality approach

The RT2005 introduced the possibility to claim for a lower than the default airtightness value in the EP-calculation, without performing a test, provided that an approved quality management approach would be applied.
This possibility is maintained with the 2012 version with strengthened and clarified requirements, because justification of airtightness level will become compulsory. Every 2005 version approved applicant will have to apply for a new approval in 2012.
A candidate submits an application to a national committee. Each application is evaluated by two independents experts who either approve the applicant, or request additional documents, or else reject the applicant.
Every year the approved applicant must provide a yearly report of its quality approach. The yearly report includes measurements on a sample (at least 5% of the production) and the last version of every quality documents.

Key elements of the quality approach

The quality application includes basic requirements for quality management approach, measurements on sample and training documents on airtightness.
The quality management basic requirements to be approved are:[1]

- Identification of “who-does-what” and when;
- Trace of each step of the approach;
- Proof of the approach effectiveness based on sample measurements;
- Proposal of a scheme to ensure that the approach will remain effective with time, based on measurements on a sample.

The process should also include training and education of all craftsmen on site. This requirement should lead to a better airtightness knowledge dissemination in the building community including awareness raising and treatment of air-leakage.
In addition, the RT 2012 application version will request to provide not only measurement to prove the effectiveness but also all documents linked with the quality approach for several randomly selected buildings.

ANALYSIS OF RESULTS OBTAINED BY APPROVED COMPANIES

Analysis’ procedure

As of September 2011, the committee set by the Ministry has approved twenty RT2005 quality management approaches, 2 are in process and 2 were rejected.
The first appliance for RT2012 is already in process.

Table 1 summarizes all approved applicants with their approval date, the number of buildings produced each year and the average $Q_{4Pasurf}$ measure in the last yearly report (5% of the production).
As we can see on the table the first builders were approved by the end of 2008, which means that they have experience with the quality approach for more than 2 years.

	Approval date	Type of applicant	Estimated production for the coming year	$Q_{4Pasurf}$ ($m^3/h.m^2$) average in the 2010 production
1	20/10/08	Builder	98	0.36
2	25/11/08	Builder	48	0.57
3	25/11/08	Builder	405	0.50
4	24/4/09	Builder	Not Available	0.53
5	26/10/09	Manufacturer	13	0.27
6	24/4/09	Builder	89	0.40
7	5/8/09	Builder	291	0.37
8	5/8/09	Builder	83	0.46
9	30/11/10	Builder	Not Available	Not Available
10	2/4/10	Builder	127	Not Available
11	30/6/10	Builder	89	Not Available
12	2/4/10	Builder	184	Not Available
13	2/4/10	Builder	508	Not Available
14	31/8/10	Builder	110	Not Available
15	27/9/10	Builder	Not Available	Not Available
16	5/11/10	Builder	Not Available	Not Available
17	6/9/10	Builder	Not Available	Not Available
18	25/11/10	Builder	Not Available	Not Available
19	2/2/11	Builder	Not Available	Not Available
20	30/6/11	Builder	Not Available	Not Available

Table 1: Approved applicants and production

Besides, those results can be compared with almost 2000 other measurements. Indeed in France a quality framework has been set for airtightness measurement [1] which includes the annual recovering of all measurements done by each authorized measurer.

Obtained results

Figure 1 compares results obtained on buildings made with (8 applicants) and without quality approach. It shows the effectiveness of the quality approach as 100% are under 0.8 $m^3/h.m^2$ when it is only represent 81% of other buildings. In 2005, the requirement for the quality approach was to build single-family houses with $Q_{4Pasurf} \leq 0.8$ $m^3/h.m^2$; in 2012 the threshold will be lowered to 0.6 $m^3/h.m^2$.
The 1792 measurements referred to in Figure 1 were extracted from the measurement databases of "technicians authorized to perform pressurization tests" in low-energy (BBC-Effinergie certified) buildings. In fact, the authorization process described by Carrié et al (2010) [1] requires for each authorized tester to send an annual report that includes all of his air leakage measurements results. Therefore, the sample is heavily biased towards low-energy buildings: 47% of the buildings tested were involved in a BBC-Effinergie certification process, whereas this certification has a market share of only 7% of all new constructions. As a result, the distribution "without approved QM approach" represented in Figure 1 is certainly quite optimistic.

If in the two samples the average is not so different (0.42 $m^3/h.m^2$ with quality approach, 0.48 $m^3/h.m^2$ without), the standard deviation goes from 1.17 without quality approach to 0.15 with quality approach. The most efficient applicant who obtain an average of 0.27 $m^3/h.m^2$ even have a standard deviation of only 0.09, cf. Table 1.

Results with the quality approach consistently show values well bellow the required limits, but the main interest of the quality approach is the reliability of results with very low standard deviation.

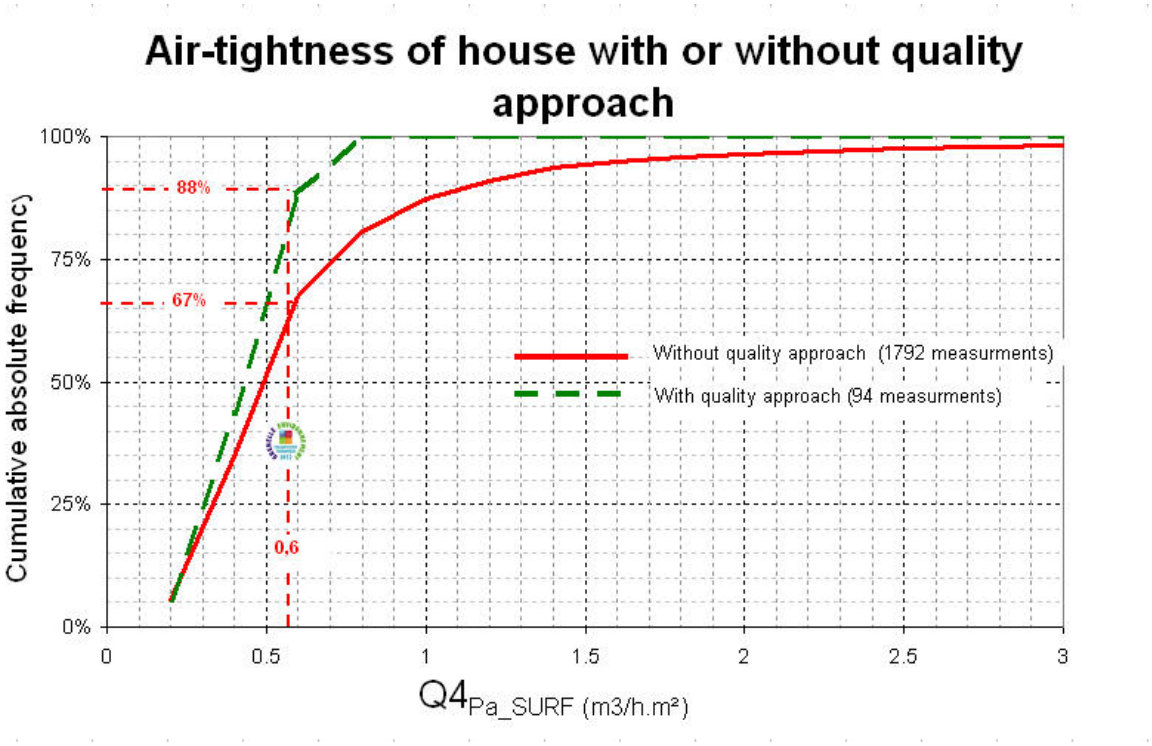

Figure 1: Distribution of measured airtightness of houses a) with implementation of an approved QM approach (dotted in green) and b) without approved QM approach (solid, in red)

Besides, based on discussions with applicants, they seem really satisfied with the benefits of the implementation of quality management approaches for various reasons. First, although it is expensive to start, it gives a positive image to the customer. Second, it requires measurement on a limited sample (typically 10% of the yearly production). Third, some mention that it has an impact on the overall building quality, which implies significant savings on customer service.

These convincing results obtained by several companies, lead to a growing confidence of the QM approach although this framework needs a careful independent evaluation.

CONTROLS CARRIED OUT BY STATE TECHNICIANS

The underlying philosophy of the quality approach was that it was better to think airtightness from the beginning than to cure at the end till obtaining the required value. The other interest was to disseminate good practice.

The results presented above are based on measurement usually performed by “authorized measurers” in ISO 9001 bodies. In the RT2005 version the measurers are not necessarily independent of the contractor, which does not guarantee for example that buildings are randomly selected.

However, because it gives significant benefits to the applicants without independent control, this QM approach was quite controversial and therefore needed an independent evaluation to

ensure its credibility. (Note that RT 2012 will require independence between the builder and the tester but state control may still remain necessary to avoid biased quality control.)

Procedure

The committee has validated the process of those controls.

Every year a state technician carries the process. He contacts every applicant approved for more than a year and asks for the list of all constructions whose delivery is expected in the coming year. The list should include the estimated date of commissioning, address, name and phone number of the future inhabitant as well as of the construction superintendent. At the end of the year, the committee checks the consistency of the list when the applicant sends his yearly report.

If not cooperative, the applicant is warned that his agreement may be suspended.

The percentage of control depends on the number of buildings and the availability of state technicians all over France. The first set of controls will cover 5% of the buildings, Table 2.

Most applicants will be controlled by different state units as they build in various locations, the distribution of controls is automatically determined by an Excel solver.

	Approval date	Type of applicant	Estimated production for the coming year	Number of building controlled by state technicians in 2011
1	20/10/08	Builder	98	5
2	25/11/08	Builder	48	2
3	25/11/08	Builder	405	20
5	26/10/09	Manufacturer	13	1
6	24/4/09	Builder	89	4
7	5/8/09	Builder	291	14
8	5/8/09	Builder	83	4
10	2/4/10	Builder	127	6
11	30/6/10	Builder	89	4
12	2/4/10	Builder	184	9
13	2/4/10	Builder	508	25
14	31/8/10	Builder	110	5

Table 2: Number of building controlled

The control consists in two different parts. First of all 5% of the production of each applicant is randomly chosen and measured at commissioning by trained and certified state technicians.

Secondly, the application of the quality management approach is checked while asking the following element for 2% of the building production:

- A brief description including at least: the kind of construction (masonry, brick, wood, etc.), the type of insulation (inside, outside, spread), the number of level and kind of floor (wood, concrete...)
- The list of companies working on the site
- The contract or subcontract signed by all companies working on the site (which should include an airtightness statement)
- Craftsmen's certificate of training
- Site supervision documents (each step of the quality approach)
- Actions in case of non-compliance (corrective treatment, reports of treatment meetings...)
- Report if a measure was carried out during construction

The documents will be requested just twice. If the applicant is unable to produce them within two months, the building is considered non-compliant with the quality management approach.

First results – 4 houses

Measurements began in June 2011 and the checking of the quality management approach will begin in September 2011. As of September 2011, four houses of two different applicants have been measured.

For the first applicant, results are in line with our expectations ($Q_{4Pasurf}$= 0.47 and 0.57 $m^3/h.m^2$).

But for the second applicant one result was much less satisfactory with $Q_{4Pasurf}$ = 1.26 and 0.51 $m^3/h.m^2$. In fact, this applicant is accustomed to deliver unfinished home, according to the future occupant wills. In the first building the screed layer was not cast and sanitary equipments weres not installed. It is likely that when the house will be finished airtightness will much improve, but as far as the applicant is supposed to deliver houses respecting $Q_{4Pasurf}<0.8m^3/h.m^2$, works made by the occupants should not be necessary to comply with the requirement. Therefore, this is considered as an non-compliance with requirements.

CONCLUSION

Airtight construction generalisation is a challenge, however, it is compulsory to address this issue given the objective to generalize near-zero energy buildings in 2020. The definition of quality frameworks for airtight envelopes achievement is one of the proposed solutions in the French regulation. Interesting lessons arose from the preliminary evaluation of this framework, whose first applicant was approved in November 2008. The wide scope of applicants, from small builder to large ones or manufacturers, is quite encouraging, especially in view of RT2012, so are the results presented in the yearly reports. No doubt that it will lead to a better dissemination of airtightness knowledge.

Nevertheless, given the first state-control results, it is clear that external checking has to be implemented in order to ensure the credibility of the approach and to value those who best meet requirements.

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