A round-robin test of Czech airtightness test providers

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ABSTRACT

The round-robin test of Czech airtightness providers was organised in order to obtain information about the measurement equipment generally used and in order to compare the test results given by different technicians operating with different devices. All the participants measured the same building under very similar conditions. The preparation of the building before the measurement and the calculation of the building reference values were done by the organisers. All the test results were evaluated according to EN 13829. The test results were expressed in terms of average n_{50} value of the pressurization and depressurization test. Following data were collected as well: C_{env}, C_L, n, V_{50}. 23 technicians participated with 14 measuring devices of 4 different types. In total, 16 particular tests were performed. The test results and ongoing simple analyses indicate that the participants provide comparable test results expressed in terms of n_{50} and V_{50} values. The test results seem to be independent of the type of measuring device. However, a systematically different course of the air leakage function was observed in case of one type of measuring device. Furthermore, it seems that the experience and skills of a technician might have a certain influence on the test result.

KEYWORDS
blower-door, round-robin tests, measurement accuracy

PURPOSE OF THE WORK

During last years the number of airtightness test providers has been growing in the Czech Republic. Concerns arise about the quality of their practice and test results that might not always be comparable. Since any official certification of the airtightness test providers is neither requested nor provided by the authorities, the quality control of the measuring practice is becoming an important issue.

As the first step to deal with this issue, the recently founded association of Czech airtightness test providers organised a round-robin test of technicians performing airtightness tests and their equipment. The round-robin test had following major goals:

- investigation on the types of measuring devices used in the Czech Republic

- comparison of the test results given by different devices operated by different technicians and comparison of the “modus operandi” of different technicians – in order to identify possible imperfections (defects, calibration errors, etc.) of the equipment or rough mistakes of the technicians

Besides the quality control, the round-robin test results could also provide information about the accuracy of airtightness measurement.

METHOD

The participants measured the same building under very similar conditions. The results of particular tests performed by different participants were collected and analysed. The major goal of the analysis was not finding the “true” airtightness of the measured building but identification of the differences between particular test results and, if possible, identification of their sources. The influence of building preparation and errors in the calculation of the building reference values were not the subject of this investigation.

The results of particular tests were expressed in terms of average n_{50} value of the pressurisation and depressurisation test. Following data of both pressurisation and depressurisation test were collected as well: air flow and air leakage coefficients C_{env} and C_L, air flow exponent n, air flow rate at 50 Pa, $\dot{V}_{50}$. The test procedure and the evaluation of test results had to follow the EN 13829.

The round-robin test was performed during two days in June 2010. The measured building was a single family house. The preparation of the building before the measurement was made by the organisers and it was not changed during the round-robin test (the preparation corresponded neither to the method A nor to the method B according to EN 13829). The temperature and the wind conditions remained approximately constant during the event (the difference between the internal and external temperature varied from about 6 to 12 °C, the wind force varied from about 1 to 2 degrees of the Beaufort scale). The participants were asked to perform both pressurisation and depressurisation test and evaluate the results according to the EN 13829. The reference values of the tested building (in particular the internal volume) were calculated by the organisers (table 1). Hence, all the participants calculated the n_{50} value from the same internal volume V and a particular air flow rate $\dot{V}_{50}$ which was the result of the particular test that they performed.

Table 1: The reference values of the tested building (calculated by the organisers according to EN 13829).

Internal volume	V	[m^3]	326
Envelope area	A_E	[m^2]	293
Net floor area	A_F	[m^2]	136

RESULTS

In total, 23 technicians from 14 companies participated in the round-robin test with 14 measuring devices. Due to a limited time schedule, it was not possible to assure that each participant performs his own test. Therefore, only 16 particular tests were performed. Each of the 14 measuring devices performed at least 1 test, in case of 2 measuring devices, the test was repeated. Sometimes, the technicians worked in pairs (colleagues from the same company, with the same practical experience).

Measuring Devices

Among the measuring devices, 4 different types were distinguished. All of them are blower doors with a fan, impermeable textile panel and an adjustable mounting frame. They differ from each other namely in the performance (table 2) and in the principle of the air flow rate measurement. In case of type 2 the air flow rate through the fan is calculated from the frequency of fan rotation. All the other types use the pressure difference across calibrated orifice plates to quantify the air flow rate.

Table 2: The numbers and basic parameters of different types of measuring devices used by the participants of the round-robin test. Number of fans is the number of fans available for one measuring device. V_{min} and V_{max} are the minimum and maximum air flow rates generated by the fans of one measuring device.

Type	Manufacturer	Model	Number of devices	Number of fans	V_{min} [m^3/h]	V_{max} [m^3/h]
1	Energy Conservatory	Minneapolis Blower Door Model 4	7	1	20	7 200
2	LTM	Blowtest 3000	4	1	250	2 500
3	Retrotec	Model Q46	1	1	8	9 514
4	Infiltec	Infiltec E3	2	1 - 3	71	9 265 – 27 795
Total:			14			

All types of measuring devices are equipped with digital pressure gauges. All types are equipped with a special software (supplied as an accessory to the measuring device) allowing an automated evaluation of measured data and calculation of test results according to EN 13829. All these software were supposed to be compatible with EN 13829, although some slight differences of the test evaluation procedures were observed among different types of measuring devices (e.g. in the measurement of zero-flow pressure differences). Except for the type 4 the software allow also pre-programming and automated control of the test which could reduce the risk of operator’s error and can theoretically improve the measurement accuracy.

Participants and their Experience

In order to estimate the professional competence of participants, information about the length of their measuring practice and the number of tests that they had performed was collected. The length (duration) of the measuring practice varies from several months to 10 years (mostly up to 2 years). The number of tests performed varies from 3 to about 350 (mostly up to 15 tests). According to this information, substantial differences in the practical experience seem to exist among the participants. The observations during the round-robin test broadly proved this presumption.

In order to investigate the impact of practical experience on the test results, an indicator of practical experience (called simply “experience” hereafter) was calculated from the length of the practice and the number of tests performed. It is a dimensionless, relative quantity which can theoretically vary from 0 (no experience) to 1 (“maximal” experience – e.g. a hypothetical technician with 10 years of practice and 350 measurements performed). In the calculation, the number of tests performed was supposed to contribute more to the technician’s experience than the length of his practice. Obviously, the majority of participants have a low experience (figure 1).

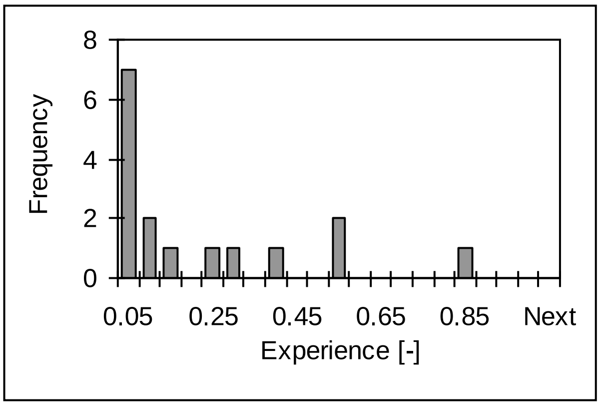

Figure 1: The experience of the round-robin test participants

Results of the Round-robin Test

In this section the results of particular tests are presented and commented. The results of depressurisation and pressurisation tests are indicated with the subscripts “-“ and “+” respectively. The results calculated as the average of a pressurisation and depressurisation test results (e.g. n_{50}) are indicated with the subscript “+/-“.

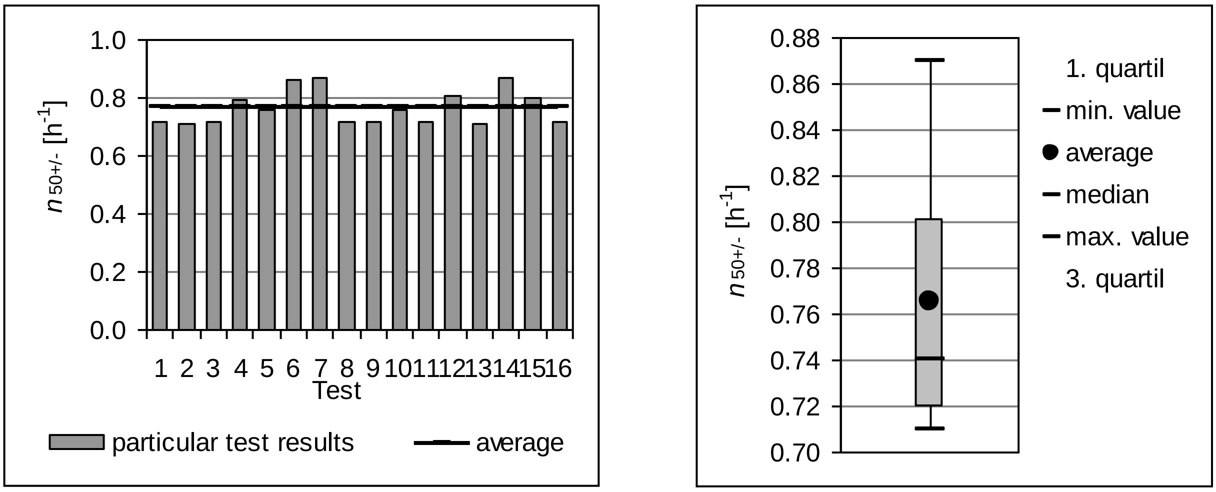

Figure 2: Test results in terms of $n_{50+/-}$

The particular values of $n_{50+/-}$ are spread between 0.71 and 0.87 h^{-1}, the average value is 0.77 h^{-1} (figure 2). No gravely erroneous values of n50+/- were reported. The majority of results are included in a relatively narrow interval from 0.72 to 0.80 h^{-1} (it has approximately the same magnitude as the expected uncertainty calculated for several particular test results by means of measuring device software according to the German proposal to the amendment of the EN 13829, the FLiB Supplement 11/2001 - with the assumption that the uncertainty in the internal volume of the building is 0 %).

Since all the particular $n_{50+/-}$ values were calculated using the same internal volume *V,* the differences between particular n_{50} values only reflect the differences between $\dot{V}_{50}$ values (it is valid for the results of both pressurisation (+) and depressurisation (-) tests and their average (+/-)). Considering the conditions of the round-robin test (building preparation common to all the particular tests, rather constant climatic conditions without apparent fluctuations and automated evaluation of measured data according to the same method), it was supposed that the differences between particular values of $\dot{V}_{50}$ should be namely caused by:

- measurement errors due to the imperfections of measuring devices (errors in the calibration, defects of different components, etc.)
- errors in the measurement procedure committed by the technicians (e.g. wrong fitting of the blower door panel)

Simple analyses of the recorded results were performed in order to identify potential causes of the errors mentioned above and to clarify whether:

- the potential measurement errors due to the imperfections of measuring devices have a character of systematic errors proper to different types of measuring devices or if they are rather a property of individual devices (the dependence of the test results on the type of measuring device was tested)
- the potential errors in the measuring procedure might be influenced by the skills and the quality of the work of the technician performing the test (the dependence of the test results on the experience of the technicians - the estimated “experience” was supposed to be a measure of the technician’s skills, since more experienced technicians were supposed to be less vulnerable to make serious mistakes)

It is difficult to identify more precisely the causes of differences between the particular test results. The reliability of the analyses is limited namely due to the statistically irrelevant numbers of test results available for some types of measuring devices and more experienced technicians and due to the statistical dependence of these parameters (figure 3). Nevertheless, several results merit to be mentioned.

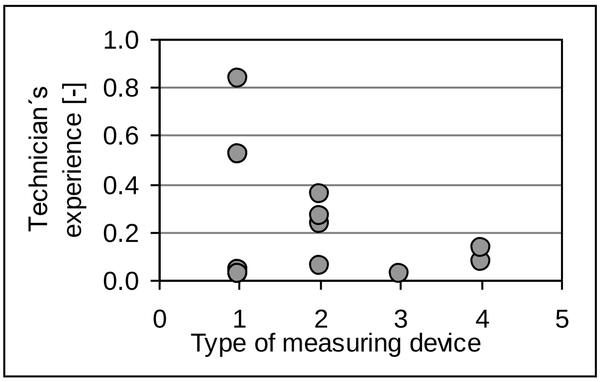

Figure 3 The type of measuring device and the technician’s experience of particular tests

Graphs on the figure 4 show the results of particular tests expressed in terms of $\dot{V}_{50+}$, $\dot{V}_{50-}$ and $\dot{V}_{50+/-}$ values, sorted according to the type of the measuring device. Due to the very limited number of test results obtained with the devices of type 3 and 4 (1 and 2 results respectively), no clear conclusions can be drawn. However, it seems that no clear correlation exists between the measured $\dot{V}_{50}$ values and the type of measuring device.

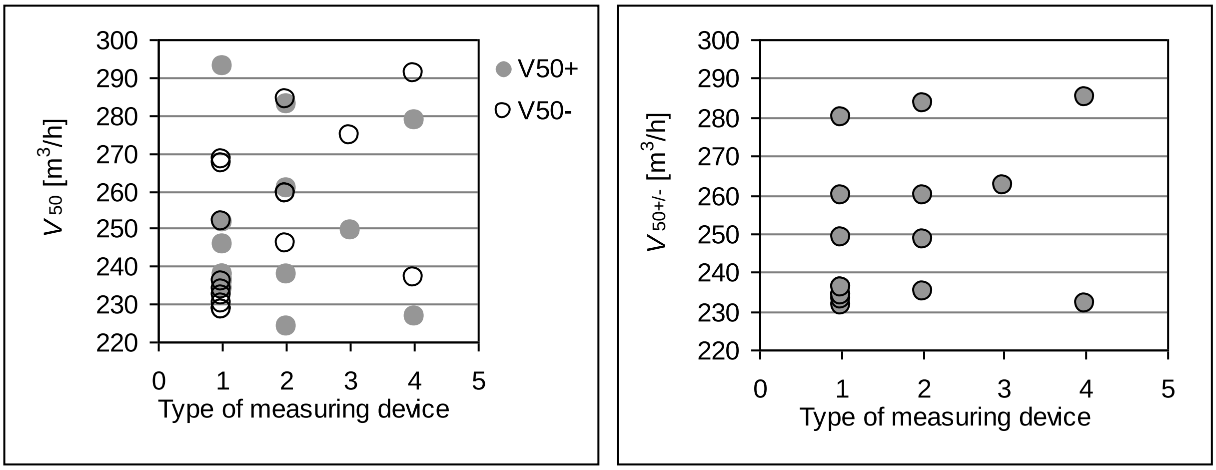

Figure 4: Influence of the type of measuring device on the test result (air flow rate at 50 Pa)

Graph on figure 5 shows the results of particular tests in function of the operating technician’s experience. The $\dot{V}_{50}$ values measured by the technicians with rather lower practical experience are included in a wider range (are more scattered) than the results from more experienced technicians. More experienced technicians seem to measure lower $\dot{V}_{50}$ values. These observations should be interpreted carefully due to a small number of the results measured by more experienced technicians.

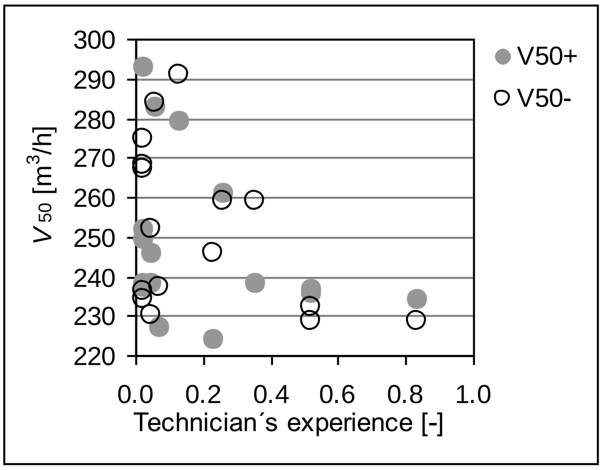

Figure 5 Influence of the technician’s practical experience on the test result

However, another example illustrates that the experience of the technician might have an influence on the test results. The figure 6 shows the overview of particular values of $\dot{V}_{50+/-}$. The results of the tests 1 and 8 were measured by the same, rather experienced technician. The results of the tests 6 and 16 were measured by a pair of technicians with a low practical experience. Whilst both results measured by the experienced technician are very similar (nearly identical), the results measured by the technicians with a low experience differ significantly from each other. The $\dot{V}_{50+/-}$ value of their first test (no. 6) lies far above the majority of other test results. The result of their second test (no. 16) is very close to the results measured by the technicians with the highest experience and it represents one of the lowest values of $\dot{V}_{50+/-}$. Furthermore, the difference between the results of depressurisation and pressurisation ($\dot{V}_{50-}$-$\dot{V}_{50+}$) is exceptionally high in case of the test 6, while it is significantly lower in case of test 16. The difference $\dot{V}_{50-}$-$\dot{V}_{50+}$ of the test no. 16 is very similar to the values achieved in case of tests performed by the most experienced technicians (e.g. tests no. 1, 2, 8).

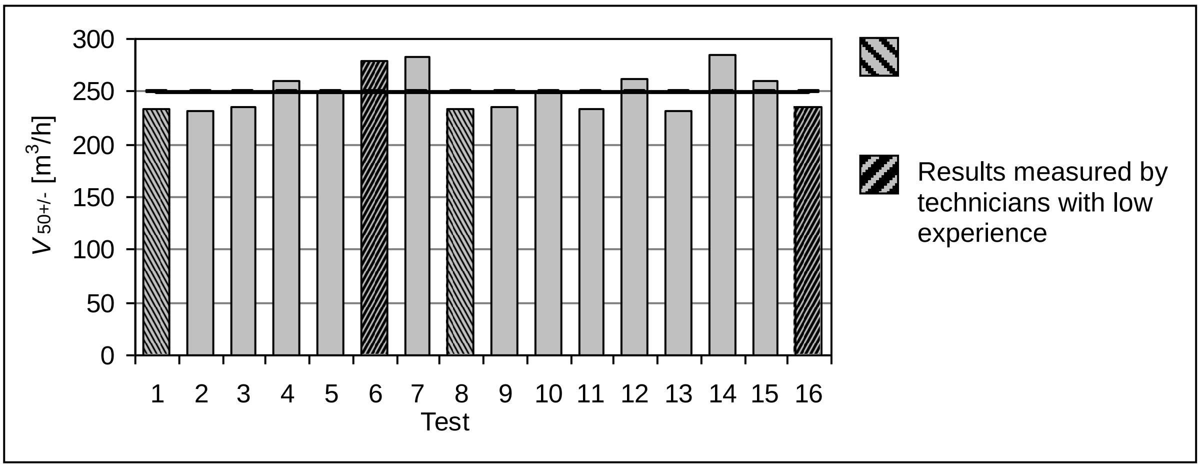

Figure 6 Results of repeated tests measured by technicians with different practical experience (the bold line represents the average of particular test results)

Graph on the figure 7 compares the values of $\dot{V}_{50+}$, and $\dot{V}_{50+/-}$ of particular tests. The differences between the tests are significant. The absolute values of the difference between the results of depressurisation and pressurisation $|\dot{V}_{50-}-\dot{V}_{50+}|$ vary from 3 to 26 m^3/h. However, smaller differences are predominant. Exactly one half of particular tests have a negative difference $\dot{V}_{50-}-\dot{V}_{50+}$, the other half positive. The total of positive differences $\dot{V}_{50-}-\dot{V}_{50+}$ is bigger than the total of the negative ones.

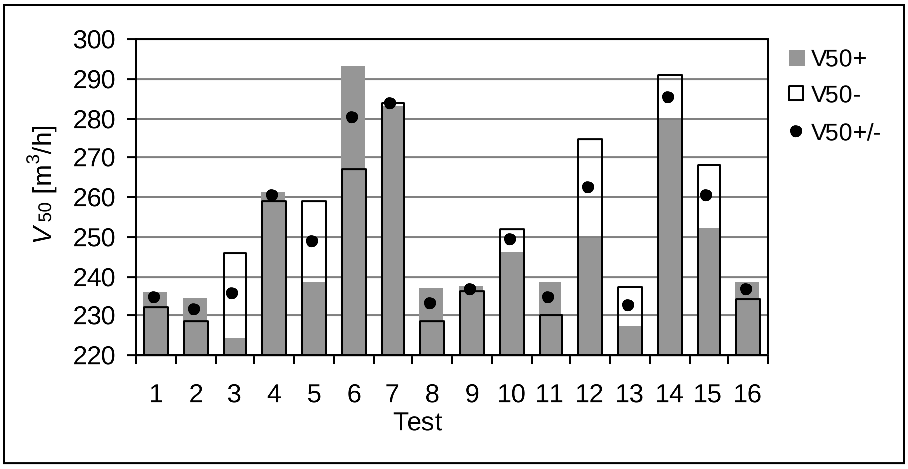

Figure 7 Differences between the results of depressurisation and pressurisation tests

Graph on the figure 8 shows the differences between the results of pressurisation and depressurisation tests in function of the technician's experience. A possible influence of the technician's experience on the difference $\dot{V}_{50-}-\dot{V}_{50+}$ was expected (see above, figure 6 and corresponding comments), however, the results plotted on the graph can not prove it. It seems that the difference $\dot{V}_{50-}-\dot{V}_{50+}$ might be influenced by specific properties of the measuring device in case of the tests performed by means of the measuring devices of type 2 (the reasons are explained below).

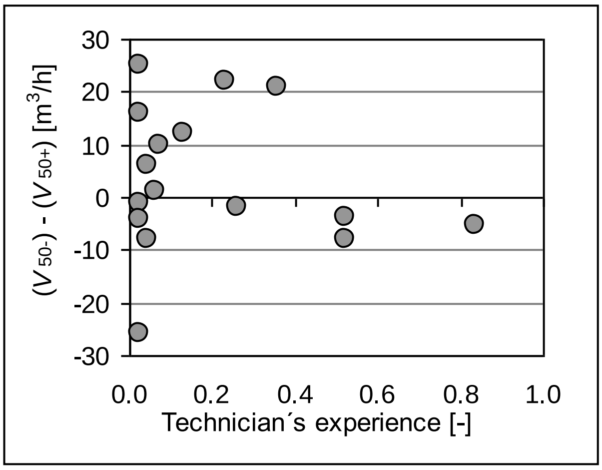

Figure 8 Influence of the technician's practical experience on the difference between the results of depressurisation and pressurisation tests

Figure 9 shows the air leakage graphs of the particular tests. The depressurisation tests performed by means of the measuring device of type 2 have a systematically different course of the air leakage function than the tests performed by means of other types. In case of pressurisation tests, this systematic divergence is not observed.

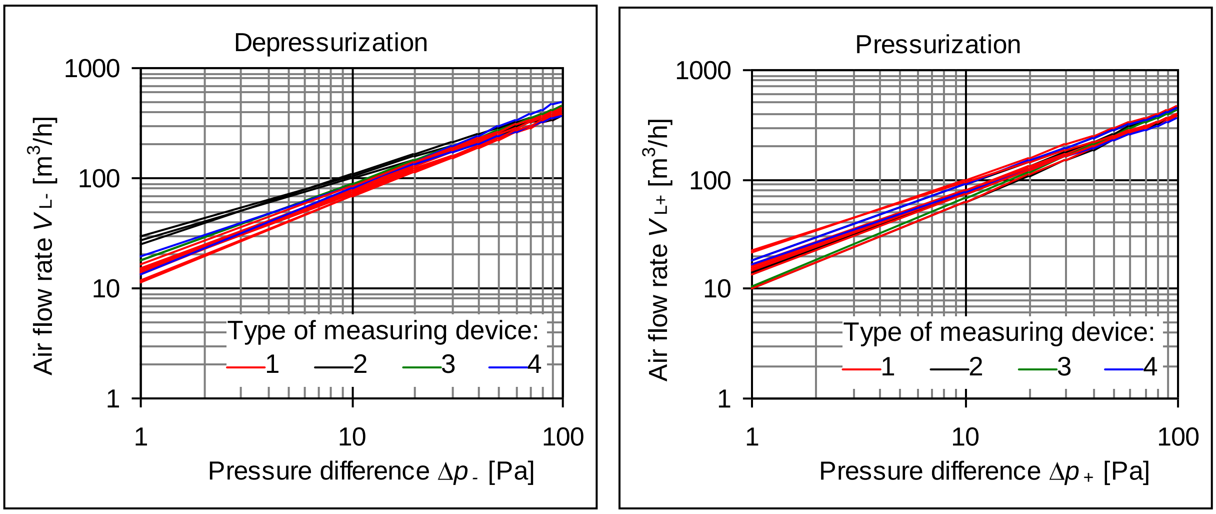

Figure 9 Air leakage graphs of particular test results

The different behaviour of the measuring devices of type 2 appears also from the graphs on figure 10. It should be reminded that the type 2 uses a different principle of the air flow rate measurement than the other types of measuring devices (see section “Measuring Devices”) – the divergence of depressurisation test results given by devices of type 2 might be related to this fact.

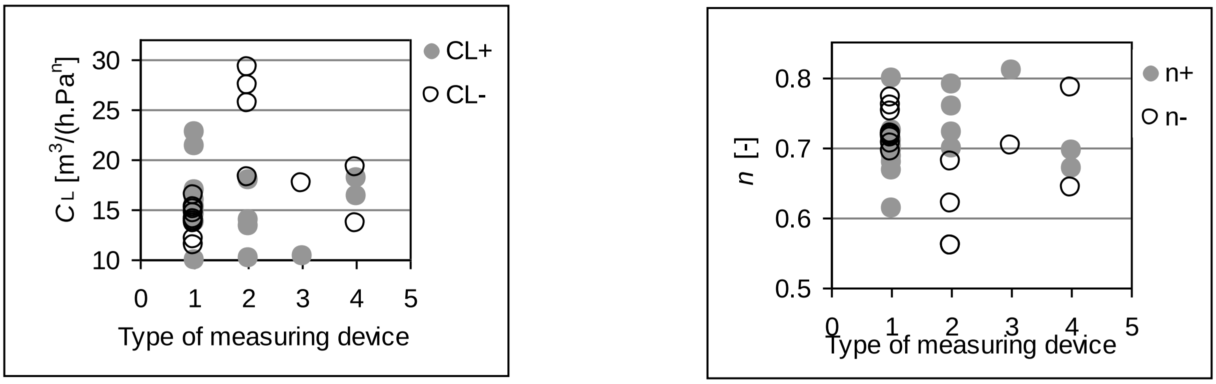

Figure 10 Influence of the type of measuring device on the air flow coefficient and air flow exponent

CONCLUSIONS

The results of the round-robin test indicate, that in similar conditions, the participating airtightness test providers operating with different measuring devices provide comparable test results expressed in terms of n_{50} and $\dot{V}_{50}$ values. Since no significantly erroneous results were reported, it seems that the tested measuring devices probably do not suffer from serious defects and the technicians are not used to proceed with grave mistakes.

The test results expressed in terms of n_{50} and $\dot{V}_{50}$ values seem to be independent of the type of measuring device. However, one type of measuring device probably gives systematically different air flow coefficients and air flow exponents of depressurisation tests than other types (for pressurisation tests, this divergence was not observed). This divergence might be related to the principle of the air flow rate measurement used in this type of device (it is different than the principle used in the other types). The results of simple analyses show that the test results might be more significantly influenced by the practical experience of the technician performing the test (more generally by the skills of the technician and the quality of his work).

In the simple analyses presented in this report it was assumed that the errors due to the fluctuations of climatic conditions are approximately constant and therefore have only a negligible effect on the differences between particular test results (e.g. all the particular tests are subject of a very similar error of this type). The validity of this assumption should be verified. Unfortunately, necessary data about the climatic conditions (namely the wind effects) were not recorded during the round-robin test. This problem could be overcome by recording the necessary data or by performing the tests in laboratory conditions.

The influence of errors associated with the calculation of building reference values and the influence of errors associated with the preparation of the building before the test were not investigated. It is generally expected that these errors might be of a high significance. The studies examining the real magnitude of these errors should complete the round-robin test.

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REFERENCES

EN 13829 Thermal performance of buildings – Determination of air permeability of buildings – Fan pressurisation method