PRESSURE DISTRIBUTION IN LARGE BUILDINGS DURING AIRTIGHTNESS TESTS

Stefanie Rolfsmeier, Paul Simons

BlowerDoor GmbH, Zum Energie- und Umweltzentrum 1, 31832 Springe, Germany
Tel. +49 (0) 5044 / 975-40, Fax +49 (0) 5044 / 975-44, E-Mail: info@BlowerDoor.de

ABSTRACT

When conducting airtightness tests of buildings, you must ensure that all building parts to be measured have air connection, so that the test object can be considered as one single zone. This also applies to large buildings like office buildings, schools, old people homes, indoor pools, etc. with several floors and rambling floor plans. Openings that are too small for a constant air flow from the leakages to the measuring device can prevent an even pressure distribution. According to the European measuring standard EN 13829, the pressure differentials inside the building during the airtightness test should not be less than 10% of the building pressure differential.

This article examines the different issues involved in bringing these theoretical considerations to the measuring practice. Which approaches in measuring technology can help improve knowledge of the actual pressure distribution and, consequently, the interpretation of the measuring results? What do the results look like? Which possibilities are there for conducting measurements even in critical conditions?

When conducting BlowerDoor tests in very tall buildings and/or buildings with very rambling floor plans, additional measuring points are set up in the zones considered critical. The pressure differentials between the BlowerDoor measuring device and these zones are recorded with the help of the TECLOG2 MultipleFan software. They can then be evaluated by the testing team, which can take the appropriate measures (e.g., close open windows, install an additional measuring device in the critical building part).

KEYWORDS

airtightness tests, big building, large building, high rise building; BlowerDoor, pressure distribution, pressure drop, “single-zone buildings”

INTRODUCTION

When conducting airtightness tests of large buildings, even distribution of the pressure generated by the measuring device must be ensured throughout the entire building for the duration of the test. Particularly when testing high-rise buildings and/or buildings with strongly structured floor plans, the room located the farthest from the measuring device should also be tested under the same conditions.

This article presents possibilities for ensuring an even pressure distribution. In addition, two examples – a high-rise building and a building with a rambling floor plan – demonstrate possible pressure distributions within a building.

REQUIREMENTS OF THE EUROPEAN STANDARD EN 13829 ON THE PRESSURE DISTRIBUTION IN THE BUILDING

A basic requirement for conducting airtightness tests according to the European standard EN 13289 is for the building to be considered a “single-zone building”. All rooms and building parts of the test object must have air connection, so that an even pressure distribution is ensured during the test. To accomplish this, all interior doors of the test building or the tested building part are opened. Usually, the size of these openings (open interior doors) is sufficient for constant air flow.

During the measurement, the pressure differential within the building should be less than 10% of the building pressure differential between the inside and the outside.

EXAMINING PRESSURE DISTRIBUTION IN THE BUILDING

To examine the pressure distribution in the building, a building pressure differential of 50 Pascal is established with the BlowerDoor measuring device. There are only two ways to check whether the pressure distribution in the building is even:

1. Measuring the pressure differential at the building envelope in the critical zone
2. Measuring the pressure differentials within the building

Both possibilities will be presented in more detail.

Time for testing the pressure distribution

The right time for checking the pressure distribution in the building is after the test set-up and building preparation, and before leakage detection. This carries the advantage that a leakage detection test of the building envelope can be performed under the same basic conditions.

Testing the pressure differential between the interior and the exterior in “critical” zones

For the analysis, a building pressure differential of 50 Pascal is established with a BlowerDoor measuring device. In the following, the pressure differentials between the inside and the outside of the “critical” zones (e.g. most remote rooms / building parts) are checked. In order to do so, an additional portable pressure gauge is placed in the area to be tested. One connection of the measuring device ends in the zone, while the reference connection ends in the same zone outside of the building. A metal capillary tube with a tube extension can be used to transfer the outside pressure to the inside. It is possible to clamp the capillary tube in a window frame without closing its opening. The resulting pressure differentials are recorded. See Figure 1 for the measuring principle.

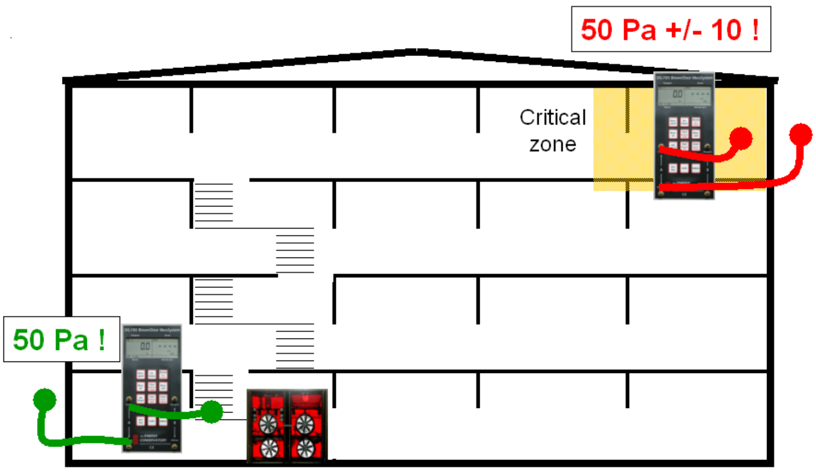

Figure 1. Measuring the pressure distribution at the building envelope

The pressure differential in the tested room must not fall below 50 Pascal minus 10%, i.e. 45 Pascal.

Testing the pressure distribution inside the building

For the analysis, a building pressure differential of 50 Pascal is established with a BlowerDoor measuring device. The pressure differentials within a building are determined by comparing the pressure near the measuring device with the pressure in “critical” zones (e.g. the most remote rooms or building parts). To do this, a long tube is led from the measuring device to the “critical” zone. See Figure 2 for the measuring principle.

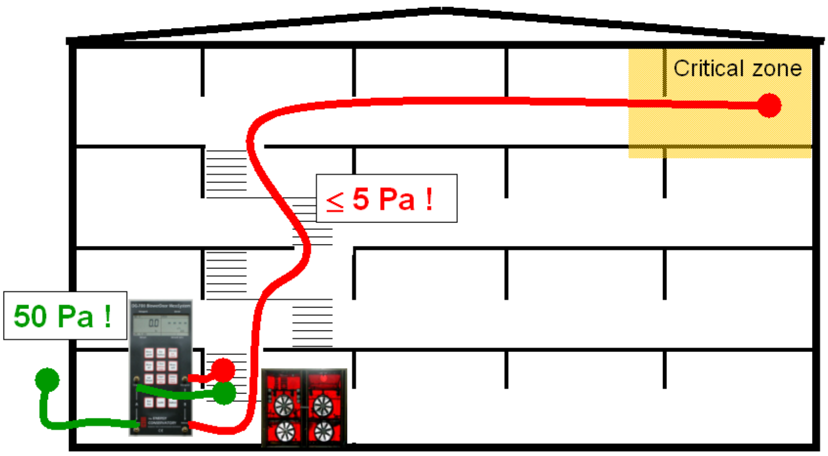

Figure 2. Measuring the pressure distribution within a building

The pressure differential within the tested room must not deviate from the building pressure differential by more than 10%, in this case 10% of 50 Pascal, i.e., a maximum of 5 Pascal.

Baseline pressure differential

Even under natural conditions, thermal forces and wind can generate a pressure differential within the building. If this is the case, the natural pressure distribution inside the building must be measured first and then taken into account when determining the pressure distribution in the building at an artificial pressure stage.

POSSIBLE SOLUTIONS FOR CASES WITH EXCESSIVELY HIGH PRESSURE DIFFERENTIALS IN THE BUILDING

If an excessively high pressure reduction is discovered in one zone when testing the pressure differentials in the building, this is caused by the following: The constant flow opening in this zone is too small or the leakages of this zone are too large for the existing constant flow opening. By setting up one or more additional BlowerDoor measuring devices in the critical zone, the same pressure level is established in all areas (Figure 3).

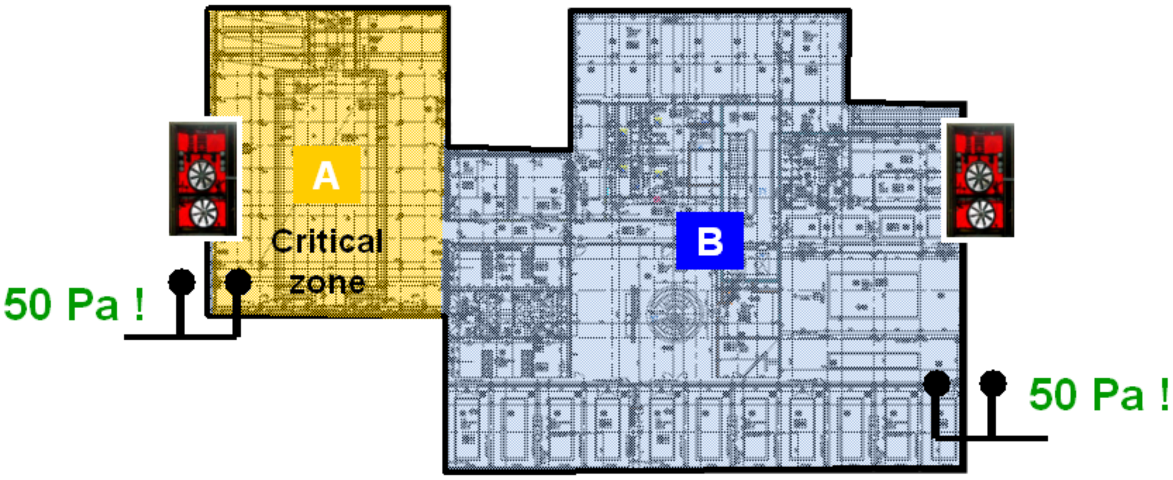

Figure 3. Distribution of measuring devices in the building in order to generate an even pressure distribution

EXAMPLE MEASUREMENTS

Demonstrations using a high-rise building and a building with a highly structured floor plan show this pressure distribution test in action. During the tests, the pressure distributions within the building were checked.

To measure the buildings, several Minneapolis BlowerDoor fans were combined. The fans were centrally controlled via the TECLOG2 MultipleFan program, which also permits the representation and recording of several building pressure differentials and internal pressure levels at once.

Example 1: Measurement of a high-rise building

Test object

In the following example, we tested a high-rise building which, once finished, will have 22 floors. A preliminary measurement of floors five to fourteen with an internal volume of 31,744 m3 was planned to determine the air change rate during construction, and to discover the existence of any severe systematic faults in the building envelope (Figure 4).

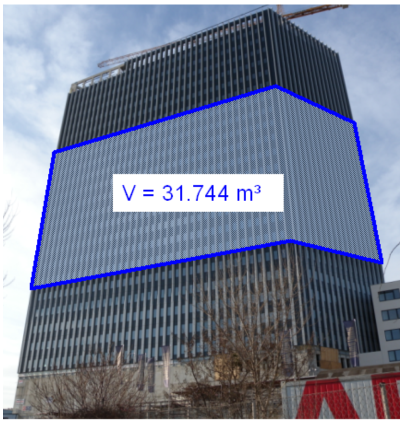

Figure 4. BlowerDoor test in the marked part of this high-rise building

Installing the measuring devices

The measuring system BlowerDoor MultipleFan with 3 fans per door frame was installed in the stairwell of the fifth floor (Figure 5). The installation opening for the measuring devices was built by the client from oriented strand boards and squared timber.

Figure 5. BlowerDoor MultipleFan (3 fans) in the stairwell

Building preparation

The tested building part was carefully separated from the non-tested areas via temporary sealing (stairwell and elevator doors were closed by oriented strand boards, end-to-end utility shafts for piping and cables were sealed, etc.).

Air connection

In order to establish a single "zone", the air connection was ensured via the continuous stairwell and the supply shafts. On each floor, the openings for the yet-to-be-installed interior doors provided the openings for constant air flow.

Basic conditions

The temperature difference between the inside and the outside was minimal. In spite of a storm forecast, the wind during the measurement remained within a tolerable range. The baseline pressure differentials were below the requirements of the European standard EN 13829.

Measuring the pressure differentials

The pressure differentials between the fifth and the fourteenth floor were measured with a highly accurate pressure gauge (DG-700). The gauge was placed near the measuring equipment on the fifth floor. One connection of the measuring channel remained free, while the other was connected to an approximately 40-meter-long tube. This was led to the fourteenth floor via the stairwell and provided the pressure from this floor (similar to Figure 2).

Measuring result

The pressure differential between the fifth and the fourteenth floor at a building pressure differential of 50 Pascal was -0.5 Pascal on average. An excerpt from the measurement program TECLOG2 MultipleFan in Figure 6 shows the result in a chart.

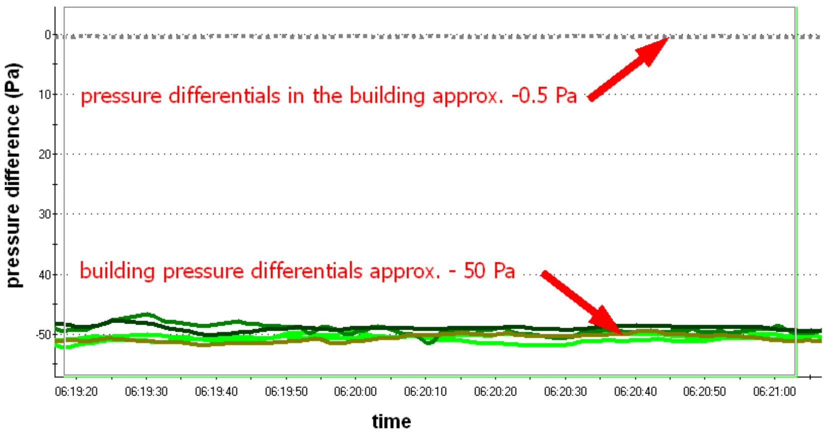

Figure 6. Excerpt from TECLOG2 MultipleFan: Building pressure differential and internal pressure distribution

The chart shows five building pressure differentials of around -50 Pascal (continuous lines), which were measured at the four different building sides and in the open stairwell. The dashed line shows the pressure distribution inside the building, approx. -0.5 Pa. It meets the requirements of the European standard EN 13289.

Example 2: Measurement of a hotel with a rambling floor plan

Test object

The next example stems from a hotel complex consisting of several building blocks of different sizes and heights. Again, only parts of the building complex (sections A, B, and C) with a volume of 23,000 m³ were measured (Figure 7).

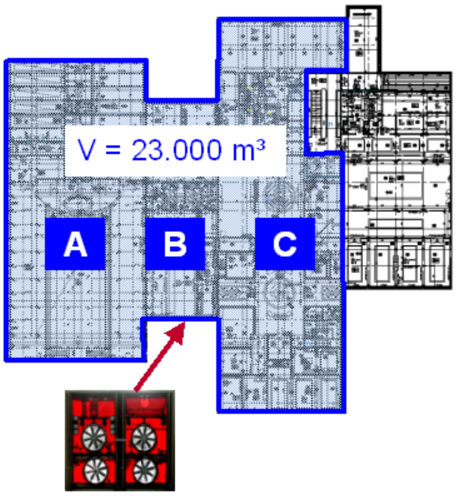

Figure 7. Partial floor plan of the hotel

Installing the measuring devices

Four BlowerDoor fans were installed in the exterior doors of Section B on the ground floor.

Building preparation

The tested zones were separated from the non-tested areas via temporary sealing (drywall in the doors of the floors and rooms, sealing of continuous shafts for piping and cables, etc.).

Air connection

Building sections A (indoor pool) and B featured sufficient air connection via diverse openings. The connection of section B to C was considered critical. There was only one air connection between these two parts of the building: a door in the stairwell on the first floor.

Basic conditions

The temperature difference between the inside and the outside was minimal, as was the wind. The baseline pressure differentials stipulated in European standard EN 13289 were not exceeded.

Measuring the pressure differentials

The pressure distribution was tested between the ground floor (section B near the measuring equipment) and the third floor (section C, most remote room). The tube length was 150 m.

Measuring result

The pressure differential between sections B and C at a building pressure differential of approx. -50 Pa was approx. 0.2 Pascal on average. An excerpt from the measuring software TECLOG2 MultipleFan in Figure 8 displays the results in a chart.

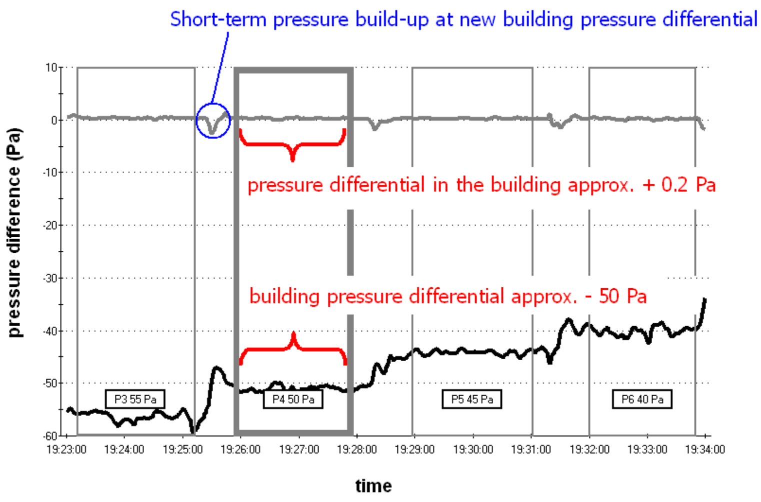

Figure 8. Excerpt from TECLOG2 MultipleFan: Building pressure differential and internal pressure distribution

The stairwell door between sections B and C, which at first had been considered too small for a constant flow opening and was thus rated critical, turned out to be sufficient. After a quick pressure build-up (see round mark) following each new setting of a building pressure differential, a constant pressure differential close to 0 Pascal was achieved. At this pressure distribution, the measurement could be conducted.

SUMMARY AND OUTLOOK

A basic requirement for air-tightness tests of large buildings is an even pressure distribution in the building. This in turn requires many openings of sufficient size for constant air flow, in order to ensure air connection in the entire tested building section ("single-zone buildings").

The pressure differentials in the building must be measured and checked, e.g., at a building pressure differential of 50 Pascal. There are two possible methods for this: either measuring the pressure differential in the "critical" zones (i.e., in the remote areas of the building) between the interior and the exterior directly at the building envelope, or by testing the pressure differential between the measuring device and the critical area within the building.

If the decline in pressure in one building section is too high, it is advisable to use one or more additional measuring devices at this location. The distribution and parallel operation of BlowerDoor fans in the building provides for an even pressure distribution.

In very tall buildings (e.g., high-rise buildings) an even temperature differential between the inside and the outside is important to ensure that the baseline pressure differential is not too high. Large buildings should also be tested at little wind or during calm weather.

If time constraints require conducting the test in spite of unfavorable weather conditions, the building pressure differential should be measured at different locations of the building and then averaged for the subsequent evaluation.