Building airtightness: standards and solutions

Now that we know that buildings leak, measures are required to make them airtight. But how airtight should buildings be, and can agreement be reached on a best practice standard?

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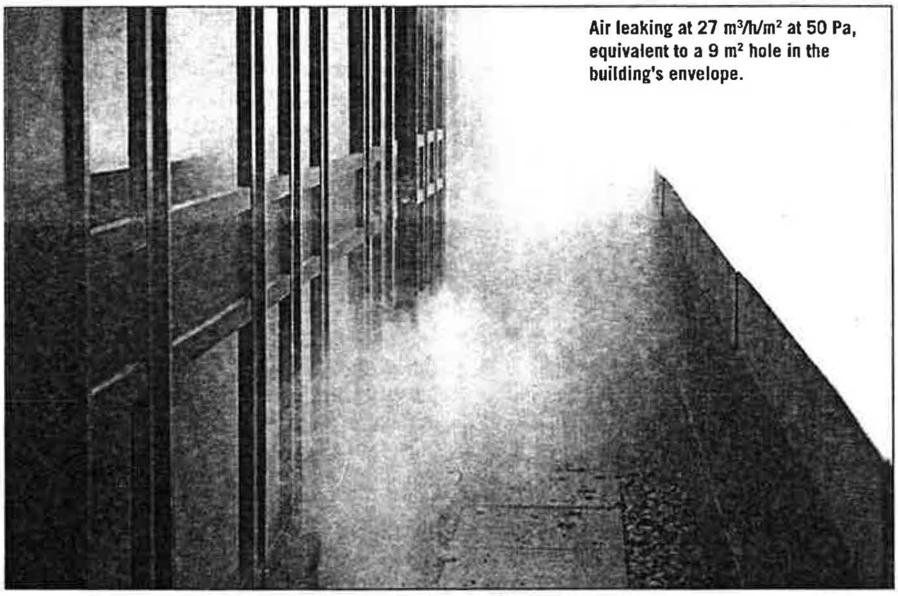


Air leaking at 27 $m^3/h/m^2$ at 50 Pa, equivalent to a 9 m^2 hole in the building's envelope.

Building components such as doors and windows have long been subjected to laboratory-based rain and wind pressure testing. Whole building air leakage is a much newer concept, but the trend is clearly towards fan pressurisation of the building and measuring the airflow at a given pressure drop between the inside and outside of the building.

The current approach is to couple an external fan to the building and record the airflow as the pressure rises inside the building. Data gathered on ordinary houses show that they typically performed at 13 ac/h, although a more recent sample had a median value of 16·6 ac/h at 50 Pa. This compares rather unfavourably with performance in Sweden, measured at 3 ac/h at 50 Pa.

Initially the leakage rate was expressed as air changes per hour and 50 Pascals. For larger buildings such as offices, superstores, cold stores and factories, the different shapes lead to a more refined basis of air leakage: airflow per hour per square metre of facade, at a given pressure. High wind speed can introduce scatter in the results during the test, and so testing is usually carried out when wind speeds are below 2 m/s.

The Air Infiltration and Ventilation Centre has published many reports collating international research and practice. Recommendations exist in many countries – including Norway, Sweden and Italy – with draft standards being prepared in others.

Measurements on eight Canadian sealed offices showed a range of air leakage which was approximately equivalent to values from 1·7 to 7·0 $m^3/h/m^2$ at 50 Pa. This study suggested that a tight office could be considered one with a leakage of 1·4 $m^3/h/m^2$, an average building at 4·0 $m^3/h/m^2$ and a leaky building at around 8·0 $m^3/h/m^2$. A similar study of eight US office buildings ranged from 3 to 114 $m^3/h/m^2$ at 50 Pa.

The UK's Building Research Establishment (BRE) has a distinguished record in air leakage research, providing design guidance on how to minimise leakage through careful detailing. The BRE defines a tight building as one with a leakage rate of around 7 $m^3/h/m^2$ at 50 Pa, with average constructions experiencing around 15 $m^3/h/m^2$ and leaky buildings performing at 30 $m^3/h/m^2$ (in practice the BRE tests large buildings at 25 Pa).

In 1997, the CIBSE issued its first guidance on air leakage in the form of Application Manual *AM 10: Designing for natural ventilation*. This asks for an airtightness of 7·5 $m^3/h/m^2$ or lower at 50 Pa (expressed as 5 $m^3/h/m^2$ at 25 Pa, but for consistency this has been adjusted to the flow equivalent test pressure of 50 Pa).

Following a study in 1995 of existing office buildings, the BSRIA recommended that all new air conditioned and low energy buildings should have an air leakage no greater than 5 $m^3/h/m^2$ at 50 Pa. The BSRIA's subsequent experience in testing buildings' air leakage shows that clients can achieve this standard, and even improve upon it, depending on the building type. The more critical the air leakage, the better the airtightness needs to be.

The leakier buildings tend to be offices because of the provision for windows and services penetrations between rooms and through floors. The tightest buildings are those with air locks and no windows, and where the designer realises that moisture ingress could be a problem, such as may be experienced in cold stores.

Based on the BSRIA database, best practice benchmarks have been set for various building types:

- ☐ air conditioned office: 3 $m^3/h/m^2$ at 50 Pa;
- ☐ supermarket sales floor: 2 $m^3/h/m^2$ at 50 Pa;
- ☐ entire supermarket: 3 $m^3/h/m^2$ at 50 Pa;
- ☐ archive store: 1·4 $m^3/h/m^2$ at 50 Pa;
- ☐ large cold store: 1 $m^3/h/m^2$ at 50 Pa;

Can we achieve these standards?

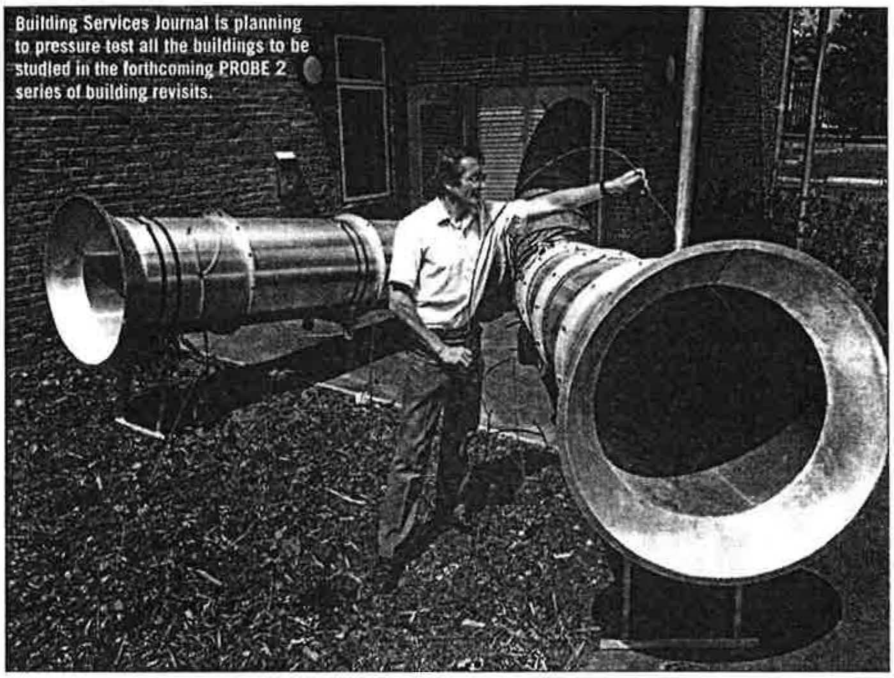
Most countries have reported a fast learning curve as builders recognise the new detailing needed to achieve airtightness. Nearly all builders fail to achieve their design targets in their first tested building, but can successfully cure the leaks and thereafter succeed first time in their subsequent buildings.

British experience based on almost 200 buildings tested by the BSRIA is that new buildings can be sealed to achieve air tightness standards of 5 $m^3/h/m^2$ at 50 Pa, provided that proper attention is given to the design of the building envelope to prevent unwanted leakage, and that design details are effectively incorporated during construction.

Problem areas include under-window gaps and in penetrations through the building for the service pipes and cables, particularly in vertical ducts that link a building's floors, from the basement right through to the roof.

If the leakage rate is very high, then a visual search of the building will usually reveal where large holes in the walls or ceiling have accidentally been left unfilled. If the leakage is modest, then two techniques may be needed to identify the crevices.

Smoke generators are favoured by the BSRIA, which are used routinely during pressure testing to mark those spots where air is escaping, but infra-red thermography can also be used: escaping warm air can be identified from the resulting thermal images.



Building Services Journal is planning to pressure test all the buildings to be studied in the forthcoming PROBE 2 series of building revisits.

BRE COMPUTER TOOL FOR PREDICTING AIR LEAKAGE

Requirement *L1* of the *Building Regulations* requires that "reasonable provision shall be made for the conservation of fuel and power in buildings by limiting the heat loss through the fabric of the building" *writes Earle Perera.*

Supporting this is an Approved Document which provides guidance on some sealing measures for the more common building situations, as do various reports produced by the Building Research Establishment[1].

Proving that airtightness has been achieved can only be quantified by carrying out a pressure test of the building envelope. This is normally conducted after the building has been constructed, or when various stand-alone phases are completed.

The testing itself involves sealing a portable fan (such as the BRE's BREFAN system or the similar device used by the BSRIA) into an outside doorway and measuring the airflow rates from the fans required to maintain a series of pressure differentials across the building envelope.

Post-construction pressure testing, though, is often a case of bolting horses and stable doors. What designers need is a method of predicting the likely airtightness of office buildings, a design tool which would provide a clear indication of the contribution of each individual tightness measure to the overall building airtightness, as well as accommodating "What-if?" scenarios.

A prototype design tool is currently being developed by the BRE. The tool works on the principle that leakage only occurs through the fabric between building components.

In the form of a spreadsheet, the tool is designed to provide the leakage index and the percentage contribution made by each component and the measures used to affect a seal.

Obviously no specific calculations can be made if the building envelope is designed from the outset for airtightness and significant gaps are left in the building envelope.

To ensure that the user is aware of the penalty for such gaps, the prototype design tool contains an additional check-box which poses the question. If the answer is 'yes', then an empirical leakage of 10 $m^3/h/m^2$ (at 25 Pa) is added to the overall calculated value.

The results will be presented as both leakage indices and whole building rates at the pressure differential of 25 Pa for large buildings, alongside corresponding values for a 50 Pa differential.

The BRE design tool is currently under development. More information will be made available at the CIBSE National Conference at the Alexandra Palace between 5-7 October 1997.

Reference

[1]Perera M D A E S and Webb B, 'Minimising air leakage in commercial premises', *Building Services Journal*, 2/97.

"New buildings can be sealed to achieve airtightness standards of 5 $m^3/h/m^2$ at 50 Pa"

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Further reading

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