Airtightness Testing

The essential guide to Part L2 of the 2006 Building Regulations

By David Pickavance and Tom Jones
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Introduction

This BSRIA Guide outlines the requirements of the proposed Building Regulations for 2006 as they apply to new buildings.

Approved Document L2A of the 2006 Building Regulations requires all commercial and industrial buildings with a gross floor area greater than 500 m² to be tested for air permeability to a minimum standard of 10 m³/(h.m²) at 50 Pa. This guide explains what the requirements mean to all parties to the construction process, and provides ready-made checklists and specification clauses to use when procuring an airtightness test.

Approved Document Part L1A also requires dwellings to achieve certain standards of airtightness. The specific requirements are explained in BSRIA’s companion guide BG 11/2004.2 Airtightness Testing for New Dwellings.

Airtightness is a vital component of sustainable design. Buildings that are not airtight will cause their mechanical ventilation air conditioning systems to struggle to maintain comfort conditions. A leaky naturally-ventilated building will suffer poor control, draughty conditions, and, in all likelihood, excessive energy consumption for heating.

Airtightness testing is now a legal requirement. Follow the rules explained in this guide, and you won’t go wrong.

David Pickavance and Tom Jones
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Who needs to read this document?

Building control officers

Building control officers need to know precisely what the 2006 Building Regulations require in terms of building airtightness testing. This guide explains the regulatory requirements in simple, straightforward terms, and how to ensure that the pressure testing has been done by a competent person.

Architects

Airtightness starts at the design stage. Architects need to know what makes a building inherently airtight, and where air leakage paths are most likely to occur so they can be designed out or at least sealed properly by the contractors.

Building services designers

An airtight building will require less energy to heat and cool, will be more comfortable for occupants, and will obviate the need for excessive design margins in the building services. Highly airtight and well insulated buildings may even remove the need for some forms of heating.

Contractors

The contractor is critical to ensuring the airtightness of the building, by good construction. Contractors are generally the procurers of airtightness testing. This document explains how to seal buildings, how to procure a test and what will happen at the test.

Building services contractors

Builders and contractors are the gatekeepers of good design, specifically when it comes to making buildings airtight. Building services contractors need to know why it is vital to reduce air leakage from shafts, raised floors and ductwork systems.
Compliance with the 2006 Building Regulations

Part L of the 2006 Building Regulations, published on the CLG website, requires new buildings to be tested for airtightness. The Approved Documents, which support these new Regulations, are in four parts.

**Approved Document Part L1A**
This refers to new dwellings, but excludes nursing homes and student accommodation. It requires samples of all types of dwellings on a development to be airtightness tested. For more details refer to the BSRIA Guide BG 11/2004 Airtightness Testing for New Dwellings.

**Approved Document Part L1B**
This refers to dwelling extensions, for which there is no requirement for airtightness testing.

**Approved Document Part L2A**
This refers to all new buildings except dwellings. All buildings with a usable floor area of 500 m² and over must be tested.

For smaller buildings, testing is not mandatory. However, an assumption of an air permeability of 15 m³/(h.m²) must be put into the National Calculation Methodology (derived from the Simplified Building Energy Model - SBEM, see www.ncm.bre.co.uk).

If the Target CO₂ Emission Rate (TER) is not met, then some action will be required to improve the energy efficiency of the proposed building. Reducing the air permeability will be a significant contributor to achieving the required TER and the building will then need to be airtightness tested.

For large, complex buildings where pressure testing of the whole building is impractical, compliance may be demonstrated by appointing a suitably competent person such as an ATTMA member like BSRIA to undertake a detailed programme of design development, component testing and site supervision.

**Approved Document Part L2B**
This refers to extensions and change of use for non-domestic buildings. There is no requirement for airtightness testing if the extension is less than 100 m² and does not increase the usable area by more than 25%. Large extensions come under Part L2A requirements and the new part of the building will require testing. Within Part L2B, there is also a requirement for consequential improvements to the existing building. Improving the airtightness of the existing building may be one way of achieving this aim.

**How to comply with Part L2A**
Testing is now a statutory requirement, governed by Regulation 20B of the...
2006 Building Regulations. Previous loopholes have been closed. The Building Regulations stipulate a maximum allowable air permeability of 10 m³/(h·m²) at 50 pa. There is also a requirement to demonstrate, via the SBEM (or equivalent) for non-dwellings, that the BER for the proposed building is less than or equal to the TER.

In many cases, building designers will choose to achieve the required energy efficiency by reducing the air permeability. As a rule of thumb, reducing permeability from 15 m³/(h·m²) to 5 m³/(h·m²) will reduce the BER by 30% in a naturally ventilated building.

The National Calculation Methodology (based on the SBEM or an equivalent) will need to be run to determine the energy efficiency of the building. The computer model requires information on U-values, thermal bridges, window glazing and frame types, details of the heating, ventilation or air conditioning system, lighting efficiencies and air permeability, along with a description of the building size, its orientation, doors, rooflights, and type of occupancy type.

Using the program, designers will need to demonstrate a 23.5% reduction in carbon emissions for naturally ventilated buildings, and a 28% reduction for other buildings, against a notional building of the same size and type that would have complied with the 2002 Building Regulations.

The air permeability value is a primary input into the SBEM. A value of 10 m³/(h·m²) is the starting value, except for buildings below 500 m² usable floor area.

The design air permeability may have to be lower than 10 m³/(h·m²), particularly for naturally ventilated buildings, since ironically it will, in general, be more difficult to achieve the required 23.5% energy reduction for these buildings, than the 28% reduction needed for mechanically ventilated buildings.

Permission to construct the building will not be granted if the BER exceeds the TER. Whatever airtightness target the designer chooses, it will need to be met by testing the completed building.

Failing airtightness targets may be costly and lead to delays on practical completion.

Prior to handover as built parameters including the measured air permeability need to be re-input to the SBEM software to demonstrate that the building does not exceed the TER – as actually built. The building control officer can then sign off the building.

For buildings less than 1000 m² there is until 31/10/07 of easement for achieving the required air permeability. Essentially, if a building fails its first airtightness test, but on re-test there is a reduction of 75% of the difference between the initial test and the design air permeability (or IF LESS DEMANDING the air permeability is within 15% of the design air permeability), then the building will be deemed to have passed.
The path to routinely achieving airtightness targets is as follows:

1. Specify the airtightness target at a very early design stage (such as the Design Air Permeability used to derive DER).

2. Specify the air seal line at a very early stage. The inside surface of the structure is usually the airtight surface. The airtight surface should be brought inside rooms which will be ventilated to outside, such as boiler rooms, plant rooms, electrical switch rooms and lift shafts.

3. Require air sealing detail drawings from the architect or design and build contractor.

4. Consider specifying an airtightness consultant such as BSRIA to review drawings.

5. Specify that airtightness testing be undertaken by an independent organisation (such as BSRIA) which is a member of ATTMA, the testing organisation for the British Institute of Non-Destructive Testing. This is referenced in the 2006 Building Regulations.

6. In liaison with the testing organisation, specify all aspects of the airtightness contract process (see page 12 for sample clauses). Where necessary, specify penalty charges for failures not rectified in a reasonable time scale.

7. Consider specifying an airtightness consultant to inspect the building during the construction process.

8. Clearly communicate the requirements to all design and construction parties.

Quality building airtightness targets

Achieving an airtightness target of 10 m³/(h.m²) is not an arduous task. For many years specifiers have demanded significantly better standards of airtightness in quality buildings to ensure that the occupants enjoy a satisfactory state of comfort and well-being.

For air-conditioned buildings, and buildings which aim to be low energy, a maximum air permeability standard of 3 m³/(h.m²) has been set by many building owners and operators. The major benefits of tighter airtightness standards are far better control, fewer staff complaints and improved energy efficiency. Equally, many clients in the retail sector have adopted lower airtightness standards than required by the Building Regulations, such as 2 m³/(h.m²) for new build projects. Even extensions to existing buildings can routinely achieve an air permeability target of 3 m³/(h.m²).

There are therefore more reasons than those in the Building Regulations for specifying tighter buildings. Where standard air-sealing details have been
specified and adopted, along with good quality control during construction, good values of airtightness have been achieved. Specifying products with adequate air permeabilities, such as blockwork and fire damper louvres, should therefore be routine. It does not need to be a painful process.

Some specialist buildings require tighter values of airtightness. For archival storage facilities, tight humidity control is required; in cold rooms air permeability values below 0.3 m³/(h·m²) are not only required but being routinely achieved.

Sensible and achievable airtightness targets
Setting an achievable airtightness target is an important element depending on the type of building. Clearly, some areas will require tight targets and special attention to achieving them, but designers should not choose airtightness targets which are very costly to achieve just to achieve the TER. Changing other parameters in the design may be more cost-effective.

The following table provides guidance on current normal and best practice. Normal practice can generally be easily achieved, but specifications substantially lower than best practice should be avoided unless it is a very

Table 1: Normal and best practice in air permeability for 2006.

<table>
<thead>
<tr>
<th>Building type</th>
<th>Air permeability in m³/(h·m²) at 50 Pa</th>
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<tbody>
<tr>
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<td>Normal practice</td>
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<td>Schools</td>
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<td>Hospitals</td>
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<tr>
<td>Cold stores</td>
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<tr>
<td>Dwellings</td>
<td></td>
</tr>
<tr>
<td>Naturally ventilated</td>
<td>9</td>
</tr>
<tr>
<td>Mechanically ventilated</td>
<td>5</td>
</tr>
</tbody>
</table>

The airtightness checklist

The following are typical examples of air leakage paths. Tick and make comment if needed.

1. Seal hollow concrete beams at the ends before delivery to site since internal penetrations of the beams would allow air to pass into the cavity.
2. Seal profiles in profiled metal sheeting for ceilings where concrete is poured onto profiled metal sheeting. The underside will have indents in the profile. These should be sealed with mastic or similar.
3. Check blockwork leakage. Plastered blockwork does not leak, and so quality of blockwork is immaterial. However, where there are raised floors and suspended ceilings, the quality of blockwork is important if these areas are not plastered. Blockwork may leak by up to 60 m³/(h.m²). BSRIA has tested over 100 blockwork walls in the laboratory and the manufacturers should have data on the air leakage of the blockwork. Painting good quality blockwork reduces the air leakage, but painting poor quality blockwork has very little effect.
4. Seal joints of profiled metal decking. The underside of profiled metal decking roofs is the air tight membrane. All joints will require to be effectively sealed during the laying of the sheets. Perforated liner sheets and using the vapour barrier should be avoided since they usually underperform.
5. Effectively seal all walls to ceiling and roof joints need to be effectively sealed.
6. Deep fill all expansion joints between concrete beams and blockwork to blockwork should be deep filled with an air tight compound.
7. Seal dry lining systems should be sealed to the floor, roof, and walls and all service penetrations sealed. Care should be exercised where internal walls meet these external walls to avoid a lattice of air leakage paths.
8. Seal joints of curtain walling systems to other building systems where problems are most likely to occur.
9. Air seal riser shafts effectively to avoid air penetrating the cavity and or plant rooms.
10. Seal windows and door frames effectively to the inside surface of the structure and seal the cavity preferably before the final finishes are carried out.
11. Seal steelwork penetrations through the inside surface of the structure adequately.
12. Seal pipework and electrical penetrations through the building envelope including penetrations to the plant room, electrical switch rooms, external lighting systems, and power and communications into the building.
13. Provide adequate seals for lift shaft doors below raised floors to prevent air penetrating the lift shaft.
14. Check doors and shutters. Loading bay doors should preferably be of the panel type with adequate seals. Security shutters are not particularly good from an airtightness point of view.
15. Fill water traps and condensate traps before testing the structure.
16. Take extra care with sealing details for renewables, such as rooflights, light pipes through roofing sheets, mounting, pipe and cables penetrations for solar water heating and photovoltaics, even mounts and cables for wind generators mounted on roofs of buildings.
17. Do not use unfaced mineral wool or equivalent to fill gaps.
18. Do not use tape to seal joints in buildings.
19. Avoid the use of expanding foam.

The airtightness checklist
What does an airtightness test involve?

Before the test

1. The integrity of the structure should be complete for the tests.

2. All mechanical ventilation openings should be sealed with polythene sheet or Cordek and self-adhesive tape. Smoke extract fans or openings should not be sealed.

3. Sufficient access to a door is required for the test equipment. BSRIA advises contractors of the amount of space needed which varies according to the size of building and air permeability.

4. All internal doors should be wedged open.

During the test

5. All exterior doors and windows need to be kept closed during the actual pressurisation tests.

6. The actual test (after set-up) is usually completed in well under one hour. During this period no personnel should enter or exit the building. It is preferable if the building is unoccupied.

7. There should be no moveable objects near the fan unit inside the building, since they would be displaced by the air flow.

Additionally for smoke tests

8. A longer period of time is required for the building to be evacuated for smoke tests.

9. For the whole building smoke test, an electrical supply will be required.

After the test

10. A statement of the air leakage rate is immediately available, and a full report with corrections for air density and air volume will be provided after the test.

There should, in essence, be no great problem for factories, warehouses, superstores and distribution centres to achieve very good air permeability standards, due to large expanses of cladding and roofing being continuous and installed by the same contractor. Schools, hospitals and prestigious offices suffer from being one-off structures, often with courtyards and lightwells, and often designed with greater architectural licence.
Construction details for special attention

special case.

**Builders’ shafts**
The air leakage of builders’ shafts acting as ventilation ductwork often runs into difficulties with regard to specification and indeed achievement of a specification.

The ductwork standard DW 144 from the HVCA recommends a maximum air leakage for low pressure Class A ductwork of 0.54 l/s m² (1.94 m³/(h.m²)) at a pressure differential of 100 Pa. For medium pressure Class B ductwork, the value is 0.18 l/s m² (0.65 m³/(h.m²)) at a pressure differential of 100 Pa.

It would be unreasonable to expect a builder’s shaft to conform to low pressure ductwork standards. However, it should achieve a permeability better than a good building.

**Floor voids**
Where floor voids are used for ventilation plenums as in displacement ventilation systems, BSRIA recommends an airtightness criterion of 0.0 litre per second per square metre of floor area at a test pressure of 50 Pa, excluding the air leakage to the occupied zone.

It is important that the conditioned air in the floor voids supplies air to the occupied zone. The system can be severely compromised if air leaks into cavities and risers, or other zones of a building.
Diagnostic tools for airtightness

In the event that a building fails an airtightness test, there are two methods of identifying air leakage paths. These are smoke tests and thermal imaging.

**Smoke tests**
There are a variety of ways for carrying out smoke tests, and all of them require the building to be pressurised.

Smoke pencils can be used to identify local air leakage paths. This is a useful technique, particularly for smaller buildings, but can be time consuming.

For larger buildings, the most useful approach is to distribute smoke generators around the whole building and leave them switched on for a period of up to an hour. The building should then be pressurised to around 30 Pa and the smoke egress from the building observed and preferably recorded on video. Such tests take less than three hours, even for quite large buildings, and give building contractors a good idea of the location of problem areas.

A slightly different technique involves pointing a smoke generator or ducted outlet towards a section of cladding or roofing, again while the building is being pressurised. This is somewhat less usual method than using smoke pencils, but allows easier identification of the air leakage paths.

**Thermal imaging**
A good thermal image requires the building to be depressurised and optimally the internal to external temperature difference should be more than 100K, the latter being a drawback in summer or before the heating system is operational.

The technique not only identifies air leakage paths but also poorly insulated areas, discontinuous insulation and thermal bridges.

To carry out the thermography test, the infrared camera should be set up for the correct background temperatures, distance and emissivities. The camera should be in focus and reflections should be avoided. The inside and outside of the building should be scanned for temperature anomalies that exist prior to the building being depressurised. All such locations should be noted and recorded.

Once the building has been de-presurised for a little while, the building should be scanned and new thermal anomalies noted and recorded. The surveyor should check for local sources of heat, check whether they were there before depressurisation, and eliminate the possibility of other causes.

The location of each anomaly should then be checked against the construction details. A report should be issued showing thermograms, location of anomalies and detailing conformance to the environmental conditions as set out above.
Airtightness specification clauses

These clauses should provide sufficient information to enable a client to procure an airtightness test for their building, without specialist knowledge of the subject.

Clauses
Suggested clauses are given below. They are not particular to any standard form of contract format, but specific versions can be produced if required, such as for SPEX or NBS Engineering Services

Clause 1 Airtightness pressure test
Carry out a building airtightness pressure test at the following property, as required by Building Regulations (England and Wales), Approved Document L2, Section 2:

Building/project: ..........................................................................................
Address: ..........................................................................................
..........................................................................................
..........................................................................................
Postcode: ..........................................................................................
..........................................................................................
..........................................................................................

Building type: ..........................................................................................

Clause 2 Test standard
The building airtightness pressure test required in Clause 1 shall be carried out in accordance with the requirements detailed in the ATTMA Technical Standard 1, Measuring Air Permeability of Building Envelopes, and BS EN 13829:2001 Thermal Performance of Buildings – Determination of air permeability of buildings – Fan pressurisation method.

Clause 3 Approved contractor
The building airtightness test shall be carried out by a member company of ATTMA (The Air Tightness Testing and Measurement Association). The company shall also be UKAS certified.

Clause 4 Air permeability standard
The building has been designed to achieve an air permeability of the following value of 10 m³/(h.m²)/………………………… (insert other – see page 7 if a building of higher quality is required) at an applied pressure difference of 50 Pa.

Clause 5 Instrumentation
The instrumentation used to carry out the building airtightness test shall be UKAS certified and have a valid calibration certificate.