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Airtightness and pressure (blower door) test

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Airtightness

The airtightness of a dwelling, or its air permeability, is expressed in terms of air leakage in cubic metes per hour per square metre of the dwelling envelope area when the building is subjected to a differential pressure of 50 Pascals ($m^3/(h \cdot m^2)$@50Pa).

The dwelling envelope area is defined in this context as the total area of all floors, walls and ceilings bordering the dwelling, including elements adjoining other heated or unheated spaces.

Air leakage

Air leakage is defined as the flow of air through gaps and cracks in the building fabric.

Uncontrolled air leakage increases the amount of heat loss as warm air is displaced through the envelope by colder air from outside.

Air leakage of warm damp air through the building structure can also lead to condensation (within the fabric interstitial condensation), which reduces insulation performance and causes fabric deterioration.

Air permeability

The air permeability of a building can be determined by means of a pressure test.

The Air Tightness Testing and Measurement Association (ATTMA) standards discusses

the methodology for air pressure testing, including

a. the test procedures,
b. requirements and
c. conditions of reporting.

Reasonable provision for airtightness

Building Regulations indicates that **reasonable provision for airtightness** is to achieve a pressure test result of no worse than $10m^3/(h.m^2)$@50Pa.

Current

- **good practice** for energy efficient dwellings includes achieving airtightness of $7m^3/(h.m^2)$ @50Pa and
- **best practice** is $3m^3/(h.m^2)$@50Pa.

Air leakage results at elevated pressure

The first and most common calculation is to convert **m^3 /(h.m^2)@50Pa** to ACH (**air changes per hour**).

With the blower door running and the house pressure at negative 50 Pascals, **a typical existing home might leak at the rate of 15 air changes per hour,** which is written 15 ACH50.

Really tight houses can get down to 1 ACH50 or even less.

In fact, **the Passive House program requires** a maximum infiltration rate of **0.7 ACH50**.

Air tightness Strategy – Design Stage - 1.

- **Simplify built** form where possible.
- **Define the line of the air barrier** as early as possible. Mark up large scale sections with a bold colored line.
- **Consider and rationalize** construction sequencing.
- **Redefine the air barrier route** and insulation strategy in critical areas to simplify details and avoid problems.

Air tightness Strategy – Design Stage - 2.

- **Decide and specify** which materials will form the air barrier.

  Consider:
  - Material air permeability
  - Buildability
  - Position within the construction
  - Long term durability
- **Consider junction details** between air barrier materials:
  - Practicality of forming the seals on site
  - Durability of the seals, especially where not accessible for future remedial work.

Air tightness Strategy – Design Stage - 3.

- **Minimize the number** of service penetrations through the external wall.
- **Consider how service penetrations** will be sealed.
- **Rationalize service routes** and penetrations.
- **Highlight air barrier critical elements** and junctions on construction drawings.
- **Apportion responsibility for sealing** critical junctions to specific trades.

Air tightness Strategy – Construction Stage - 1.

- Appoint a site **"air barrier manager"** to coordinate and inspect the overall formation of the air barrier.
- **Brief the whole construction team** (not just management) on the need for and importance of the air barrier.
- **Inform the team of the air barrier line**, the materials which will form the barrier and the critical junctions.
- **Encourage operatives to draw attention** to unforeseen difficulties rather than using makeshift solutions.

Air tightness Strategy – Construction Stage - 2.

- **Air barrier management to undertake**:
  - Coordination of the formation of the air barrier
  - Site quality assurance
  - Check and sign off all "hidden" air barrier elements before covering up.
- **Review the construction as work proceeds** to identify any weaknesses in the air barrier
- strategy / areas not previously considered and feed this information back to the design team.

Air tightness Strategy – Construction Stage - 3.

- **Establish solutions** to any problems identified.
- **Undertake airtightness testing** at the earliest possible opportunity.
- Use an **established pressure testing company** capable of giving good diagnostic feedback.
- All materials and workmanship including air tightness tapes and sealants to be supplied and completed as per guidelines in **Technical Guidance Document D**.

How to achieve air tightness - and why

- Air tightness means **cutting out unwanted draughts.**
- Draughts can be so slight as to be imperceptible, but even slight draughts increase heat loss, sometimes dramatically.

The way to good air tightness is a continuous airresistant layer all around the inside of the building.

How to achieve air tightness - and why

Continuous air resistant layer includes:

- under and around the ground floor,
- across the external walls and
- under the roof, to seal the inside from the outside.

With masonry walls - whether concrete block or concrete - this is most easily done by using a wet plaster finish.

It can also be done

- by using dry-lining boards and by taking extra care to seal around all aps, all perimeters, and
- at windows and external doors.

With timber frame or steel frame walls, it's most easily done

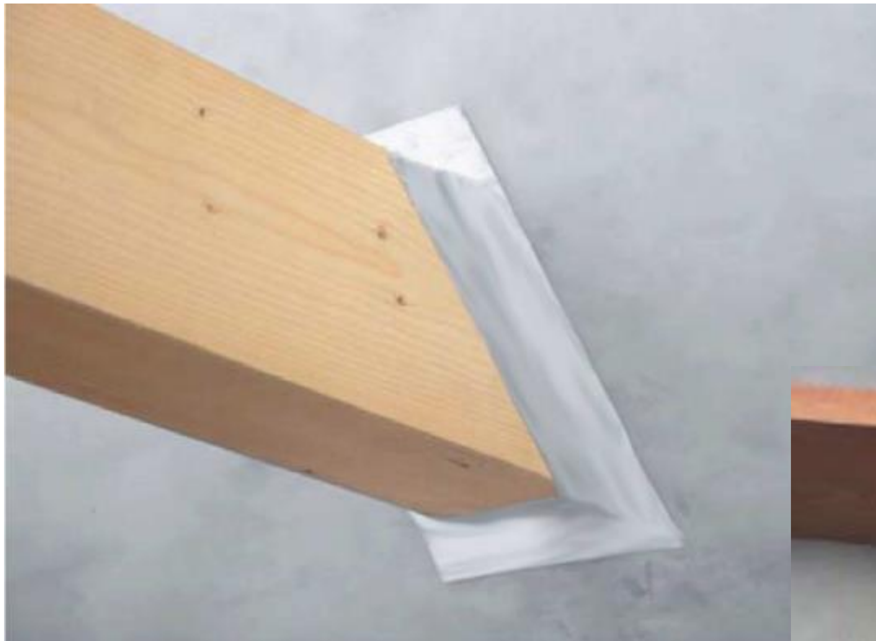
- by using plasterboard board with perimeters and joints all thoroughly sealed

Points to watch:

- Plaster between the joists at suspended timber floors
- Make sure there's no gap along the skirtings at floor level
- Where pipes or wires pass through the outside wall or the roof, seal around them to draught-proof the opening
- Tape around window and external door frames to stop the draught at the edges

Points to watch:

Sealing the junction between the joist and the external wall



Sealing where pipes enter the roofspace

How to achieve air tightness – Ground floors

Concrete ground-bearing floors:

- When properly installed, both the floor slab and the radon barrier give excellent air tightness.
- The junction at the external wall is key. Make sure the radon barrier is carried up the side of the external wall and across to the inner leaf. Then appropriate air tightness sealant or tape behind the skirting to seal between the radon barrier and the wall plaster or plasterboard.

With timber frame external walls, it's essential to maintain air barrier continuity between the wall construction and the ground floor slab. See the details sheets on the next slide.

Points to watch – Ground floors

Bonding an air-tight membrane to the concrete floor slab

How to achieve air tightness – Ground floors

Concrete suspended floors:

- A well-cast concrete floor slab is airtight.
- As with ground-bearing slabs, the junction at the external wall is key. A properly built masonry inner leaf built off the slab will be air tight also. If the wall is timber frame or is not built off the slab, there's potential for a gap.
- As with a ground-bearing slab, use sealant or tape behind the skirting to seal to the wall plaster or plasterboard.

How to achieve air tightness – Ground floors

Timber floors:

- Boarding is prone to shrinkage.
- This can render the floor leaky. Fixing plywood sheeting across the boards and taping gaps can create an air tightness barrier.
- A continuous sealed floor finish can also provide an air tightness barrier.

How to achieve air tightness – Masonry walls – 1.

The masonry walls may be cavity walls, with inner and outer leaves of blockwork (medium density or lightweight), brickwork or concrete, with a cavity which is usually insulated, and frequently with additional insulation on the inner face.

Alternatively, they may be built of single-skin masonry, frequently of hollow blockwork or of precast or insitu concrete, with insulation applied internally, sometimes externally, or sometimes both.

How to achieve air tightness – Masonry walls – 2.

For a well-built blockwork inner leaf with a coat of wet-finish plaster, will, if properly applied and with proper detailing, deliver air tightness.

Properly applied dry-lining boards applied to the inside face can also provide air tightness. For enhanced performance, use a purpose-made airtight membrane. However, the issues surrounding continuity of thermal insulation and continuity of air tightness at openings, roofs and suspended floors vary widely between these wall types.

The details in Section 2 show these issues in detail.

The following identifies key principles.

Air tightness with cavity masonry external walls

The nature of cavity construction makes it difficult to achieve good air tightness by sealing externally.

The simplest way to achieve good air tightness is to plaster the inner leaf. Dry lining with proper sealing of all perimeters and joints will also achieve good air tightness.

The key areas to watch are junctions at opes, at floors, and at service penetrations - see sections 5-10.

How to achieve air tightness – Timber and steel frame – 1.

The internal plasterboard layer provides air tightness and is simply executed.

Sealing the junctions of the plasterboard with the surrounding construction is key.

This includes at intermediate floors, roof and ground floor, external wall opes and service penetrations.

For best practice, use an air-tight membrane as illustrated on the next slide.

How to achieve air tightness – Timber and steel frame – 2.

Joints sealed in air tight membrane

How to achieve air tightness - Intermediate floors – 1.

Air tightness at intermediate floors is a matter of closing the gaps above and below where floor spans onto the external wall, and around any joists, beams or joist hangers.

In timber floors, where joists run parallel to the external wall, or when hangers are used for joists requiring support, air tightness is achieved by bedding the hangers in mortar, and by plastering the external wall the same as for the rest of the wall.

With timber frame or with dry-lined masonry, carry the boards into the floor zone and tape around the joists or hangers, see below.

Where timber joists span onto the external wall, carry the boards into the floor zone and tape around the joists or hangers, as per Figure on the next slide.

How to achieve air tightness - Intermediate floors – 2.

Sealing at intermediate floors:

First stage:
point up around joists

Second stage:
tape joists to wall

How to achieve air tightness - Intermediate floors – 3.

With concrete intermediate floors, when the floor spans onto the wall, pay attention to any gap under the slab, especially with precast concrete slabs.

If a blockwork wall is built off the floor slab above, this will give an excellent basis for air tightness once the blockwork is plastered right down to the slab.

How to achieve air tightness - Separating wall junctions – 1.

The concern at separating walls is the structural continuity which is usual between the separating wall and the exterior wall. This can result in breaks air tightness.

Where a separating wall is of cavity construction, and where the cavity is joined to a cavity in the external wall, close off the cavity paths to cut down on air routes.

This can often be done using the fire stopping required.

How to achieve air tightness - Windows and external door opes – 1.

Air leakage often occurs between window or door frames and the surrounding construction.

Appropriate air tightness sealants are required between plaster finishes, window boards and frames. This also applies to internal door frames (particularly the architrave over the door head) where air leakage may enter the wall lining void and track to the external cavities.

Approved air tightness sealants and tapes are available to assist the formation of air barrier continuity at such interfaces.

How to achieve air tightness - Windows and external door opes – 2.

For air barrier continuity:

- Apply appropriate flexible sealant or a tape to at all interfaces between the internal air barrier and the window or door frame
- If forming the air barrier to the walls with the blockwork inner leaf or a scratch coat on blocks, install an appropriate air tightness sealant between the cavity closer and blockwork wall.
- Appropriate air tightness tapes can be used to seal between the wet plastered finish of the wall and the window frame.
- Seal all penetrations through air barrier using an appropriate air tightness flexible sealant or tape. Approved air tightness sealants and tapes are available to assist the formation of air barrier continuity at such interfaces.

How to achieve air tightness - Windows and external door opes – 3.

Sealing under way at junction of timber frame wall and external wall ope

How to achieve air tightness - Trickle ventilators – 1.

Some trickle ventilators can permit significant levels of leakage to occur during the air leakage pressurisation test. It is important to check the manufacturer's product literature to ensure that the ventilators provide a sufficient level of air tightness when closed and that they are correctly installed.

How to achieve air tightness - Service penetrations – 1.

Holes and chases are formed for many different services by different specialist contractors.

They may be in roof spaces (recessed light fittings, water pipes, soil vent pipes, rainwater pipes, ventilation ducts, television cables); in external walls (soil and waste pipes, electrical cables) and in ground floors (soil and waste pipes, incoming mains). Penetrations may also be required behind bath panels, shower trays, kitchen units and into service shafts.

A key element in maintaining thermal continuity and air tightness around service opes is to agree standard sealing procedures with subcontractors and make sure they have the right materials and tools.

How to achieve air tightness - Service penetrations – 2.

Try to locate the following so as to minimise services and structure penetrations through the envelope:

- W.C. toilet overflows
- Kitchen cooker hood extracts
- Condensing boiler flues
- Outside taps
- Soil vent pipes
- Waste pipes
- Trickle vents in walls
- Air intake vents
- Canopies to entrances
- Metal balconies
- ESB connections and meters
- Gas connections and meters
- Security alarm systems
- External security lighting
- External security cameras and sensors

How to achieve air tightness - Service penetrations – 3.

For good thermal performance and air tightness:

- Core drill service penetrations to minimise damage to the insulation layer.
- Make good any damage caused to the insulation layer by filling any gaps with loose fibrous insulation or approved expanding foam.
- Drill holes to provide a snug fit and reduce oversize to a minimum.
- All penetrations through the air barrier line must be effectively sealed following installation of the services. This can be achieved with the use of appropriate air tightness tape, air tightness grommets or air tightness sealants.

How to achieve air tightness - Service penetrations – 4.

When installing **socket outlets or switch plates** in an air barrier formed by a plasterboard lining, apply a continuous ribbon of dabbing sealant compound around the hole and metal electrical enclosure prior to installing the plasterboard, as this will ensure good seal between box and plaster board and the cable penetrations and the metal box, providing greatest structural integrity for this application. This will reduce air leakage through the sockets / switches into the void beyond. Consider using proprietary gasketted socket boxes and membranes.

Construction of a services zone inside the air tightness barrier can also reduce the number of penetrations in the barrier.

How to achieve air tightness - Service penetrations – 5.

Recessed light fittings may permit air leakage to breach the plasterboard ceiling line into the voids or attics beyond. They should never be allowed to penetrate the primary air barrier unless the units are of an air sealed type or a further secondary air barrier formed beyond.

This needs a special detail because of the fire risk.

How to achieve air tightness - Service penetrations – 6.

Extract fans should be installed and sealed to prevent air leakage occurring through plasterboard finishes.

A continuous ribbon of adhesive should be installed around the duct penetration at the air tightness barrier. Where possible the ducts should also be sealed to the blockwork inner leaf.

Extract fans may also be fitted with external flaps to minimise air infiltration through the unit.

How to achieve air tightness - Service penetrations – 7.

Ply backing on lightweight frame, to hang services and minimise penetrations through insulation and air tightness barrier

Sealing around connection to electrical socket outlet

How to achieve air tightness - In the roof – 1.

Air tightness under the attic

Proprietary attic trap doors with low air permeability characteristics should be fitted in lieu of site manufactured doors. Where site manufactured doors are installed these should be complemented with draught stripping to minimise air leakage into the attic space above.

Dormers

The plasterboard cheek linings will form the air barrier. The linings should form a continuous air barrier and be sealed to the window frames. Proprietary products are available to assist the formation of air barrier continuity at such interfaces.

How to achieve air tightness - In the roof – 2.

Roof with ventilated counterbattens and unventilated attic

Sealing around frame of access hatch to attic

The pressure (Blower door) test

Blower door

A blower door is a machine used to measure the airtightness of buildings. It can also be used to measure airflow between building zones, to test ductwork airtightness and to help physically locate air leakage sites in the building envelope.

Source: http://en.wikipedia.org/wiki/Blower_door].

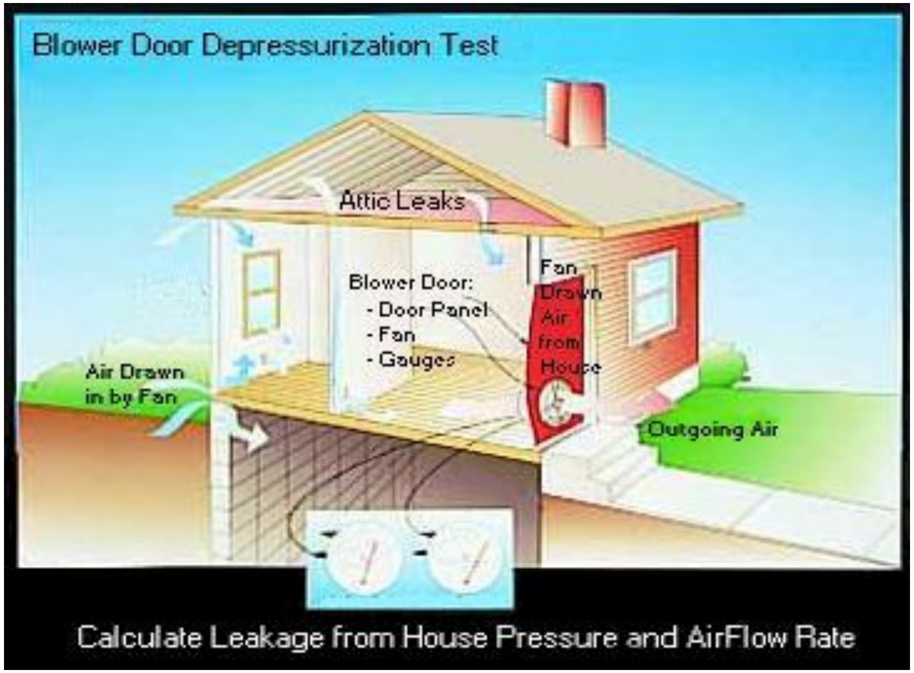
Three components to a blower door

1) **a calibrated, variable-speed fan**, capable of inducing a range of airflows sufficient to pressurize and depressurize a variety of building sizes,
2) **a pressure measurement instrument**, called a manometer, to simultaneously measure the pressure differential induced across the face of the fan and across the building envelope, as a result of fan airflow, and
3) **a mounting system**, used to mount the fan in a building opening, such as a door or a window

The pressure (Blower door) test

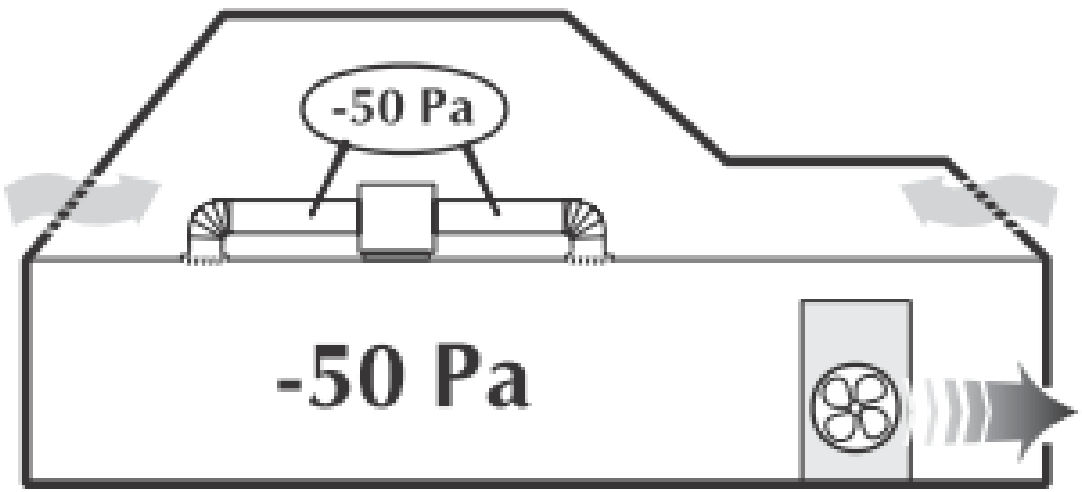
A powerful fan set temporarily in a doorway creates a pressure difference between the house and the outdoors, usually by depressurizing the house.

All the air that the fan blows out of the house is replaced by air coming in through all the leaks. For every cubic foot of air that blows out through the fan, a cubic foot leaks in.



Recommended web side: http://www.youtube.com/watch?v=lHjI2TfI5Xg

Blower door - untaped
- depressurize house and ducts



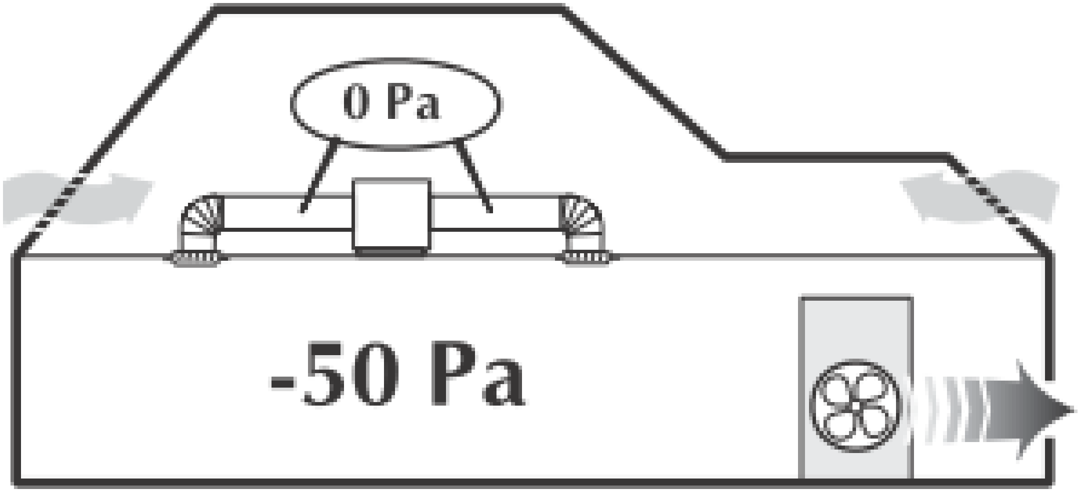
The blower door measures the airflow required to depressurize the house to -50 Pascal (**$m^3/(h\ .\ m^2)$@50Pa**).

This test condition is known as Untaped and is the basis for the Air Changes per Hour calculation.

Source: http://www.southface.org/default-interior/Documents/blower_door__duct_blaster_testing_factsheet.pdf

Blower door - taped

- depressurize house only



After taping over all the supply and return duct grills, a second blower door test can be performed to determine the **Taped** measurement. This number indicates how much air leakage is through the building envelope only, because any duct loss is blocked out.

Source: http://www.southface.org/default-interior/Documents/blower_door__duct_blaster_testing_factsheet.pdf

Blower door test results
- building tightness

Newly constructed homes should test at less than 7 ACH at 50 Pascals pressure (7 ACH50).

Reasonable air-sealing efforts that are required a range of 5 to 7 ACH50 or better.

Older houses tend to be between 10 and 20+ ACH50 but there is broad variation.

Energy efficient homes with controlled ventilation often have tightness levels of 1 to 5 ACH50.

ACH = air changes per hour

Sources and more information:

http://europa.eu/legislation_summaries

http://www.seai.ie/Your_Building/BER/BER_FAQ/FAQ_BER

http://en.wikipedia.org/wiki/Blower_door

http://www.southface.org/default-interior/Documents/blower_door__duct_blaster_testing_factsheet.pdf

http://www.youtube.com/watch?v=lHjI2Tfl5Xg