Floors
While only the lowest floor in the building is likely to form part of the air barrier, it is nevertheless important to consider intermediate floors as well, as they can provide routes for indirect air leakage. With all floor types it is not only the bulk area of floor that needs to be considered you should also ensure that it is well sealed at its junction with the wall.

Solid concrete floors
In-situ concrete will provide good airtightness across the floor slab; its only real weakness comes at construction joints within slabs, penetrations and junctions with walls. However, a solid concrete floor will provide good airtightness if constructed with a damp-proof membrane that is sealed to a damp-proof course within the wall and penetrations are sealed.

Suspended concrete floors
With care, a well-designed and constructed suspended concrete beam and block floor can provide a high degree of airtightness. Points to consider are as follows.

- The leakiness of the floor will depend on the permeability of the floor system components, and gaps between components.
- Even though it is common to apply a cement slurry before applying the topping it will not provide a total seal.
- A floor screed will provide reasonable airtightness, as will a topping that is laid over a vapour control layer (or radon barrier) which has all joints sealed. In both cases, attention will be needed to seal between the floor and wall.
- Where hollow beams are used, it is important to seal the ends of the beams to prevent air moving from one area to another.
- Where services penetrate the floor it is common to remove a whole block resulting in an oversized hole around the service pipe or duct. Gaps like these must be sealed.
Suspended timber floors

The main routes for air leakage through a suspended timber floor are via cracks around joists that are built into the masonry wall, holes made in the floor for services and the space between the last joist or strutting and the wall. For ground floors, while it is possible to seal the skirting to the floor and wall, it is preferable to create an air barrier below the floor surface, ideally in a position that will allow services to run within the floor but prevent air from being driven into the space above the floor insulation. Some important points to consider are as follows.

- Solid strutting of joist-sized timber should be fixed between joists at their supports to provide an edge fixing for the flooring panels and to confine the problem of air sealing to the perimeter of the floor (Figures 1a and 2).
- Using joist hangers reduces the amount of sealing compared with traditional building joists into masonry. However, it is important to be aware that if they are not properly secured joist hangers can twist when loaded. Therefore, ensure that several courses of masonry are in place above the hangers before loading the joists. Pre-formed polypropylene shoes are now available to provide a seal around built-in joists.
- When joist hangers are used, whether at ground or intermediate floor level, an attempt should be made to minimise air leakage by fixing a timber batten to the side of the joist or strutting and packing fibrous insulation into the gap more tightly than would otherwise be necessary to avoid thermal bridging (Figure 3). This gap also provides an emergency drainage route for spilt water (Figure 1).
- An alternative method is for the skirting to be sealed to the wall and floor, and any gaps around service penetrations made airtight. The air space behind any drylining should also be sealed by a continuous ribbon of plaster adhesive at skirting level.
- It is also worth considering parging the masonry around the joists to reduce air leakage around the floor.

Raised access floors

Raised access flooring is not usually intended to be airtight and will be leaky at joints within the floor and around its edges. Where a raised access floor is to be used the structural floor supporting it will need to be airtight. The wall will also need to be sealed down to the structural or true floor level.

Service penetrations through ground floors

All services that pass through the ground floor are a potential cause of air leakage. The risk is greatest with suspended ground floors. Gaps and holes in the ground floor where pipes rise from voids below should be sealed against air leakage. Hatches and covers giving access to services in suspended timber ground floors should be tight-fitting or draught-proofed to prevent air leakage (Figure 4).

Walls

Masonry walls

Typically, brickwork tends to be far more permeable than blockwork so where an external masonry cavity wall forms the air barrier it is best to use the blockwork inner leaf as the air barrier rather than the brick outer leaf. Even so, all blockwork leaks to varying degrees. Generally, dense concrete blocks tend to be less permeable than lightweight blocks. The airtightness of masonry walls can be improved by applying a fairfaced finish or by coating with emulsion paint, block filler coatings, wet plastering or parging. If blockwork is not to be plastered, coated or drylined, then fairfaced blockwork should be used as it will give a greater degree of airtightness than common blockwork.

Before specifying the type of blocks, check manufacturers’ airtightness data against the proposed airtightness criteria of the building to be constructed. Sealing works will be needed where blockwork walls form part of the external envelope, or they form separating walls between conditioned (heated) spaces and unconditioned (unheated) spaces (eg lift shafts and plant rooms).
Masonry walls should be sealed throughout their full height including above suspended ceiling level and below raised access flooring level (Figure 5). This means continuing the fairface, plaster or paint coatings into the ceiling or floor void should be considered. With fairfaced blockwork make sure the joints are fully filled on the front and back of the wall. To maintain the quality of the jointing throughout the blockwork, routine checking is required. Ensure that the ‘soft joint’ between the top of the blockwork and underside of the horizontal structure above (eg floor slab or roof) is sealed with an impermeable material. Don’t be tempted to fill the joint with inappropriate materials like mineral wool. If hollow blockwork has been used, the top course may require capping off to prevent indirect air leakage through the edges of the blockwork.

**Remember!**

Masonry walls should be sealed throughout their full height including above suspended ceiling level and below raised access flooring level.

Vertical interfaces between sections of blockwork, and between blockwork and structural columns or other cladding systems, will need to be sealed to ensure airtightness. The type of sealant that may be used will depend on whether the joint is rigid or whether it will need to accommodate movement. Check with the manufacturer to ensure that the right sealant has been selected and that it will be compatible with the surfaces to which it has to adhere.

**Fairfaced blockwork**

Air leakage through sections of fairfaced blockwork wall can be reduced considerably when joints are adequately sealed. Mortar between blocks needs to be complete and continuous across both the horizontal and perpendicular joints.

To maintain the quality of the jointing throughout the blockwork, routine checking of workmanship is required. Include checking of joints as part of the quality plan for the job.

**Plastered walls**

Plastering a wall will considerably improve its airtightness. However, it is important that the whole wall is completely plastered from floor to ceiling. With larger buildings, ensure the wall is sealed above suspended ceiling level, and below raised floor level. If possible, extend the plaster finish to true ceiling level (ie the underside of the floor slab) and true floor level (ie the top of the floor slab).

**Remember!**

In buildings with suspended ceilings or raised access flooring it is important that walls are sealed to true ceiling level (ie the underside of the floor slab) and true floor level (ie the top of the floor slab).

**Coating blockwork**

Coating blockwork will increase its airtightness. Emulsion paint reduces air flow through blockwork. Block filler coatings are more effective, but are more expensive. The lower the airtightness specification of the block, the greater the likelihood that a more specialised product will be required. Check with the manufacturer that their product is going to suit the airtightness requirements of the project. Painting or coating blockwork either side of joints is no substitute for careful sealing.

**Movement joints**

Care is needed to maintain airtightness when providing movement or expansion joints. By their nature, expansion joints have to be able to accommodate movement. Any sealants used therefore must be capable of accommodating movement. Simply applying expanding foam or mastic sealant on its own is unlikely to provide a seal that will provide both airtightness and allow movement. A ‘backer’ piece is required to prevent uneven adhesion and thickness of gun-
applied sealant. A common alternative is to use a preformed compressible foam seal. While these can prove effective, it is important to check with the manufacturer that the material used will achieve the required level of airtightness and that it will be compatible with the surfaces to which it has to adhere. This is important as air leakage audits have shown that not all compressible seals are airtight when installed. Don’t be tempted to fill the joint with inappropriate materials like mineral wool. For a good seal across the joint, set flexible material back in the joint. To ensure completeness always seal joints before fixing trunking, etc. to the walls.

**Drywall and drylining**

With careful detailing, drywall or drylining systems can be used to provide an effective air barrier, often avoiding the need for a secondary air barrier. To be effective, the plasterboard should be continuous above suspended ceilings and below raised floors, with all edges sealed to provide air barrier continuity at true ceiling and floor levels, and at junctions with structural columns and walls. Where drylining is applied to masonry, there will always be a gap between the plasterboard and the masonry. Unless the dry lining is carefully detailed, cold air that permeates the masonry can flow along this gap and into the building or warm air can escape. Take care therefore to seal all edges of the plasterboard, seal at junctions with internal partition walls and seal around penetrations.

- **Sealing edges**
  Ensure that the plasterboard is sealed to the frame, pay attention to corners and mount plasterboard on ribbons of plaster or adhesive around all edges rather than on dabs.

- **Sealing around penetrations**
  In addition to penetrations for piped or ducted services passing through the wall, you should also consider electrical fittings such as socket boxes and wall-mounted recessed light fittings. While air leakage audits have shown that both can prove to be leaky, in a well-sealed building air leakage through sockets does not usually produce air permeability rates higher than those specified in the national Building Regulations. At socket outlets, wall switches, etc., provide a solid ribbon of bedding adhesive around each electrical box (Figure 6). Based on the degree of replication, where possible, try to avoid mounting sockets, light fittings or other features which result in penetrations through the drylining, on an external wall. In larger buildings with substantial electrical services (eg hospitals and laboratories), the sockets are often within wall-mounted trunking that minimises the aggregate effect of penetrations through the wall.

- **Differential movement**
  To be effective as an air barrier material, plasterboard has to be continuous, abutting other components and elements. In some cases, these will expand/contract at a significantly different rate to the plasterboard. Identify locations where differential movement is likely and select sealants accordingly.

- **Interfaces with drylined partitions**
  It is important to prevent indirect air leakage at the junction between a drylined external wall and a drylined internal partition. This can occur with partitions of both solid construction (eg drylined block walls) or hollow construction (eg metal studwork walls). Air leakage audits have shown that both these types of wall provide an air path from within the building via the space behind the plasterboard forming the partition wall to the void between the drylined wall and substrate forming the external wall. To reduce the effects of indirect air leakage through internal partition walls abutting external walls, the following measures can be adopted.

- **Sealing partition walls to drylined external walls**
  It is important to maintain the air barrier where partitions meet drylined external walls. There are two approaches for achieving this.
  - Continue the drylining forming the surface of the external wall across the junction with the partition (Figure 7).
Fix the partition directly to the masonry wall and seal the plasterboard face of the partition to the masonry. Then seal the plasterboard forming the drylining of the external wall where it abuts the face of the partition (Figure 8).

It is not always possible to abut the plasterboard against the substrate of the external wall. In this case, the end of the partition will have to be sealed (Figure 9). Tests have shown that considerable air leakage can occur through the holes in the metal stud framing. Some twin-frame bracing systems may have an even larger free area through which indirect air leakage can occur. The openings in the end of the partitions can be closed off using an appropriate tape, a shaped closer piece or a vapour barrier. Can-applied sealants may not completely close the hole and can be an uneconomical method of reducing air leakage as the sealant will continue to fill the space between the frame and the external wall substrate. They may also expand beyond the width of the partition and require trimming before the wall boarding can be placed on the frame.

With both solid and hollow walls, sealing works will be required above suspended ceiling level and below raised floor level.

Timber-frame systems
The most common approach with timber-framed construction is to provide a vapour barrier between the plasterboard internal finish and the timber framing. If an impermeable vapour barrier (eg polyethylene sheet) is used timber-framed construction can be made airtight. Vapour control layers in the form of membranes and reinforced sheets are used in a wide range of construction types and are recognised as an effective air barrier material. It is important, however, to check with the manufacturer that a specific vapour control layer or breather membrane product will be suitable as an airtightness layer. Many products are colour coded so that their installation on site can be easily checked.

Most timber-frame systems used in the UK comprise large prefabricated units that are craned into position on site. Many arrive on site complete with the vapour barrier in position. Alternatively, it is installed on site. In either case, it is important to ensure that the vapour barrier is continuous and sealed at the perimeter, around openings for doors and windows, and around service penetrations. Also ensure that each unit is sealed to the next or where it abuts other construction.

One approach to sealing between units is to extend the vapour barrier at the edge of the unit so that the overlap can be sealed to the next unit. An alternative to providing a separate vapour barrier is to use a plasterboard that has a thin polyethylene film backing (duplex board). Where this is sealed to the framing it has been found to provide a high degree of airtightness. You should also ensure that the sole plate is sealed to the substrate. A mastic or similar sealant can be used for this.

Structural steel-framed systems
There is a range of different types of structural steel-frame systems on the market, all of which can be designed and installed to provide a high degree of airtightness. Most of the comments made about timber-framed systems apply to steel-framed systems. Again, it is important to avoid penetrations wherever possible and to remember to seal the bottom rail to the substrate.

Curtain walling
Generally, curtain-walling systems will provide a high degree of airtightness. However, just because curtain walling provides adequate weather protection it does not necessarily mean that the system is airtight. It is possible for air to enter hollow sections through drainage holes which can result in indirect air leakage. It is also important to ensure that draught-stripping used within the curtain walling will be durable for the life of the building or that it is of a design that can be replaced later. And no matter how good the curtain walling is, it is essential that the curtain walling is sealed to adjoining construction.

With many systems it is possible to design in seals that can be ‘zipped’ into the curtain wall framing and then sealed with an appropriate sealant to the adjoining...
Increasingly EPDM (Ethylene Propylene Diene Monomer) membranes are used for this purpose. The alternative is to follow the same approach as described for doors and windows.

**Profiled metal walls and roofs**

Where profiled metal sheeting forms the main air barrier and an unperforated liner sheet is being used, the liner sheet can be used as the air barrier. Where this is the case, sealing is needed between each sheet. There are currently two main methods of sealing between liner sheets: tape or butyl sealant.

Tape forms an effective seal but is prone to damage during the construction phase and its adhesion qualities can also be susceptible to weather conditions. On the other hand, testing has shown that butyl sealant results in marginally more air leakage than tape, but it is a more robust solution. In both cases, the seal is needed on both end and side laps (Figures 11 and 12). Typically, two continuous runs of butyl sealant are used for end laps between roofing sheets, the lower seal is primarily a weather seal and the upper seal is to prevent moisture entering the overlap from inside.

Check with the cladding manufacturer for advice on sealing. Tests have shown that very small air paths may be present over and under the butyl sealant when compressed. A run of sealant along the edge of the join can be used to increase the airtightness of the joint between liner sheets.

Where a perforated liner sheet is being used, a separate air barrier will need to be provided. This is often satisfied by using a well-sealed vapour control layer within the wall structure.

With profiled metal roofs it is common to provide a separate vapour control layer. With careful detailing and installation this can also double as the air barrier. All joints in the vapour control layer will need sealing, either using tape, gun-applied sealant or, where appropriate, heat welding. Heat-welded joints offer the best seal but it is important to check that the material is suitable for welding. You will also need to consider how the vapour control layer can be sealed around rooflights.

In deciding whether to use the vapour control layer as the air barrier you should consider:

- Can the vapour barrier sheet in the roof be linked to the air barrier system within the external wall construction, and where necessary to any internal walls separating conditioned spaces from unconditioned spaces?
- Are complicated linkages between the air barrier materials in the roof and walls necessary to do this?
- Will penetrations through the vapour barrier require sealing before the roof construction is complete?
- Where it is to be used within the wall construction, how effectively can sections of vapour barrier be linked together?

While profiled metal cladding has many advantages one problem is that along two sides of each sheet, whether in the form of built-up or composite systems, the profile results in trapezoidal gaps. Unfortunately, these are often replicated along considerable lengths of the external envelope or along walls separating conditioned spaces from unconditioned spaces. Generally, sealing works will be needed between roof and/or wall cladding and other components forming the general line of the air barrier, and at eaves level and vertical corners.

The best way to seal trapezoidal gaps is to use proprietary trapezoidal closers, which are designed to be air impermeable, are preformed to fit a range of profiles, and are easy to install (Figures 13). Even so, it is important to ensure that operatives understand why they are being installed, and to check that they have been correctly

**Remember!**

Where a perforated liner sheet is being used then a separate air barrier will need to be provided.
installed, particularly where they are less easy to access.

Even though trapezoidal closers are specifically made to fit certain profiles, testing has shown that the addition of an appropriate gun-applied secondary seal around their edge to seal them to the metal sheet and adjoining substrate will increase their airtightness (Figure 14).

While attention is often paid to detailing around service penetrations through metal cladding, it is important to consider sealing around structural members that penetrate the cladding (eg ‘I’ beams). These can often prove difficult to make airtight and will require bespoke seals to be manufactured.

**Roofs and services in roof spaces**

The detailing necessary for a roof will be largely determined by the location of the air barrier within it. The air barrier can either use the roof structure or it can be located at ceiling level, in which case the roof structure would fall outside the air barrier.

In cases where the roof structure is used as the air barrier, it will probably mean using a vapour control layer as the air barrier. As with all construction relating to the air barrier, all penetrations for services, vents, flues and chimneys will require sealing. In addition, attention will be needed to ensure continuity of the air barrier at eaves where the barrier transfers from the roof to the external walls.

It is common to use the ceiling as the line of the air barrier with pitched roofs. While it is generally easier to make the ceiling airtight, the roof structure service penetrations can pose problems. Large roof voids are obvious places to route or locate services. Water storage cisterns have traditionally been located in the loft space. These, together with electrical cables, soil and vent pipes and, more recently, ventilation ducts, all present a number of locations for air leakage through the holes and gaps around these services that pass through the ceiling into the loft space.

Loft hatches provide another location for air leakage. Warm moist air entering the roof space through gaps around services and around the loft hatch can result in condensation occurring on the cold surfaces within the roof so it is important to seal these gaps. You should seal around the loft hatch frame, draught-strip the hatch and provide catches so that the hatch compresses the draught-strip (Figure 15).

All service penetrations should be sealed including light fittings. Gaps around cables serving ceiling roses should be sealed from above, after the rose has been wired and before loft insulation has been laid. This prevents sealant displacement during wiring up when cables are often pushed back up into the roof space.

**Remember!**

Minimise the number of service penetrations through ceilings and roofs.

**Rooflights and solar pipes**

It is important to seal around large penetrations such as rooflights and solar pipes. Be aware that rooflights while weathertight may not be completely airtight. You should check with manufacturers details. Where a vapour control layer is used as the air barrier it can be dressed around and sealed to the rooflight frame (Figure 16).

**Vapour barriers and vapour control layers**

Vapour control layers in the form of membranes and reinforced sheets are used in a wide range of construction types and are recognised as an effective air barrier material. However, you should check with the manufacturer whether a particular product will be suitable as an airtightness layer. Polyethylene sheet is widely used as a vapour control layer or airtightness layer in timber-frame construction. Care is needed to ensure that the polyethylene sheet is not accidentally damaged by following trades. Reinforced sheets provide additional robustness where it is required and are far more likely to be used in larger buildings and for horizontal surfaces such as roofs. Reinforced vapour barriers can be used in built-up metal roof and wall construction as an alternative air barrier material to the liner sheet. It
is important that any damage to the polyethylene sheet is repaired before it is covered by following works (Figure 17). Some important points to consider are as follows.

- The use of the vapour control layer will be more effective if it is continuous around the walls and roof of the building (Figure 18). It is less likely to be continuous and unbroken in buildings with overhanging eaves where the liner sheet continues from inside to outside the building.

- Butyl strips may be used to seal between sections of vapour barrier. If small gaps remain along the length of the join, a secondary sealing strip may be appropriate.

- Heat welding may be used effectively to seal horizontal sections of vapour barrier, but currently it cannot be used to seal vertical sections of vapour barrier.

- Mechanical fixing of the vapour barrier to other components will not necessarily give an effective air seal. Small gaps along the length of the join are usually present. Comparative testing has shown that an additional gun-applied sealant will reduce air leakage through this type of joint.

- Where services penetrate the membrane, a rigid material will be required to which the vapour barrier can be sealed. For electrical services specify how the service will be supported and sealed to allow future removal or addition to the services without damage to the vapour barrier (Figure 19).

Suspended ceilings

Suspended ceiling systems generally comprise loose-fitting components that do not provide an airtight barrier. Where suspended ceilings are used, the air barrier will normally be incorporated within the roof above.

References and further reading

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GG 67 Part 2  
© BRE 2006  
February 2006  
ISBN 1 86081 901 X