Historic England

Energy Efficiency and Historic Buildings

Draught-proofing Windows and Doors

This guidance note has been prepared and edited by David Pickles. It forms one of a series of thirteen guidance notes covering the thermal upgrading of building elements such as roofs, walls and floors.

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Illustrations drawn by Simon Revill.

Our full range of guidance on energy efficiency can be found at:
www.HistoricEngland.org.uk/energyefficiency

Front cover
A brush pile seal being inserted into a window sash.
© Core sash windows.

Summary

This guidance note provides advice on the principles, risks, materials and methods for improving the thermal performance of existing windows and doors by draught-proofing. Draught-proofing is one of the most cost effective and least intrusive ways of improving the comfort of occupants and reducing energy used for heating with little or no change to a building's appearance. It also has the added benefit of helping to reduce noise and keeping out dust. Research has shown draught-proofing can reduce air leakage from windows by between 33% and 50%, therefore significantly reducing the heating requirement needed for the room.

Historic windows and doors make a major contribution to the significance and character of historic buildings and areas so every effort should be made to retain them rather than replace them. Windows and doors can tell us a lot about the history of a building, changing architectural taste and style, social hierarchy, building economics, craft skills and technical advances.

Older buildings are prone to heat loss through cracks and gaps which develop as various building elements move and distort over a long period. This is often the case for windows and doors which can be a major source of heat loss. However, less than a quarter of the heat lost through a typical traditional window escapes by conduction through the glass, the rest is by draughts (air infiltration). Since draughts make people feel colder, the occupants often turn up the heating and run it for longer.

Windows and doors should be assessed for repairs before embarking on any draught-proofing measures. Traditional windows and doors can almost always be repaired, even if in very poor condition.

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Introduction

Energy Planning

Before contemplating measures to enhance the thermal performance of a historic building it is important to assess the building and the way it is used in order to understand:

- the heritage values (significance) of the building
- the construction and condition of the building fabric and building services
- the existing hygrothermal behaviour of the building
- the likely effectiveness and value for money of measures to improve energy performance
- the impact of the measures on significance
- the technical risks associated with the measures

This will help to identify the measures best suited to an individual building or household, taking behaviour into consideration as well as the building envelope and services.

Technical Risks

Altering the thermal performance of older buildings is not without risks. The most significant risk is that of creating condensation which can be on the surface of a building component or between layers of the building fabric, which is referred to as 'interstitial condensation'. Condensation can give rise to mould forming and potential health problems for occupants. It can also damage the building fabric through decay. Avoiding the risk of condensation can be complex as a wide range of variables come into play.

Where advice is given in this series of guidance notes on adding insulation into existing permeable construction, we generally consider that insulation which has hygroscopic properties is used as this offers a beneficial 'buffering' effect during fluctuations in temperature and vapour pressure, thus reducing the risk of surface and interstitial condensation occurring. However, high levels of humidity can still pose problems even when the insulation is hygroscopic. Insulation materials with low permeability are not entirely incompatible with older construction but careful thought needs to be given to reducing levels of water vapour moving through such construction either by means of effectively ventilated cavities or through vapour control layers.

The movement of water vapour through parts of the construction is a key issue when considering thermal upgrading, but many other factors need to be considered to arrive at an optimum solution such as heating regimes and the orientation and exposure of the particular building.

More research is needed to help us fully understand the passage of moisture through buildings and how certain forms of construction and materials can mitigate these risks. For older buildings there is no 'one size fits all' solution, each building needs to be considered and an optimum solution devised.

Technical Details

The technical drawings included in this guidance document are diagrammatic only and are used to illustrate general principles. They are not intended to be used as drawings for purposes of construction.

Older buildings need to be evaluated individually to assess the most suitable form of construction based on a wide variety of possible variables.

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1 Repairing Windows and Doors

Figure 1
Historic glass should be retained in any programme of repair.
© Clive Murgatroyd.

1.1 Need to repair

All types of windows and doors will decay over time, so regular inspection and maintenance will always be a good investment. Before installing any draught-proofing to windows or doors, it makes sense to identify and make any repairs that are needed first. Straight-forward repairs can reduce air infiltration and heat loss by up to a third.

Many old buildings have distorted gradually over a long period owing to settlement and thermal movement. Older buildings can tolerate a surprising amount of movement so that windows and doors may have gradually adjusted to suit this re-alignment. Often the window sashes hold their shape better than their frames resulting in gaps and sashes sticking within the frame.

1.2 Repair or replace?

Traditional timber and metal windows and doors can almost always be repaired usually at a cost significantly less than replacement. Repaired originals will also have character and historic value which a replica window would not have. Total replacement of a window or a door even as an exact replica may require consent if the building is listed.

Historic glass should be retained in any programme of repair. Modern glass is made by a float process that produces precisely flat, optically perfect glass. Historic glass, which was produced by one of several different processes, has a quite different character. The imperfections in hand-made glass are a feature that makes many older windows so attractive.

1.3 Loosening stuck windows

Windows that are firmly stuck in place may have assumed a structural role and be taking the weight of the wall above. This is usually because a lintel has failed or moved. They should not be forced open as they might break and it has been known for parts of a wall to collapse when windows are opened. First assess what is happening structurally. If there is any doubt, insert props into the window frame before attempting to open them.

Particular care should be taken when removing a window frame for repairs. Even where the window is still operable, its frame may carry some structural loads. Some early 20th century bay windows were specifically designed to be structural.

Windows that are painted shut should be opened carefully, using sharp knives and only gentle pressure. Some windows and doors may have been discreetly nailed or screwed closed – these should be checked before using force.

1.4 Preparing to repair

Before windows are removed for repair they should be carefully recorded, at least with photographs and some basic measurements. Sashes, casements and other parts should be labelled to ensure that they go back in the correct positions. Before stripping many layers of accumulated paint, think about having a paint analysis. This might reveal information about the previous colour schemes which could inspire future paint schemes. If possible consider leaving a small section of existing paint layers ***in situ*** for future analysis.

The timber used in the past to make windows and doors was of a high quality and very durable. Many Georgian and Victorian windows are still in place today whereas modern softwood windows can need replacement after only twenty years. Repairing windows is the best way of maintaining the visual character and architectural significance of a building's elevation and can add to its value.

Before starting any upgrading work such as draught-stripping or the addition of secondary glazing, assess what repairs are needed to make the windows fully operational. Windows decay over time so regular maintenance, cleaning and painting is always a good investment.

For listed buildings, the total replacement of a window or door is likely to require Listed Building Consent.

Figures 2-3
Before installing any draught-proofing to windows identify and make any repairs that are needed.

Lead Paint

Lead paints can be harmful to health, particularly for children.

Lead based paints are often found on older buildings. Sometimes these paints have been over-painted. If there is any uncertainty about the presence of lead paint on windows that are to be stripped, it should be assumed that lead paint is present and precautions taken accordingly.

The use of lead paints has now been generally banned because of the hazard to health. However, there is an exception to the ban which allows them to be used on Grade I and Grade II* listed buildings. On those buildings the traditional appearance of the lead paint, together with its longevity and its fungicidal and insecticidal properties, mean that it is often still used. It should only be applied by professional decorators using appropriate protective equipment, and it is not recommended for use where it may be in the reach of children.

1.5 Repairing wood windows and doors

The base of doors and their frames are particularly susceptible to wet rot as are the lower horizontal rails and sills of windows but such decay can be repaired using carpentry techniques. Repairs will usually be weaker than the original joint and repaired sections may also expand and contract at slightly different rates, putting strain on the junctions and leading to cracks which may then foster further decay. Regular maintenance of repaired windows is particularly important.

The approach to the repair will depend upon the extent of the decay, the performance requirements, and the significance of the original material. If a window or door is historically or visually important, and not likely to be subject to heavy wear and tear, it is usually best to keep as much as possible of the original material and splice in sections of new timber. Where a decayed window or door is in poor condition and not important historically, it may be appropriate and more economical to replicate it completely in carefully selected, good quality new timber. The decision will depend on how effective and long-lasting the repair is likely to be. Repairs using epoxy resin can in many cases be used alongside carpentry repairs to prolong the life of doors and windows.

Paint analysis

Many surfaces in historic buildings have been over-coated many times during their history without stripping of the layers beneath. These layers form an important archaeological record.

Often a fragment of the surface coatings can be removed containing all of the accumulated layers. This composite piece can be sent away for analysis in a specialist laboratory, where each of the layers can be revealed by analysing the material and colour of each layer. This can reveal a wealth of information about the history and presentation of the building. In the past these techniques have led to the discovery of hidden wall paintings beneath plain surfaces. More frequently they provide the evidence to justify a change in presentation of the outside of a building from a modern paint scheme to a traditional scheme which has proven historical precedent.

Fragments of coatings sent for analysis need only be very small and should only be taken from an inconspicuous section of the window or door.

Figure 4 (top)
Metal windows can suffer from surface rust, distortion and excessive build-up of paint but they are capable of repair.

Figure 5 (above)
Leaded light windows can be difficult to make draught free and secondary glazing might need to be considered.

1.6 Repairing metal windows

Metal windows can suffer from surface rust, distortion, excessive build-up of paint, and failed hinges and fittings. Rust expands up to seven times the volume of un-oxidised metal, so corrosion often looks much worse than it actually is. Even windows which appear in a very bad state at first sight can usually be repaired.

Rust and paint can be removed by acid pickling or flame cleaning. Firms specialising in this can be found. Any necessary repairs to wrought iron or steel windows can be made by a metalworker welding in replacement sections. Cast iron windows cannot be welded because they tend to crack when heated, but they can be repaired using a technique known as 'cold stitching'.

1.7 Repairing leaded light windows

Leaded light windows are found in buildings from many periods. Their repair is a specialist task and should be approached with caution, particularly if the windows are particularly old and significant. A list of specialist contractors can be obtained from the Institute of Conservation (ICON). It may not be sensible even to attempt to repair leaded light windows to draught-free levels, but sometimes internal or external secondary glazing can be added to provide protection and draught-proofing.

2 Draught-proofing Rather than Double Glazing

Double glazed windows usually have sealed glazing units with two panes of glass separated by an air gap (typically of 12-18 mm) which improves thermal insulation, particularly if the glass is coated and the air gap is filled with an inert gas. It is an important development that has produced significant energy savings and reductions in carbon dioxide emissions, particularly in new buildings. The Building Regulations make double glazing practically compulsory in new building.

The replacement of existing windows with double glazed units can in many cases lead to a change in appearance, particularly the flatness of new glass and the need for thicker timber sections and glazing bars. The additional weight of glass (up to four times more than the weight of single glazing) and the balancing of the opening sashes pose added problems.

In historic buildings, there should be a strong preference for repair rather than replacement as the use of double glazing will often lead to a loss of significant historic fabric. Adding secondary glazing would often be the preferred option.

The benefits of double glazing over other methods of window repair are often over-estimated. Much of the comfort and energy efficiency benefits of new double glazing come from the reduction of draughts that will result from well-fitted window frames with integral draught-proofing. These benefits are also available through repair and draught-proofing of the existing windows, or from fitting secondary glazing.

In terms of noise reduction, the important criteria are that the windows are well fitted and draught-proofed. Secondary glazing, with its larger gap (ideally 100 mm) between the panes, is a better sound insulator. Shutters and heavy curtains also work well.

Further details on double glazing can be found in our publication: *Traditional Windows: their care repair and upgrading*.

3 Issues to Consider Before Draught-proofing

Figure 6
A fan pressurisation test is the most effective way of quantifying the amount of air infiltration and locating draughts that may not be immediately evident.
© Oxley Conservation.

Before embarking on draught-proofing a whole building, it is sensible to identify the extent of draughts and where they enter. A fan pressurisation test is the most effective way of quantifying the amount of air infiltration and locating draughts that may not be immediately evident (via cupboards, ducts and skirting and window boards). Temporarily taping around the windows during the test can show how much they leak. Smoke puffers can also show how big the draughts are and where they go. If the tests are repeated after draught-proofing has been carried out this will confirm its effectiveness and may highlight any areas missed.

Quantifying draughtiness

The draughtiness of a building depends upon the amount of air that can pass through its external envelope – walls, floor and roof. This is referred to as the air permeability. The industry standard is to express the permeability of a wall, roof, or whole building envelope assuming a pressure difference of 50 Pascals across the wall. The permeability is then measured as the amount of air (in cubic metres) that will pass in an hour through a square metre of wall (or roof, or floor) and expressed as $m^3/h/m^2$ (m^3/hm^2 or m/h) at a pressure difference of 50 Pascals (50 Pa).

While permeability is what causes draughts and ventilation, what is more important for the building and its occupants is the rate at which air moves through the building. This is most simply measured as the number of times that the air in the building changes each hour (written “ac/h” or sometimes “ach”). Again this will depend upon the pressure difference between the outside and the inside of the building, and again the industry standard is to assume a pressure difference of 50 Pa.

The relationship between these two measures is given by the following formula:

$$\text{Air changes per hour} = \frac{\text{Permeability x external surface area of building}}{\text{Internal volume of building}}$$

The conversion from air changes per hour at 50 Pa to air changes per hours under normal conditions (around 4 Pa) is complex, depending upon the location of the building, its orientation and its geometry. A very approximate rule of thumb is to divide the ac/h @50Pa by 20 to obtain ac/h (typical).

3.1 Maintaining Ventilation

Some degree of ventilation is essential for the fabric of older buildings which need to 'breathe' – releasing and absorbing moisture. Moisture from rising damp, driving rain, defects and condensation can move through traditional permeable building materials until it eventually evaporates both internally and externally through permeable surface finishes. Ventilation is critical to this mechanism. Whilst draught-proofing reduces air infiltration, older buildings can tolerate some draught-proofing and still have adequate ventilation for the fabric to continue to breathe satisfactorily.

In rooms being used for living and sleeping about 0.4 air changes per hour will be enough to ensure that the air stays fresh. Ideally some of this ventilation should be from controllable sources that can be closed when the rooms are not in use. New construction is often built to be as airtight as possible with controllable mechanical ventilation sometimes linked with heat recovery systems. Retrofitting mechanical ventilation systems into existing buildings can be very difficult, and potentially damaging.

For older buildings in reasonable condition, between 0.4 and 0.8 air changes per hour are recommended. Since air infiltration rates in many older buildings are greater than this, draught-proofing is normally beneficial.

In buildings that are effectively draught-proofed, water vapour may also need to be removed at source – particularly from kitchens, bathrooms and laundries – so that the vapour is not spread about the building. Some local air extraction (natural or mechanical) may be required in these areas.

Special care should be taken in rooms with open fires or other combustion appliances, to avoid depriving them of sufficient air. Specialist advice should be sought before sealing any rooms containing gas or oil burning appliances.

Unheated spaces, such as roof and sub-floor voids, are often designed to be cross-ventilated by outside air and should not be draught-proofed. Damp cellars may not benefit from draught-proofing either.

4 Draught-proofing and the Building Regulations

Standards for air-tightness for new buildings are wide-ranging in scope and apply to the whole building and not just for individual elements. There are no specific requirements for draught-proofing existing buildings, but Building Regulations will apply if:

- The doors or windows are beyond repair and there is no alternative to replacement , or
- The building is undergoing a 'change of use'

Where Building Regulations do apply, a dialogue will probably be required between the local authority Building Control Officer or Approved Inspector and the local planning authority to agree what works would be acceptable and what would require permission. Upgrading existing windows by adding effective draught-proofing, or where new windows are required, replicating the historically/architecturally important single glazed windows enhanced by draught-proofing, might form part of a compromise reached to improve the energy efficiency of a traditional building whilst retaining its historic significance.

5 Draught-proofing Products

This guidance describes generic draught-proofing products and how they can be used. Always check the manufacturer's own instructions to be sure that the product is suitable for the application. Choosing the right products for draught-proofing can be difficult. When windows and doors are often distorted many products will not work effectively as they can only deal with a specific range of gap widths. Some products are also applied to the surface of a door or window frame, while concealed solutions are generally more suited to historic buildings.

When choosing a draught-proofing product the following should be considered:

- How big are the gaps to be sealed?
- How variable is the width of the gaps?
- Does allowance need to be made for seasonal expansion and contraction of the door or window?
- Is it important that the draught-strip is not seen? What about when the window is open?
- Does the draught-strip need to match the colour of the frame? Painting the flexible part of a seal is not recommended as it changes the characteristic of the product
- Will the draught-strip be renewed every time the door or window is redecorated? If not, it will either need to be capable of being removed and reinstalled after decoration
- There is a British Standard (BS7386) which covers the quality of draught-proofing products. Specifying and purchasing products that meet that benchmark will help ensure minimum standards are met

There are two main types of draught-proofing seals:

- Compression seals
- Wiper seals

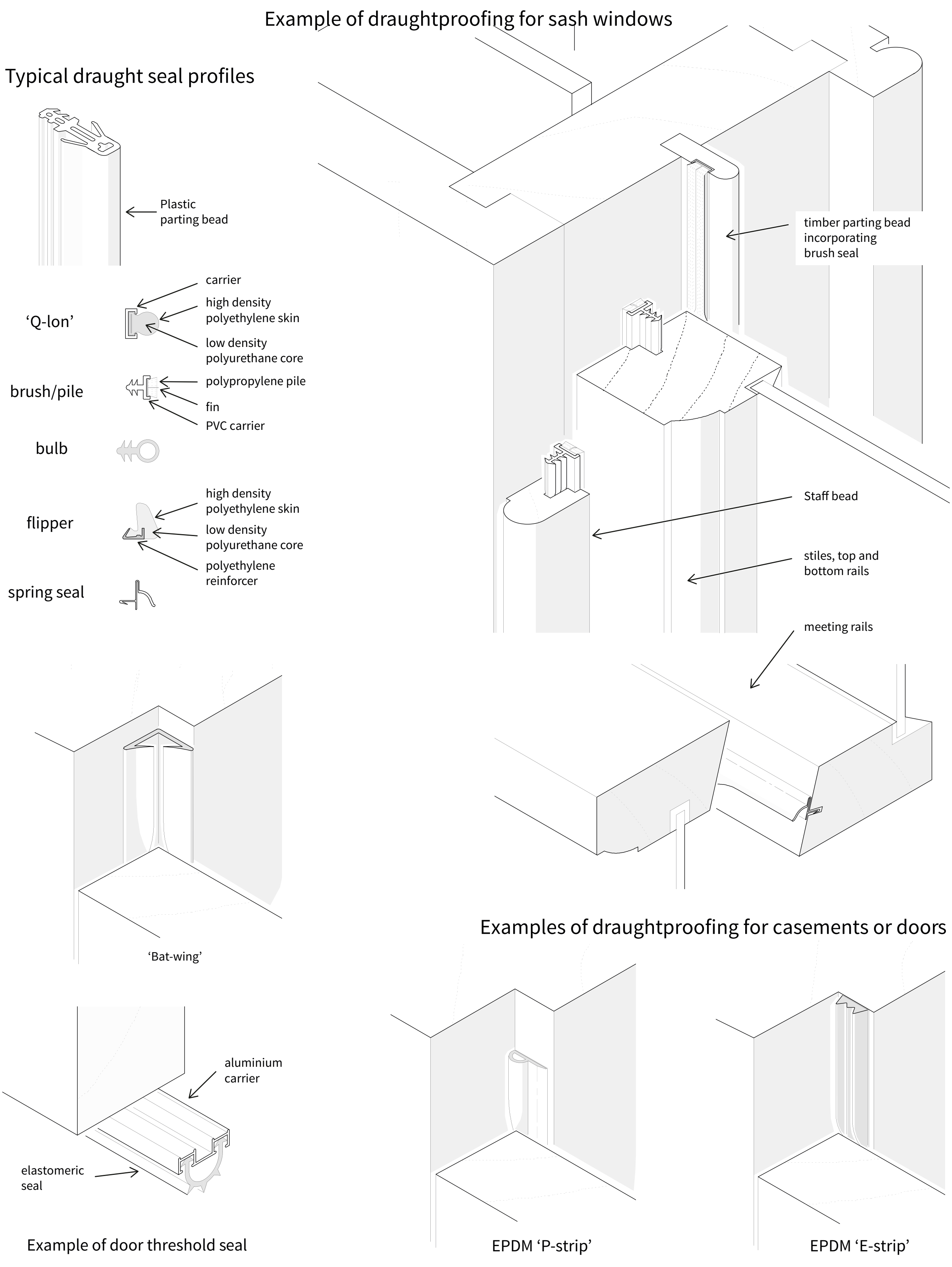

Figure 7
Draught-proofing options for sash windows.

5.1 Compression seals

Applications

Compression seals are used where the moving part of the door or window closes against the frame. Typical applications include around the sides and top of a door or around the entire edge of a casement window. Compression seals can also be used along the bottom and top rails of a sash window.

Compression seals are usually quite cheap and easy to install. They are most appropriate for sealing narrow, even gaps. They require some compression to be effective, but cannot be compressed too far, so a given size of seal therefore only works on a narrow range of gaps. This makes them difficult to fit to casements and doors with some warping because of the variation in gap thickness.

Since compression seals are typically mounted to abut the face of a casement or door they are relatively unaffected by the effect of seasonal expansion and contraction of doors and windows.

Materials

Compression strips are available in a range of materials. The simplest to install are self-adhesive strips of EDPM rubber. These are available in a variety of profiles and thicknesses to cater for different gap widths. Foam strips are cheaper still but have a short life.

Silicone and EDPM “O” tubes are available in a variety of diameters. Some attach to the frame using an adhesive others come on a carrier strip that is either attached to or cut into the frame.

V-shaped silicone and EDPM seals are an alternative that can bridge a greater range of gap sizes.

Silicone is taking over from EDPM as the material of choice for compression strips because it is available in a range of colours, including white. Brush pile seals, more typically used as wiper seals and described below, can also be used as compression seals.

For metal windows, particularly those with irregular gaps, a silicone gel or polymerised rubber can be used to create a compression seal. The gel is applied from a tube onto the frame. Non-stick tape or more usually grease is applied to the meeting surfaces of the window, which is then immediately closed to squeeze the sealant into a perfect fit. When the sealant is dry (a few minutes), the window is opened, the seal trimmed, and the release tape or grease removed.

5.2 Wiper seals

These are used when the moving parts slide past each other.

Applications

Wiper seals are the only way of sealing the sides and meeting rails of sliding sash windows and sliding doors.

Wiper seals can also be fitted to the edges of casement windows or doors. Here they can still work, even when the window or door is moderately warped.

Wiper seals are frequently used at the base of doors where they are attached to the face of the door. Door threshold seals are also available that fix to a groove in the door and/or the threshold beneath the door. These require a relatively even gap and a smooth surface to make a good seal.

Materials

The most common wiper seals are brush pile seals. These are capable of sealing a range of gap sizes, and adapt to fill uneven gaps well. Some include a thin plastic fin or fins in the centre to make a better seal.

Other wiper seals are made of silicone or thermoplastic strips where a heavy duty seal is needed. V-strip wiper seals are also available, and can be used between the stiles and boxes of sliding sashes.

Some wiper seals are supplied with a simple backing strip for gluing or pinning to a window frame. Others require a narrow groove cut into the wood into which the base of the seal is pushed.

Figure 8 (top)
Brush pile seals added to a sash window.

Figure 9 (middle)
Brush pile seals can be inserted into window and door beads.
© Core sash windows.

Figure 10 (bottom)
A brush pile seal being inserted into a window sash.
© Core sash windows.

Figure 11 (top)
Secondary glazing can provide very effective draught-proofing as well as improved thermal efficiency.

Figure 12 (above)
Shutters can be draught-stripped which will minimise heat loss when the shutters are closed at night.
© Linda Hall.

5.3 Secondary glazing

Secondary glazing is sometimes chosen more for its draught-proofing qualities than for thermal and noise insulation; particularly where other solutions are not feasible, for example when gaps are too large to seal, the windows are too significant to alter, or to protect stained glass. If secondary glazing is installed, the original windows should not be draught-proofed to help avoid condensation occurring.

5.4 Draught-proofing shutters

Shutters can also be draught-stripped using the same products as above. This will minimise the heat loss when the shutters are closed, usually at night. However, this is of limited benefit:

- Draught-proofed shutters will add little benefit to draught-proofed windows. As the windows will be closed more often than the shutters, the windows should receive priority
- Shutters spend much of their time folded back, and are often visible when they are not in use. Visible shutters are frequently important to the look of the exterior or interior of the building. It is difficult to hide a draught-strip in both the open and closed positions
- Many shutters were designed to control light and privacy, not heat loss, for example to darken rooms for sleeping, to reduce solar gain in summer, or to protect delicate contents from ultra-violet light. Some have holes to allow ventilation when closed

6 Where to Get Advice

This guidance forms part of a series of thirteen documents which are listed below, providing advice on the principles, risks, materials and methods for improving the energy efficiency of various building elements such as roofs, walls and floors in older buildings.

This series forms part of a wider comprehensive suite of guidance providing good practice advice on adaptation to reduce energy use and the application and likely impact of carbon legislation on older buildings.

The complete series of guidance is available to download from the Historic England website: HistoricEngland.org.uk/energyefficiency

Roofs

- *Insulating pitched roofs at rafter level*
- *Insulating pitched roofs at ceiling level*
- *Insulating flat roofs*
- *Insulating thatched roofs*
- *Open fires, chimneys and flues*
- *Insulating dormer windows*

Walls

- *Insulating timber-framed walls*
- *Insulating solid walls*
- *Insulating early cavity walls*

Windows and doors

- *Draught-proofing windows and doors*
- *Secondary glazing for windows*

Floors

- *Insulating suspended timber floors*
- *Insulating solid ground floors*

For information on consents and regulations for energy improvement work see historicengland.org.uk/advice/your-home/saving-energy/consent-regulations/

6.1 Contact Historic England

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