Historic England

Energy Efficiency and Historic Buildings

Secondary Glazing for Windows

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

Front cover
Slim profile secondary glazing used in conjunction with opening shutters.
© Storm Windows.

Summary

This guidance note provides advice on the principles, risks, materials and methods for upgrading the thermal performance of windows by the addition of secondary glazing. Older windows can often be draughty as over time they distort and gaps open up as joints become weakened. Although adequate ventilation is important in older buildings, excessive air leakage through windows is uncomfortable for occupants and wastes heat.

Secondary glazing when carefully designed and installed allows the original windows to be retained unaltered, and where necessary repaired, whilst reducing air leakage and conducted heat losses. As a result there is no loss of historic fabric and in most cases the installation is easily reversible.

Research has shown heat losses by conduction and radiation through a window as a whole can be reduced by over 60% by using secondary glazing with a low emissivity (Low-E) hard coating facing the outside. The research has also shown that further savings can be made if the secondary glazing uses insulating frames or incorporates double glazed units. Besides increasing the thermal performance of windows, secondary glazing unlike double glazing can have a number of other benefits including being highly effective at reducing noise.

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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 What is Secondary Glazing?

Secondary glazing is a fully independent window system installed to the room side of existing windows. The original windows remain in position in their original unaltered form. Secondary glazing is available as openable, removable or fixed units. The openable panels can be either side hung casements or horizontal or vertical sliding sashes. These allow access to the external window for cleaning and the opening of both the secondary glazing and external windows for ventilation. Fixed forms of secondary glazing are designed to be removed in warmer months when the thermal benefits are not required.

Figure 1
A 19th century secondary glazing arrangement comprising two sets of bouble hung sashes.

Secondary glazing is nothing new, in the 19th century some buildings were constructed using a second double hung sash window or solid panels with counterbalancing weights fitted in the space below the window. Their function was to cut down the heat loss and provide some measure of acoustic insulation to the window opening.

The use of glazed external protection for windows using either glass or plastic sheet is referred to as ‘storm glazing’ or ‘isothermal glazing’ rather than secondary glazing. This method is often used to protect stained glass in churches.
With this system it is important to understand the potential conditions this creates in the airspace between the existing glazing and the additional external glazing where ventilation will be required. Account should also be taken of the environmental conditions inside the building before designing the installation. One option is to install storm glazing in the winter months and remove it in the summer months.

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.

Figures 2-3
Before starting any upgrading work such as draught-proofing or the addition of secondary glazing, assess what repairs are needed to make the windows fully operational.

1.1 Repairing existing windows

Traditional timber and metal windows can almost always be repaired, even when in very poor condition and normally at significantly less cost than complete replacement. The timber used in the past to make windows 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 is likely to require Listed Building Consent.

1.2 Secondary glazing or 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.

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

The benefits of double glazing over other methods of window upgrading are often overestimated. Much of the comfort and energy efficiency benefits of new double glazing come from the reduction of draughts that result from newly-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. With continual improvements in the performance of secondary glazing it may even be possible for the performance of secondary glazed windows to exceed that of new double glazing.

In terms of noise reduction, the important criteria is that the windows are well fitted and draught-proofed. Secondary glazing, with its larger gap between the panes, is a better sound insulator. Shutters and heavy curtains can also make significant improvements to noise insulation.

1.3 Secondary glazing or draught proofing?

Draught-proofing is usually the first option to consider for improving the thermal performance of windows in an older building. As windows are often a major source of air infiltration, draught-proofing is one of the best ways of improving comfort and reducing energy use, with little or no change to a building's appearance at minimal cost.

However, secondary glazing can provide a considerably higher thermal performance than draught-proofing alone. It may also be chosen where installing draught-proofing seals to the windows is particularly difficult. Similarly many metal-framed windows have gaps that are too large to seal. Windows with leaded lights may allow air infiltration around the lead which can only be satisfactorily addressed with the addition of secondary glazing.

Depending on the building's use, location and the occupants' comfort requirements other benefits of secondary glazing, such as noise reduction, may have a bearing on the design solution.

If secondary glazing is the preferred solution then the outer windows are best left without draught-proofing so that there is a degree of ventilation to the air space between the outer windows and the secondary glazing to prevent the build-up of condensation.

Figure 4 (top)
Draught-proofing should be the first option to consider for improving the energy efficiency of windows in an older building.
© Core Sash Windows.

Figure 5 (above)
Secondary glazing can provide considerably higher thermal performance than draught-stripping alone.

2 The Benefits of Secondary Glazing

Although the primary purpose of secondary glazing units in older buildings is to improve the thermal performance of windows by draught-proofing as well as reducing the conduction of heat through glass, secondary glazing can provide a number of other benefits.

2.1 Thermal benefits

Heat loss from a room through a window during the heating season is complex as three main mechanisms are in play:

- By convection and conduction, from the warm room air to the colder surfaces of the glass and the frame
- By the colder surface of the window absorbing infra-red radiation from the room
- By uncontrolled air leakage, which can either bring in cold air from the exterior or take warm air out from the interior; often called air infiltration, this can occur even when the window is closed

Heat loss through the glass and frames

Whether it leaves the room by convection, conduction or radiation, the lost heat all passes through the glass and the frame as conduction. The glass is the most conductive part of the window but heat is also lost through the frame albeit at a lower rate.

Single glazing is a poor thermal insulator and readily conducts heat. A typical 4mm thick glass has a typical U-value of 5.4W/ m^2K. The thermal loss through a single glazed window will depend on the total area of glass, the conductance of the frame material and the quality of the fit of the framing and glazing materials. A typical value of a timber framed single glazed window is 4.8W/ m^2K.

For thermal performance, the optimum airspace between panes is 16-20mm. A larger air space allows convection currents to develop within the cavity and more heat to be lost. The positioning of the secondary unit is usually dictated by the window reveal and can often only be fitted at a distance of about 100mm from the primary glazing. However, a significant proportion of the thermal benefit of secondary glazing comes from decoupling the frame from the primary timber moving parts and frame and this can reduce the U-value to approximately 2.5W/ m^2K. The use of low emissivity glass for the secondary glazing can further improve the thermal performance to less than 2.0/ m^2K. To maintain this figure it is important to keep the coating clean – the standard is ‘visually’ clean.

Heat loss through air leakage

Heat losses from a typical traditional window are predominantly through gaps around the window. With larger windows the proportion of heat lost by conduction through the glass tends to be greater.

Since draughts, caused by convection and air infiltration make people feel colder, the occupants may turn up the heating and also run it for longer. Purpose-made secondary windows with efficient perimeter sealing (to prevent condensation on the primary window) and brush or compression seals on the opening panels, form an effective seal over the whole of the frame of the original window and can significantly reduce excessive draughts.

Before embarking on a programme of draught-proofing, think about a fan pressurisation test to find out the sources of air infiltration and determine which windows need attention as they can vary considerably in the amount of draughts they let in.

2.2 Noise insulation

Windows are one of the most vulnerable parts of a building to noise transmission due to their relatively lightweight construction. Depending on the number of openings and the quality of the seals between the openings, a single glazed window without seals may only achieve a noise reduction of 18-25dBA.

A secondary window with an air space of 100mm or more de-couples the movement of the two panes of glass and reduces the resonance between the two. Sound insulation of up to 45dBA can typically be achieved. Higher levels of sound insulation are obtained as the gap increases particularly if the reveals are lined with an acoustic material, though minimal improvements occur with cavities beyond 200mm. The use of thicker or acoustic laminate glass within the secondary window also improves the acoustic performance of the installation.

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 draughtiness 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). 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 too complex to explain here. In one building a real 0.8 ac/r was equivalent to 14 ac/h (50Pa).

Condensation

All air contains some water vapour, but warm air can hold more vapour than cold air. When warm, damp air is cooled it will reach a temperature at which is cannot hold all the vapour, and the water will condense out. This temperature is called the dew point.

Warm damp air passing over a cold surface may be cooled locally below the dew point in which case condensation will take place. This effect causes the familiar condensation on the inside of cold windows.

Condensation on the outer window may arise if the secondary system is opened for ventilation in cold weather particularly where rooms are relatively humid.

These condensation risks will be minimised where the secondary glazing is either:

- able to be kept closed in cold weather, because there are alternative means of ventilation- older buildings commonly have adequate ventilation from other parts
- located where the normal direction of air flow is from outside to inside, for example on the windward side of a building, on the lower floors or where a designated natural or mechanical extraction system helps to ensure in ward airflow
- fitted with devices which avoid reverse air flow in adverse circumstances
- where the primary and secondary assemblies incorporate some alternative means of ventilating between the exterior and the room interior but bypassing the cavity between the primary and secondary glazing

2.3 Protection from ultra violet light

Ultra Violet (UV) light from the sun can cause extensive damage to paintings, fabrics, furnishing and other objects. The use of a film either in laminated glass in the secondary glazing unit or applied as a film to the primary window, will absorb UV light and reduce this risk of damage.

2.4 Solar gain

Windows can admit large amounts of solar energy leading to overheating. Secondary glazing can make this worse if they restrict summertime ventilation. However, curtains or blinds, glare coatings and summer ventilation of the air space can be used to help make the room cooler during the day. Some secondary glazing systems can be taken down in the warmer months.

2.5 Security

A second window provides an additional barrier to entry and therefore can provide improved security. This can be particularly appropriate when the use of an historic building is being changed and a higher degree of security is required. The secondary glazing can provide that additional security whilst retaining the existing windows.

3 Secondary Glazing Systems

3.1 Materials

When selecting secondary glazing units for a building it is important to use a system in keeping with the design and materials of the room. There are several proprietary secondary glazing systems available which provide installations that are configured to suit the particular needs of the building.

Proprietary systems normally have painted aluminium frames. This allows the design of slim-profile systems that can fit within the depth of the staff bead of a typical sash window so shutters and window sills can be retained. Systems with more substantial framing sections are stronger and can accommodate seals, fixings and counterbalancing. The systems may use an aluminium outer frame fitted to a softwood ground or seasoned hardwood surrounds depending on the design and fixing details. The suppliers of these systems provide design, manufacture and installation services.

Alternatively, a bespoke system can be designed comprising a sub-frame, commonly of timber, into which opening casements or sliding sashes are fixed. Individual glazed windows can be hinged so that they fold up like shutters or operate like sash windows.

Figure 6 (top)
Horizontal sliding secondary sashes used with a leaded light window.
© Selectaglaze.

Figure 7 (above)
Vertical sliding secondary sashes used with a double hung sash window.

3.2 Sliding systems

Horizontal sliding systems comprise two or more panels running on glide-pads or rollers for larger windows, with the panels sliding within the frame. Most panels can be easily removed by lifting into the head frame and swinging them out.

On vertical sliding systems, the two panels slide within the frame. Some operate on spring balances which fully support the weight of the sash and those that do not can be difficult to operate and are only suitable for very small windows. For sash windows they usually have the upper sash innermost, to improve operability and allow the latch on the primary sash to be reached more easily. Tilt-in vertical sliding systems allow the sashes to hinge inwards for cleaning. Restrictor stays and braking mechanisms to inhibit sliding in the open position can be fitted.

These styles are suitable where regular ventilation is required.

3.3 Hinged systems

Hinged casements are available as single or double leaf with the frame dimensions dependent on the window size. Casements are often fitted with restrictor stays.

This type of system is frequently used where the whole window is to be covered to avoid any sightlines on the secondary unit.

These work well for large panes, where high compression seals are required to optimise noise insulation or to minimise airflow, or where full access is required for cleaning/maintenance or to provide a means of escape. In situations with security demands, multi-point locking make can be used.

These styles are suitable where regular ventilation is required. Since the sash projects into the room when opened for ventilation this may create a safety hazard. A stay can be fitted to hold the window open at a preset minimum.

3.4 Lift outs

These are best used for windows that are fixed or seldom opened and where access is only occasional necessary for cleaning. They are also useful for windows of unusual shapes.

Where it is proposed to remove secondary glazing it is advisable to have dedicated storage available and a system of numbering/identifying them so they go back in the same order.

3.5 Removable

A lightweight and easy to remove system is a magnetic secondary glazing system. Multi-polarised magnetic strips fitted to UV stable clear cast acrylic combine with opposite magnetic strips on the edge of the window frame to hold the panel in place.

3.6 Fixed

Fixed panels are useful where no access is required or in combination with other opening panels. Careful consideration needs to be given to how to access the glass and the cavity space to clean and maintain. With fully fixed panels to avoid the risk of condensation within the cavity can be reduced by providing vents in the secondary glazing unit.

3.7 Shaped

There are limitations but it is possible to shape all styles of secondary glazed units to the shape and style of the external window.

Figure 8 (top left)
Side hung casement secondary units fitted to double hung sash window.

Figure 9 (top right)

Fixed secondary units added to high leaded windows.

Figure 10 (bottom left)
Curved headed secondary casements.

Figure 11 (bottom right)
Special secondary glazing units can be made.

4 Installing Secondary Glazing

Secondary glazing can have minimal visual impact if carefully planned. The design should seek to be as discreet as possible with small frames concealed from view from the outside and unobtrusive internally.

There are many different ways of installing secondary glazing to a window opening. Consider the designs and specifications as early as possible in the project to ensure a successful result. A good way to start is to contact one of the specialist companies who offer help and advice on the proposed installation.

Whilst the framing material may be lightweight glass is deceptively heavy, 10Kg/m^2 for 4mm thick panes and 15Kg/m^2 for 6mm. Manufacturers provide guidelines for size and weight limitations for the safe handling of the proposed secondary glazing unit.

In the design process the following is an indication of the type of factors to be considered with key issues being the minimisation of damage and ease of use. The purpose of the installation will guide the fixing position and type of glass specified.

Figure 12
Vertical sliding secondary sashes used with a cast iron window.
© Selectaglaze.

Figure 13
Secondary glazing carefully incorporated with window reveal panelling.
© Selectaglaze.

4.1 Existing window design

The design of the original window can be used to determine the style of the secondary glazing to be installed. The dimensions of the primary window are fixed but the secondary glazing can be designed into manageable sized units.

4.2 Physical constraints

Secondary windows are usually located immediately inside the existing sashes or at a suitable position within the depth of the window reveal. A survey of the existing window opening by the specialist company will identify the limitations, for example whether there is sufficient depth in the reveal to locate the secondary glazing.

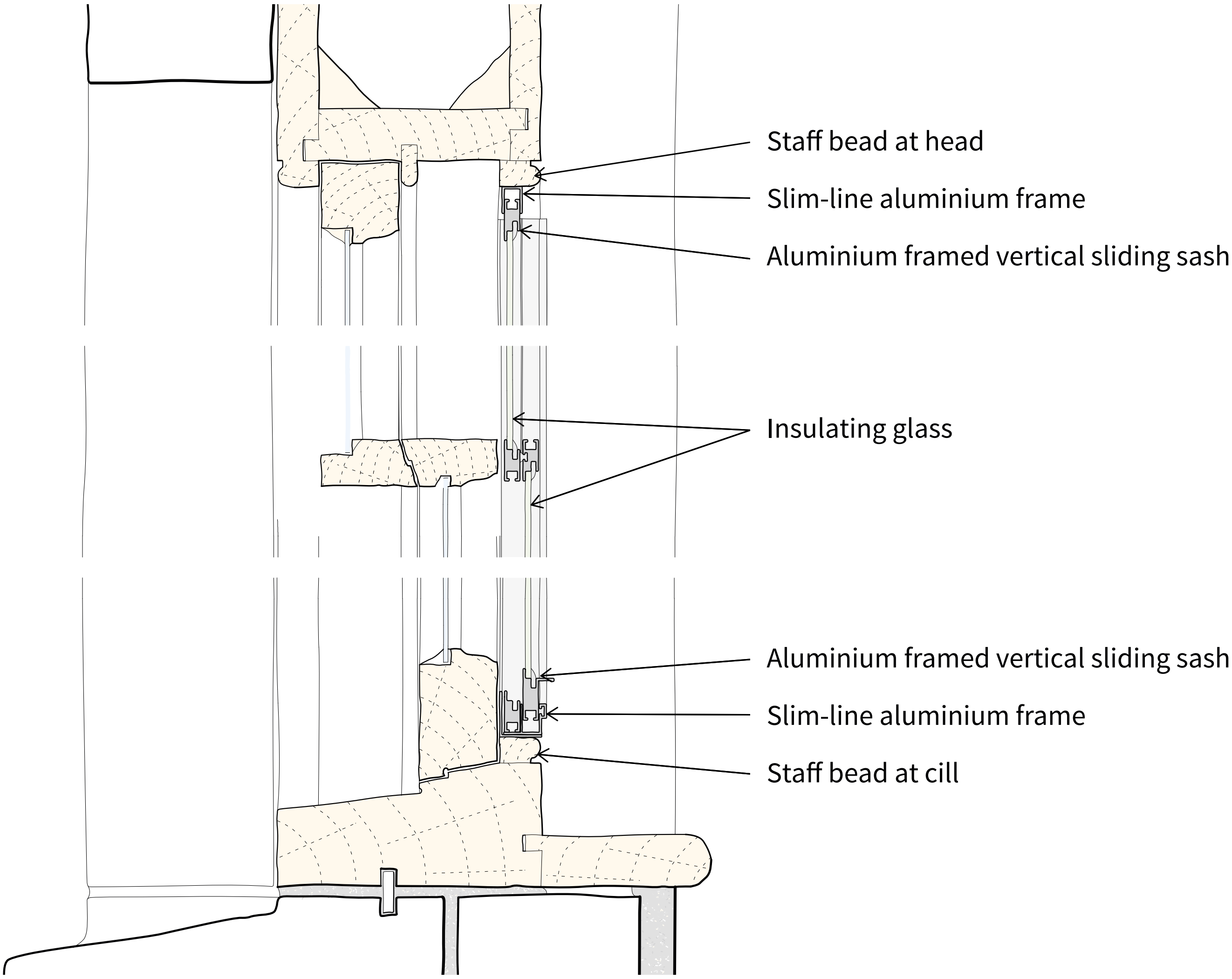

Figure 14: Slim-line secondary glazing fixed within depth of staff beads (allows continued use of shutters)
Where shutters are in use, secondary glazing can be incorporated by fitting slim units within the depth of staff beads. In this situation a casement opening arrangement would allow easy cleaning of the outer window.

4.3 Shutters

Where shutters or other joinery are present, careful thought will be required. Sometimes secondary glazing can be positioned between the primary window and the shutters so that the shutters still function. If the shutters are housed within the window reveal it may be possible to install secondary glazing on the room side of the shutters. If the secondary glazing cannot be inserted without making the shutters inoperable the shutters could be fixed shut but not altered so that they can be brought back into use at a later date.

4.4 Visual impact

Secondary glazing can be visually intrusive externally and internally if badly designed. To minimise the visual effect of secondary windows externally, try to make sure the secondary glazing is not smaller than the glazed area of the existing window. Try to place any divisions in the glazing behind the window meeting rails or glazing bars. The flat reflections of modern glass within secondary glazing can be minimised by using anti-reflective glass.

Figure 15 (left)
Slim profile secondary glazing used in conjunction with opening shutters.
© Storm Windows.

Figure 16 (centre)
A secondary glazing unit colour matched to the primary window for minimal impact.
© Selectaglaze.

Figure 17 (right)
Secondary glazing added to these windows makes no visual impact externally.
© Selectaglaze.

4.5 Ventilation

The original window should not be sealed so there is some ventilation to the air gap to limit the risk of condensation on the inner face. The secondary glazing unit should be well sealed.

Removable secondary glazing can be taken down in warmer weather to allow full operation of the original opening windows. Dedicated storage space will be required or they are likely to get damaged.

Adequate room ventilation must be maintained with secondary glazing. This may require trickle vents to be fitted. Air movement is important in traditional buildings to allow the fabric to 'breathe' – the release and absorption of moisture. The moisture may enter the fabric from external or internal sources and move through the traditional permeable building materials, until it eventually evaporates both internally and externally through traditional surface finishes. It is important there is sufficient ventilation to allow this evaporation to take place. As a rule of thumb in a traditional building this is about 0.8 air changes per hour – twice that recommended for a modern building.

The air infiltration rate in many traditional buildings is often more, so secondary glazing is normally beneficial in reducing draughts. However, the maintenance of adequate ventilation rates for the health of the building and its occupants is essential. The need to remove water vapour at source – particularly from kitchens, bathrooms and laundries – and not let it spread about the building unnecessarily needs to be assessed. 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. The draw of stoves and open fires should be checked after installation of secondary glazing. Specialist advice should be sought before sealing any rooms containing gas or oil burning appliances.

Special care should also be taken in damp buildings. Usually the dampness originates from a defect, for example a blocked gutter, which needs to be tackled first. Only after the faults have been repaired and the building dried out with the assistance of good ventilation, should one begin to think of secondary glazing.

4.6 Maintenance

It is important that secondary glazing should not prevent access to the original glazing or cavity for maintenance and cleaning. The size, weight and design of the secondary window should allow this to happen with ease. The secondary window itself will also need to be cleaned.

On completion of an installation, the suppliers should provide a maintenance manual for the secondary glazing, with instructions for cleaning, lubrication of locks, hinges and rollers and tension adjustment of spring balances.

Some specialist secondary glazing companies can offer a service to remove, clean and re-instate the secondary glazing.

4.7 Secondary glazing and the building regulations

Thermal regulations

The Part L Approved Documents set U-value standards for windows but these will only apply to existing buildings:

- If the windows are beyond repair and there is no alternative but to replace them or,
- If the building is undergoing a 'change of use'

The Part L Approved Documents (2010) standard for windows is 1.6W/ m^2K. This performance figure can be achieved when secondary glazing with low E glass is used in combination with the primary window. Thus secondary glazing offers the opportunity to improve the energy efficiency of an older building whilst retaining its historic appearance and significance. If double glazed secondary glazing is used then a significantly lower U-value can be achieved.

Under Controlled Fittings, Clause 4.19 suggests where there is a need to maintain the external appearance of the façade or the character of the building, existing single glazed windows be supplemented with secondary glazing fitted with low-e glazing.

Safety regulations

The Requirement N1 of the Building Regulations will dictate the type of glass to be used in critical locations as identified by the Approved Document.

For further information on windows see our publication *Traditional windows their care, repair and upgrading*.

5 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/

5.1 Contact Historic England

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