

Historic Buildings & Energy Efficiency

A Guide to Part F of the Northern Ireland Building Regulations 2006

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INTRODUCTION

This booklet has been prepared by Northern Ireland Environment Agency: Built Heritage (NIEA: BH) to provide guidance on how to comply with Part F of the Northern Ireland Building Regulations in regard to historic buildings.

NIEA is an agency within DOE and is committed to its aim to improve energy efficiency whilst also ensuring that the new Part F is exercised in a way that does not harm the special interests of historic buildings. Part F recognises the special circumstances of historic buildings. A sensible and reasonable approach should achieve a practicable improvement, although not always to the recommended standard.

The reuse of historic buildings is by its nature energy efficient as the energy required for the manufacture and transport of materials in new construction is saved. This is known as “embodied energy” and can offer a significant reduction in energy use and carbon emissions.

What triggers the Part F Requirements?

For existing buildings, Part F generally requires energy conservation upgrading only for elements which are to be ‘substantially replaced’ as part of the works. The requirements do not apply to normal repair and patching work. While a ‘material change of use’ could trigger wider-ranging upgrades, Part F states that consideration would be on individual merits and would need to take account of historic value.

Other requirements

This booklet relates to Part F only, work may also have to comply with other relevant building regulations.

Early Consultation

An early dialogue with Building Control and an NIEA Conservation Architect is recommended when dealing with a listed building. On other historic buildings, the Conservation Officer, based in your local Divisional Planning Office, should be contacted.

Who should use this guide

The guide has been written for those who would normally refer to Part F technical guidance notes. However, it has also been written to be a useful source of information for anyone considering works to improve the energy efficiency of a historic building.

Good practice guides

Additional guidance may be sought from the following:

English Heritage publication: A Guide to Part L of the Building Regulations.

Good practice guide 171 Housing Energy Efficiency: Best practice programme. These guides are not written with historic buildings in mind but offer a useful background to energy saving techniques.

Thermal Insulation: Avoiding risks. BRE Report No 262. This analyses the potential problems in achieving a balance between heating, insulation and ventilation.

Robust Details. DEFRA and DTLR. This publication, although not written for Historic Buildings, provides a useful guide to the technical principles discussed in Part F.

Thermal Insulation: Avoiding risks. Stirling, 2002 3rd ed., London: CRC Ltd.

SECTION A GENERAL PRINCIPLES

1. PRINCIPLES OF REPAIR AND ALTERATION TO HISTORIC BUILDINGS

1.01 The sensitivity of the historic fabric varies from building to building and within buildings. It is essential that a methodical approach is taken to assessing the impact of proposed interventions.

Conservation plan

1.02 It is recommended that a Conservation Plan be prepared. It should address all points of interest in the historic fabric

- (a) external features
- (b) spaces and layouts
- (c) internal features
- (d) historic features
- (e) technological interest

Core principals for intervention

There are core principles looked for by NIEA:PHB in any intervention in a historic building. Based upon international conventions, these are

1.03 maximum retention of existing fabric
Replace existing fabric only where really necessary, for example, replace only the decayed portions of structural timber rather than an entire joist or truss.

1.04 minimum intervention
Have a conservative approach.

1.05 reversibility
If mistakes are made, the ability to undo work and bring the fabric back to its original state is invaluable.

1.06 legibility of new work against the existing is usually preferable.

Irreversible interventions such as spraying insulation onto the underside of historic roofs or into voids should be avoided.

1.07 sustainability

The advantage of using traditional materials is that data is available on their long term performance. This can be important when replacing elements in buildings which are themselves over 100 years old.

1.08 take a holistic approach

- (a) Understand the existing environmental response of the fabric;
- (b) Ensure the way the building responds is not compromised by the alterations; and
- (c) work with existing fabric.

In addition the Conservation Plan should consider

- (a) compatibility between new and older materials
- (b) use of materials

Modern materials should be used with caution. They can have an adverse reaction in contact with historic fabric. To use modern substitutes and to introduce impermeable materials or membranes into permeable traditional construction is usually not good practice and can lead to trouble. Obvious examples include the use of cementitious mixes for plasters, renders or pointing, where incompatibilities in flexural strength, permeability and porosity can lead to disastrous salt migration and damage.

As a general rule, materials and techniques designed for new construction should be used with care and if possible, avoided, as their long term or side effects on a building or its occupants may not be fully understood. That said, some new synthetic or natural materials used thoughtfully and skilfully, e.g. permeable insulation, can facilitate the most conservative and economical work.

Bear in mind any contribution their manufacture or use of new materials may make to greenhouse gasses and carbon emissions.

2. RISKS OF INTERVENTION

Ventilation vs. Insulation

2.01 The final result of intervention must leave a stable balance between ventilation and insulation. Condensation on or within the historic fabric can result from misapplication of insulation. This can lead to sudden accelerated decay of materials, which have been stable for the lifetime of the building.

Beware of

2.02 Trapped moisture

Older buildings allow moisture to move through the fabric. This allows the building to dry out in balance with any moisture ingress.

Care is required that alterations do not affect:

- (a) permeability – the ability of a material to allow water vapour to pass through
- (b) capillary action – the ability of the fabric to ‘wick away’ water and speed drying
- (c) hygroscopicity – some materials will rapidly absorb water vapour and release it slowly, acting as a reservoir to even out surges in vapour levels

2.03 Condensation within the structure

Particular care is required where insulation together with impermeable or semi permeable sheeting (such as roofing felt or vapour barriers) are used. Ideally the fabric of the building should become more vapour permeable as one moves outwards from the warm interior.

2.04 Condensation at cold bridges.

If the insulation of one element is improved while an adjacent area is not insulated, a local cold spot known as a thermal or cold bridge is created.

For example, an external wall may be dry lined but not the window reveal in the same wall. The exposed edge of the newly insulated wall actually becomes colder relative to the newly warm wall, and at greater risk of condensation.

If such cold spots cannot be successfully detailed, then added insulation may not be desirable, or the amount of heating and ventilation may need to be increased to help avoid mould growth or condensation.

How much ventilation?

2.05 In new buildings following the principles of “build tight – ventilate right” the degree of ventilation can be accurately assessed. The regulations then give guidance how to meet ventilation targets by the use of fixed ventilation such as trickle vents and active ventilation such as extractor fans.

An holistic approach will balance ventilation requirements against the pattern of building use, hygroscopicity of the fabric, and tolerance of the building and contents to humidity.

2.06 In an historic building, which has been made more airtight through renovation work, incorporating trickle vents into historic fabric can be a problem. It is not appropriate to put trickle ventilators anywhere on a traditional window. Traditional ventilation bricks may offer an alternative.

2.07 The use of mechanical ventilation packages to achieve ventilation requirements can offer an alternative to trickle vents and individual extract fans. On smaller buildings, a central ventilation fan and mini duct “packages” which satisfy the requirements of Part F are available.

Mechanical Ventilation Systems can frequently be combined with heat reclaim or pre warming of replacement air to reduce carbon emissions and heat loss.

2.08 Where a building is in intermittent use and the sensible vapour gains are small, a “set back” policy can be adopted. A church for example may need very much less ventilation during the week than at the weekends. Combining minimal ventilation and heat with dehumidification can offer a solution that is energy efficient and kind to the building fabric and contents.

Summary

2.09 As they have a higher moisture level than modern construction, historic buildings usually need more ventilation than modern ones. In the past, they were often ventilated more than necessary to avoid condensation as a side effect of loose-fitting doors, windows and other openings. In addition, open fires created generous rates of exhaust ventilation through chimneys.

However, this “super ventilation” can give rise to excessive heat loss through warm air escaping to be replaced by cold. Control of this air egress can have a significant effect on improving heat retention.

2.10 If ventilation of a historic building is reduced by too much, condensation, mould and fungal growth may occur, leading to deterioration of the fabric and a poor environment for occupants. Great care is therefore required in selecting an appropriate ventilation rate for a historic building. Although the actual amount of ventilation needed varies with context, and particularly with the amount of vapour occurring in the building (from the nature of its occupancy) and moisture in the fabric.

Avoid

1. Trapping moisture in the building fabric
2. Cold bridges
3. Insufficient ventilation
4. Excess ventilation

SECTION B BUILDING ELEMENTS

3. WINDOWS

The importance of windows

3.1 Window openings and frames establish the character of a building’s elevation. They should not be altered in their proportions or details, as they are conspicuous elements of the design. The depth to which window frames are recessed within a wall is a varying historical feature of importance and greatly affects the character of a building: this too should be respected.

The importance of conserving traditional fenestration and its detailing cannot be stressed enough. Consent for replacing traditional, single glazed sash windows with double glazed PVCu windows will not be given.

The fundamental objections, amongst many, are that double glazed sealed units thicken the dimensions of glazing bars inappropriately, or result in extremely poor facsimiles stuck to the face of the glass.

Old glass is of interest and is becoming increasingly rare. It is of value not just for its age, but because it has more richness and sparkle than today’s flat sheets with their uniform reflections. Where it survives, it must be retained and alternative means of thermal improvement considered.

Window types and materials

3.2 Most historic windows are timber-framed. With the advent of the sash window in the 1700s, softwood imported from Scandinavia and the Baltic States became predominant. This fully mature, slow-grown, naturally resinous, high-quality, durable timber continued to be widely used until resources were exhausted in the early 20th century.

The materials used in most historic windows are therefore not a renewable resource: it is very difficult to source timber of this quality and durability today. Where possible windows should be repaired and continue to be used. Traditional sliding sashes lend themselves to replacement of decayed elements which rarely form a significant proportion of the total window.

Iron framed windows have been used since medieval times. All-metal window frames, both sash and casements were introduced in the Regency period in housing and industrial and institutional buildings. Mass production in the early 20th century allowed hot-rolled steel to be used for, among others, the famous Crittall windows which were strong, slim and non-combustible.

All these windows are important historically and should be conserved.

Draught stripping

3.3 Air infiltration through old windows is often their primary source of heat loss.

Draught proofing and weather stripping can be very effective in reducing not just heating bills by limiting the number of air changes per hour (3/hr to .7/hr are possible reductions), but also reducing levels of noise and dust.

However, care should be taken to provide adequate ventilation to remove internally generated moisture and pollutants, together with additional moisture from sources such as rising damp. (see NIEA technical note on windows). A good draught strip should be durable and inconspicuous. A number of firms now provide an effective specialist installation and refurbishment service for existing windows. According to some manufacturer's figures these products reduce the number of air changes from between 2.5 and 3.0 to 0.7 per hour. In terms of reducing heat loss, draught proofing a single-glazed window has roughly the same effect as fitting an additional sheet of glass.

Improving window insulation

3.4 In many historic buildings the proportion of the windows as an area of the total external surface of the building is small. The windows do not therefore form a major source of radiant heat loss, typically less than 17% of the total for the building. Attempts to improve insulation should bear this in mind and the possibility of more cost effective insulation improvements should be considered

No historic window can reach the U-values recommended in Part F (i.e. 2.0-2.2 W/m² deg C). So-called 'facsimile' replacements have been developed with double-glazed sealed units and low emissivity glass, but in most cases these fail to provide an adequate visual alternative.

Except where replacement is unavoidable, the aim should be to improve thermal performance whilst retaining the existing windows.

At night, when the temperature difference between interior and exterior is most acute, and in the winter, when daylight hours are short, thermally lined curtains can lift the thermal performance of single glazed windows to almost Part F standard.

Secondary glazing

3.5 Secondary glazing can offer a useful method of reducing heat loss and can be acceptable in historic buildings.

The design of such glazing should seek to be as invisible as possible with small discreet frames concealed from view from the outside and unobtrusive **internally**.

An essential feature should be the ability to remove the glazing without trace. Indeed such secondary glazing is frequently installed as 'seasonal' glazing and is removed in warmer weather.

Where a room has seasonal secondary glazing on a number of windows only one need have opening secondary glazing. The method of operation should match the historic window; sliding or opening casement as required.

Secondary glazing is less efficient than sealed units in reducing heat loss but is as effective in sound reduction.

Where new single glazed replacement windows are being used, sound reducing laminated glass can make a significant contribution to sound reduction. The increase in weight and thickness (from 4 to 6mm) may make replacement of glass in historic sliding sash windows a problem.

However, not all windows are suitable for secondary glazing. Problems include the narrowness of the internal cill or reveals; the difficulty of accommodating the new panes within an oddly shaped or unduly protruding architrave: or clashes with internal shutters.

Shutters

3.6 Internal and external shutters are important features and often contribute to the design of an interior.

Repairing and using close-boarded and panelled internal shutters can minimise heat loss after dark in winter and when rooms are unused and also reduce unwanted solar gains in summer.

Internal shutters can also be draught proofed to improve thermal performance, in a similar manner to windows.

Rooflights

3.7 Most old rooflights are single-glazed, cast iron set in timber frames.

Frames are often ill-fitting and draught proofing may improve this. Where replacement is essential, double-glazed copies of original rooflights are available. Made in cast metal and factory finished these can be acceptable in historic buildings.

1. Renovate rather than replace
2. No PVC double glazing
3. Retain historic glass
4. Draught strip

Not all modern replacement rooflights are acceptable even if labelled “conservation type”.

4. DOORS

Typical Construction

4.1 Most external doors on historic buildings were made of timber, many in hardwood frames. The doors were normally either panelled or sheeted.

Panelled doors are made from a frame, usually morticed and tenoned together, with panels fitted between stiles, muntins and rails. Doors usually have four or six panels. Panels are normally timber but may be of decorative glass.

Sheeted doors also have a frame but this is covered with planks of timber tongued and grooved into each other to form a sheet of timber.

Thermal Properties

4.2 Solid doors often have reasonable insulating properties. Most of the heat loss normally occurs by air infiltration around the perimeter of the door or where gaps have developed around panels, through locks, etc.

Repairs and draught proofing will work in much the same way as for windows. As for windows, the draught proofing should be unobtrusive and removable without permanent damage to the historic joinery.

Lobbies with an internal partly glazed screen and door are common features to historic buildings. They are an extremely practical way of reducing heat loss. The internal door should be draught proofed as well as the main door.

Where an internal lobby has been removed it should be restored. Internal doors to hallways and stairwells can be draught proofed to create a “lobby”; reducing heat loss from other rooms.

Glazed Doors

4.3 If a door – including the frame – has more than 50 per cent of its internal face glazed, Part F treats it as a window. Original doors are an essential part of the character of the building and must be kept. Replacement with PVC or modern alternatives will not be acceptable.

Flooring Generally

5.1 The appearance of a floor can be a highly distinctive feature of a historic building. Generally floors should not be lifted because of the damage that is inevitably caused: a worn, uneven appearance is often valued and cannot be completely re-created. However, if floors have to be lifted or replaced, there are opportunities to improve insulation.

Solid Floors

5.2 Solid floors, such as those laid with stone, tile, brick, woodblock and early concrete, cannot be insulated without first excavating them.

This should only be undertaken if it is the only way to remedy some destructive defect.

On reconstruction, a damp proof membrane (DPM) will usually be incorporated as normal practice. However, membranes can cause more problems by diverting moisture up walls and columns. Lime based, “breathing” insulated floor substrates with no DPM may offer a solution.

Remember that the bulk of heat loss occurs in the first 1metre strip of a solid floor next to an external wall.

1. Renovate if possible
2. No PVC replacement doors
3. Use painted timber
4. Reuse draught lobbies

5. FLOORS

Suspended Floors

5.3 Floorboards can often be lifted and insulation installed with comparative ease.

However, care should be taken if:

(a) The floorboards have a structural function, i.e. acting as a plate membrane and providing lateral restraint to walls whether by original design or not. Removal of all boards simultaneously could lead to structural failure of the walls.

(b) High quality boards such as broad oak or elm or very long prime grade Baltic pine are used, particularly if these have been undisturbed and cannot be lifted without causing damage to the boards or joists.

(c) There are historic examples of sound deadening (pugging) or fireproofing between joists. This will usually take the form of sand, sawdust or ash laid between the joists; these details should be preserved. However these will not normally be present on a ground floor where heat loss is an issue.

(d) There is plasterwork to a ceiling underneath. The removal and replacement of boards can degrade existing lath and plaster ceilings and lead to failure and collapse of sections.

More frequently upper floors are altered to increase fire resistance. NIEA prefer that this be done with care from above retaining the historic plasterwork.

Underfloor Ventilation

5.4 Suspended timber ground floors over earth are – or should be – ventilated underneath. There is usually intended to be cross-ventilation between underfloor openings or airbricks on opposite sides of the building.

However, in practice, air often comes in through external underfloor vents and then passes between the floorboards before rising up within the building or into flues. This can be a major source of heat loss. Adding insulation (or less permeable floor coverings) can reduce this airflow and increase moisture levels both under the floor and in the building. This increases the vulnerability of the floor to infestation; particularly dry rot.

The adequacy of underfloor and building ventilation should therefore be considered as part of the technical design.

Underfloor heating

5.5 Low pressure hot water underfloor heating is increasingly popular and is now available in a range of forms that allow it to be installed on both solid and suspended timber floors.

Where the existing ground floor has already been lost or requires replacement this can be a suitable form of heating in an historic building. The low temperature radiant heat is kind to historic fabric and avoids condensation arising from sharp changes in air temperature relative to the fabric.

It will not be suitable for use where existing historic timber floors are still in place. Moisture content can be reduced to less than 5% in boarding over this type of heating. Historic timber flooring in a previously unheated space may never have had a moisture content less than 12 to 15% posing dangers of splitting, twisting and cupping.

1. Check ventilation is maintained under timber ground floors
2. Use damp proof membranes (DPMs) with caution
3. Take care to avoid damaging original floorboards

6. WALLS

Historic buildings often have very thick stone walls. All materials have some insulating qualities and such walls can be inherently more insulating than modern construction. The large thermal mass of such walls can sometimes be used as a “thermal flywheel” to even out fluctuating heating and cooling loads. Historic stone and plasterwork can also act to even out fluctuations in humidity

Improving insulation externally

6.1 The opportunity to improve the thermal performance of walls externally is likely to be extremely limited in a historic building.

The impact external insulation has on the appearance of the building: changes in proportions, details (such as quoins window reveals, cills, thresholds etc) are unacceptable in terms of Listed Building Consent. A rare exception may be where existing rendering requires complete replacement. However:

- (a) modern external insulation and rendering systems may not be appropriate owing to dimensional differences.
- (b) generally repairs should be carried out on a like-for-like basis, which means adhering to the original mix of materials.
- (c) transpiration is an important mechanism for reducing dampness and condensation in historic buildings. Insulating rendering systems may be less breathable than the original finish.

Insulation internally applied

6.2 In historical terms it is important to ensure that the internal face of walls are always investigated with care in advance of any changes. Ancient or interesting features – such as early plaster and paint schemes – may be hidden in the plaster or behind panelling or other coverings. Timber panelling, plaster mouldings or enriched decorations are important and need to be preserved.

Where complete internal re-plastering is required – particularly where it has been done before and when little or nothing of historic interest survives – there may be opportunities to incorporate internal insulation. However:

- (a) the dimensional changes may be unacceptable at window and door openings and where original surface details such as dados, cornices, etc survive.
- (b) moisture may be trapped and interstitial condensation may occur.
- (c) insulation covers up the mass of internal walls, reducing their effect in stabilising the indoor temperature and humidity levels.
- (d) thermal bridges may occur at edges and junctions, such as between floors and internal walls creating ‘cold spots’ and local condensation/staining.

The principle holds for this type of intervention as for any other in an historic building: the response of the existing building to its environmental conditions must be fully understood before change is contemplated.

Cavity walling

6.3 Cavity wall construction in brick became widespread from the 1920’s onward.

A number of listed and historic buildings have this form of construction. Cavity construction offers the potential for reducing heat loss by filling the cavity with insulating material.

1. Do not reduce transpiration (breathability) through the building fabric
2. Use new damp proof courses as a last resort
3. Beware of interstitial (concealed in fabric) condensation

7. ROOFS

External Appearance

7.1 The roof of a historic building is often its most striking feature. Most have survived in remarkably unchanged condition for many centuries. In others the roof has been redone several times in the life of the building

Design Life

7.2 With stone, slate or tile re-covering tends to become necessary when the fixings fail; and much of the covering material may be re-used on the same building or elsewhere.

With thatch, shingles, lead and other metals, failure is more often attributable to the natural life of the covering itself.

However failure in an historic roof may be attributable to an error or inherent weakness in the original design or construction method which has led to repeated repair cycles. If a thorough understanding is gained of the way the building works it may be possible to correct this.

Roof Structures

7.3 Unless there has been substantial water leakage, the roof structure will usually be in good condition. Often this is attributable to the generous amount of ventilation in historic buildings and in their roofspaces.

Even though a historic building may generate a lot of moisture internally – some of which finds its way to the roof – it is quickly removed. The moisture-buffering effect of the large amounts of hygroscopic material in many historic buildings can also be helpful.

Improving Thermal Performance

7.4 Proposals to improve the thermal performance of the roofspace have to be considered in relation to the use and performance of the rest of the building.

For example:

- (a) Modern living tends to introduce more moisture into buildings and roofspaces
- (b) Ventilation rates are often reduced, exacerbating the problem
- (c) Added insulation tends to cause roofspace temperatures to drop, adding to potential moisture problems. Issues and solutions tend to vary with the type of roof: pitched or flat, with or without ventilated roofspaces. These are outlined in the following paragraphs.

Pitched Roofs with Ventilated Roofspaces

7.5 For traditional roofs with 'cold' roofspaces ventilated by outside air, it will often be possible to lay insulation over the ceilings or between floor joists in the conventional manner. The use of semi-rigid batts will guarantee a minimum thickness, but a wide range of other materials is also available. Air infiltration from the building into the roofspace should be reduced, in particular by closing up holes around pipe, duct and cable routes, especially from high humidity areas.

Even where holes are well sealed, air and water vapour from the building will still get in. In winter, the extra insulation makes the roofspace colder than before, so the risk of dampness and condensation may increase, particularly if ventilation is limited or poorly distributed.

Sometimes additional roofspace ventilation may have to be introduced. However, research has shown that not all roofs in historic buildings – particularly low-pitched ones – benefit from this.

Beneficial effect is lacking when the extra ventilation serves merely to lower the temperature while not sufficiently diluting the moisture which escapes into the roofspace from the building below. In such circumstances it is essential to understand what is happening to the internal environment, in order to determine the likely effect of new insulation and ventilation on the existing fabric. Do not introduce additional ventilation gratuitously.

Pitched Roofs with Insulation at Rafter Level

7.6 This is where there are "rooms in the roof ventilation" path beneath the roof felt, then an insulation layer between the rafters, followed by a vapour control layer and the internal lining (plasterboard). Where there are service runs these should be boxed to avoid perforating the vapour control layer. It is important to maintain the through flow of air when detailing new dormers or rooflights. Few older buildings could meet these requirements due to restricted rafter depth. New high performance very thin insulating materials may offer a solution.

In utilitarian attic spaces internal furring strips can increase the depth of the rafter to allow the furring of the desired thickness of insulation.

Warm roof design

7.7 An alternative is to fit insulation between and to the full depth of the rafters, to lay a breather felt over this and to refix the roof on battens and counterbattens with over felt eaves ventilation,

This has the advantage of bringing the roof structure into the controlled environment of the heated space and minimising stress on the fabric from extreme thermal and moisture changes.

The trouble is that problems may arise where the increased thickness of the roof, which arises from the extra layer of battens, alters the roof appearance. This can give an unacceptable degree of change to the historic details at eaves ridge and verges, In a terrace building where only one roof in a continuous run is to be replaced a visually unacceptable step change in the roof finish at the party wall can result

Flat and Low-pitched Roofs

7.8 Most historic flat roofs are covered with lead, a few being clad in zinc or copper. Repairs and replacements using bitumastic materials and felts have been widely used. Flat roofs show a wide variety of designs, although most are akin to the 'cold roof' with a small roofspace (sometimes deliberately ventilated to the outside, but often not) above the ceiling. Some roof-decks in fact form the ceiling, though this is mostly confined to churches.

Flat roofs with ventilated cold decks

7.9 These have always been problematic technically. They are a poor option in the temperate, humid climate of the UK and usually it is not possible to upgrade their thermal insulation.

If there is no alternative to cold deck designs, Stirling recommends providing a continuous vapour control layer above ceiling level, lapped and taped throughout, and sealed to the walls at the edges. Service penetrations should be avoided unless this is impossible, in which case they should be carefully detailed and effectively sealed. Cross-ventilation should be generous, without any blockages, and with open eaves at each end: cold roofs should be used with caution if the structure spans between parapet or abutment walls.

In spite of the above, research has shown that even with little roofspace ventilation and no air vapour control layers at ceiling level, lead roofs have often survived well by virtue of the balanced environment which has been created. The summer heat dries the timbers and other porous materials in the roofspace. In winter, moisture from below is absorbed or buffered by the timber which then dries out thoroughly again in the summer. In effect, this mechanism has allowed some metal roofs and timber structures to survive for centuries. Adding ventilation and insulation to this type of construction – or increasing moisture levels within the building – can change these conditions for the worse. Moisture problems affect not only the timber substrates and roof structure, but can also shorten the life of metal roof coverings by inducing corrosion on the underside.

Flat roofs with warm decks

7.10 To upgrade the insulation of a 'cold' flat roof, states that the preferred option is to convert it into a sandwich or inverted warm deck roof. However, while sandwich construction can work for felt and asphalt roofs, installations in the 1970s and 1980s showed that a continuously-supported metal sandwich roof could draw external moisture into the sandwich itself and suffer from decay and corrosion. Lead roofs on historic buildings were particularly susceptible, as described in English Heritage's advisory note on the subject (English Heritage and LSA, 1997) and warm roofs are not recommended.

Ventilated warm roofs

7.11 Modern practice for metal-clad roofs is set out in three volumes of the Lead Sheet Association's Manual (LSA, 1990, 1992, 1993), which advocate the use of ventilated warm roofs. The principle here is the creation of a new insulated and ventilated roof deck structure, completely isolated from below.

If this is correctly detailed and carefully constructed it is an effective design, but great care is required with continuity of ventilation and of vapour control, as discussed in *Lead Roofs on Historic Buildings* (English Heritage and LSA 1997). However, on some historic buildings, notably those where the roofs are prominent or the abutment detailing or appearance is important, e.g. under a clerestorey window cill or low parapet, it is not acceptable to raise the roof by the requisite height – often about 250mm. There may also be structural problems. In these cases, the opportunity to improve insulation may be limited, and it is important to heed the warning about the gratuitous introduction of additional ventilation.

Materials and Details

7.12 Thermal bridges can occur at gaps in the insulation and at junctions with chimneys and outside walls. Care will be needed to ensure that these do not introduce condensation problems, as discussed earlier in this section.

Sarkings. Tile, stone and slate roofs used to be laid without sarking felts, although sarking boards were occasionally used.

Re-roofing today almost invariably includes underfelts, to allow re-roofing to take place in bad weather; and to provide secondary protection against wind-driven snow and rain.

Vapour-permeable materials are preferred; as a general rule, the more vapour-permeable the better. However, even they reduce air movement, and alternative provision for ventilation may be necessary, though designed 'breathing' construction is now becoming possible. The additional ridge and eaves ventilation required can be unsightly.

Insulating foam. Isocyanurate is sometimes sprayed directly onto the underside of slates and tiles, it sets into a hard layer with strong adhesive properties. Foams are claimed to improve insulation and waterproofing, prevent tiles or slates slipping, and avoid condensation.

Sprayed insulating foams on slates and tiles are NOT recommended for historic buildings: they prevent the slates and tiles being salvaged during the next re-roofing, the tiling battens and the upper parts of the rafters are sealed in, which may lead to rotting and premature degradation, and the normal flow of air into the roofspace is restricted.

Thatch

7.13 Thatch provides one of the best natural insulators and should not need further insulation. A 300 mm thatched roof made of water reed (thermal conductivity 0.09 W/m deg C) or straw (thermal conductivity 0.07 W/m deg C) will have a U-value of 0.3 W/M² deg C and 0.23 W/M² deg C respectively. The roof structure associated with thatched building is often of great historic interest and extreme care should be taken to avoid damage to this important feature.

Bats

7.14 If bats are present in the roofspace they should not be disturbed. This does not necessarily mean building work, repairs or timber treatment are ruled out. Advice is available from the Bat Conservation Trust (www.bats.org.uk) or (www.ni-environment.gov.uk).

SECTION C

8. SERVICES

Introduction

8.1 There is generally no reason why historic buildings should not be reasonably efficient, comfortable and healthy.

The new Part F takes account of recent thinking on the importance of reducing carbon emissions in addition to issues of thermal comfort and reduction of fossil fuel consumption.

Rather than simply lay down standards for the minimum acceptable heat loss of elements, Part F looks at measuring the performance of the building as a whole. This is done by the use of Standard Assessment Packages (SAP).

The SAP analysis will give the building a rating for energy consumption and carbon emission and this can be measured against the target figure(s) in Part F.

Because reductions of carbon emissions are central to the new Part F, the use of energy from carbon neutral sources (green energy) can be used to reduce the SAP rating of a building and help offset poor performance of individual building elements.

The use of renewable energy is therefore very attractive for anyone considering the thermal performance of a historic building with regard to Part F.

As a matter of good practice, but particularly where improvements to the fabric are impossible, it is important to consider improving the services to a level beyond the minimum service efficiency required in Part F.

The last twenty years have seen significant advances in efficiency of boilers, lamps, controls etc. The replacement cost of old inefficient equipment can often be quickly recovered in fuel cost savings. Efficiency rates of new boilers can be checked by visiting www.boilers.org.uk. The Energy Savings Trust endorses a range of energy efficient oil, LPG, and high efficiency condensing boilers. Information is available on www.est.org.uk.

Existing services

8.2 Sometimes the services in a historic structure will themselves be of historic interest. If so, advice will need to be sought from NIEA:HBU or Conservation Officer on whether they should:

- (a) Remain in use unaltered
- (b) Be refurbished and re-used
- (c) Be left for visual effect or for historic reasons but be functionally replaced
- (d) Be taken carefully into storage.

When installing new services it is necessary to avoid;

- (a) Covering up or interrupting the view of important features and details
- (b) Passing too close to important surfaces (e.g. of plaster or panelling) which might be consequentially damaged in the course of the work or in use afterwards (e.g. from dirt traps and/or from cleaning behind pipe lagging run close to surface)
- (c) Staining by patterns of heat and air movement
- (d) Disturbance of the heat and moisture balance as discussed in chapter 2. Risks of Intervention

Constraints of this kind may affect the choice of options and consequently their energy efficiency levels. For example, it might not be possible to replace a conventionally-flued heater with a more efficient balanced-flue version because of the destruction caused by the hole, the visual appearance of the outdoor terminal, or the technical risks of disturbing a rubble-filled wall.

Apart from these considerations, the energy efficiency of building services in a historic building should cause few problems, provided that care is taken. Much advice is available in CIBSE Guide F (1998), and in the publications of the Energy Efficiency Best Practice programme.

Heating

8.3 Historic buildings have tended not to be heated to the high air temperatures typical in modern buildings. For some of today's uses (e.g. residential and commercial), occupiers will expect modern standards. For other uses, such as buildings on display to the public, less heating will often be appropriate.

The elements of a heating system normally contained within the building can be considered in three parts: The primary heat source, distribution system, and heat emitters.

The primary heat source is normally the boiler. This can be used with a range of fuels, oil, gas or "green fuels" such as woodchip/pellets.

Alternatively it can be in the form of a heatstore solid state or water topped up from low tariff or site generated electricity. A heatstore can also be used in conjunction with a combined heat and power system (CHP) where the heat is a by-product of the generation of electricity.

Consider the following factors:

(a) The positioning of new flues. Integration into historic fabric must be done carefully to avoid spoiling existing elevations and roofscapes or requiring the removal of excessive fabric. Balance flues or small diameter flues from condensing boilers are easier to incorporate into existing buildings.

(b) Fuel storage for gas oil and renewables can pose problems of integration and access for deliveries.

Underground storage may be possible for oil.

The distribution system can be low pressure hot water (LPHW) or air. LPHW does not normally pose integration problems. Plastic pipe work is particularly accommodating for threading through existing voids. However reversibility/replacement issues must be considered when embedding the pipe work in the structure of floors and walls.

Ducted hot air systems will be practical in only a few types of historic building.

The heat emitter was traditionally the standard "radiator". Where they are not original to the building installing new radiators can pose integration problems. Under windows they can mask historic joinery details and interfere with traditional window curtain treatments. On an internal wall they can be visually intrusive and thermally inefficient.

Pure convectors, (sometimes fan assisted), are normally used with electricity as the primary heat source but may be used with LPHW in larger buildings such as churches. Integration can be a problem in historic buildings.

Low temperature radiant heating has many advantages in historic buildings. Comfort conditions can be achieved with less energy use. Radiant heat raises the temperature of the building fabric before the internal air temperature reducing the risk of condensation. With LPHW systems, pipes can be embedded in the floor and electrical systems are also available for small areas.

Plastic heating pipework appears to have overcome durability problems experienced in their early use. However, historic buildings have a lifespan measured in hundreds of years and the issues of reversibility should be considered.

Underfloor heating is frequently installed as part of a replacement floor.

This may be best with a lime concrete and expanded clay aggregate construction. New DPMs in ground floors may force moisture up walls creating problems where none previously existed.

Hot Water

8.4 In most cases, good practice standards of hot water systems installation will apply equally to new and to historic buildings. Two points may however be made:

- (a) Some large historic buildings have sprawling systems. When alterations are being carried out, an attempt should be made to simplify them, reducing the length of pipe runs, improving insulation, and possibly installing more local water heaters
- (b) When taps, shower heads, etc are being renewed, replacements should be sought which are economical in their use of hot water.

Lighting

8.5 As with hot water, it is tempting to ignore lighting energy efficiency in a historic building and to install what is felt to be aesthetically best (often thought to be incandescent tungsten filament lighting). However, while there can be good reasons for this - incandescent is the oldest form of electric lighting - most historic buildings pre-date it and it would have been installed first as innovation.

It is important to review the balance between aesthetic and efficiency criteria and to develop an appropriate solution in the circumstances. Tungsten may be the correct choice where illuminance levels are low and the lighting is used infrequently. However, the use of more energy-efficient and long-life lamps should be investigated, as this reduces replacement costs as well as energy consumption.

Low and zero carbon emission

8.6 There is a Government intention to increase regulation standards every 5 years to achieve the carbon emissions reductions envisaged in the White Paper on Energy. i.e:

Government targets:

60% reduction of CO₂ by 2050

20% reduction by 2010

Figures relative to 1990 baseline consistent with 45% min reduction by 2035.

Because increasing standards for new buildings has a diminishing potential for achieving further savings, the focus may move towards improvements to existing buildings as opportunities arise.

Over time, buildings that have higher emissions than average will require to be upgraded. There will be more emphasis on the choice of heating fuel, and on the efficiency of electrical systems.

It will become normal to measure the 'Carbon Rating' of a building before a sale or change of tenancy, and this will increasingly be done when determining which improvements are to be carried out to satisfy building regulations. The use of low or zero carbon emission (LZC) alternatives to fossil fuel can be particularly suitable for historic buildings.

The majority of LZC energy sources can deliver emission reductions in the range of 10-20% (figures from BRE report 3/2005 for Guide 4 from the Office of the Deputy Prime Minister) and several can deliver much higher reductions.

1. Insulate heating and hot water pipes
2. Use low energy lighting
3. Use high efficiency appliances
4. Use low and zero carbon emission energy sources

LZC energy sources included in Guide 4 and accepted by ODPM are

- (a) absorption cooling,
- (a) biomass (and CHP),
- (b) ground source cooling,
- (c) ground source heat pumps,
- (d) photovoltaics (solar electric),
- (e) solar thermal water heaters,
- (f) wind turbines

Oil condensing boilers are higher efficiency and as replacements of conventional boilers can reduce carbon emissions. On larger schemes, consider diesel or gas mini combined heat and power, especially with electricity use on site or with other premises to export electricity to. Using LPG for cooking and instant hot water can help to control emissions in residential premises.

CONCLUSION

In conclusion, the NIEA supports the principles which lie behind the revised Part F of the Northern Ireland Building Regulations. While it is important that the character of our historic buildings is maintained for the appreciation of this and future generations it is also important to maximise energy efficiency. Early consultation with Building Control and the area Conservation Architect or officer will help achieve this.

Historic buildings however, function differently from modern construction. A full understanding of the processes at work is necessary to avoid problems.

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