



ENGLISH HERITAGE

ENERGY EFFICIENCY AND HISTORIC BUILDINGS

**Application of part L of the Building
Regulations to historic and traditionally
constructed buildings**

November 2010

Content

Summary	03
Introduction	05
1.0 Background to the legislation	08
2.0 Part L of the Building Regulations and existing buildings	11
3.0 Understanding the building before carrying out upgrading works	22
4.0 Energy efficiency-meeting the requirements of part L	39
5.0 Upgrading building elements	49
6.0 Further information	62
English Heritage Regional Offices	69

Summary

English Heritage supports the Government's aims to improve the energy efficiency of existing buildings through Part L of the Building Regulations. Many improvements can be carried out, often at a relatively low cost, significantly enhancing the comfort of the building for its users, as well as providing savings on fuel bills. Such improvements can also help in meeting the Government's greenhouse gas emission reduction targets.

However, reducing carbon emissions from buildings is not just about heating and insulating the building fabric. Much can be achieved by changing behaviour, avoiding waste, using energy efficient controls and equipment, managing the building to its optimum performance, all of which is as relevant to older buildings as new ones.

For historic buildings and those of traditional construction an appropriate balance needs to be achieved between building conservation and measures to improve energy efficiency if lasting damage is to be avoided both to the building's character and significance and its fabric. For example, it would be neither sustainable nor cost effective to replace a 200-year-old window that is capable of repair and upgrading with a new double glazed alternative, and even less so if the new window were to have an anticipated life of only 20-30 years, as some do. Depending on the circumstances a good case might be made for well designed and carefully installed draught-proofing or secondary glazing.

An informed approach can achieve significant energy efficiency improvements in most cases although not always to the standards recommended in the regulations.

Achieving an informed *appropriate balance* requires an understanding of the regulations and the building, particularly:

- Understanding the energy efficiency requirements as set out in the *Approved Documents- for Part L of the Building Regulations* which should be applied as far as is practically possible up to the point at which alteration to the building's character and appearance and performance becomes unacceptable
- Understanding the point at which alteration to the building's character and appearance and performance will become unacceptable depends on understanding the significance of the building and how the building works as an environmental system

Once the building's significance, construction and the way it performs have been fully understood then the appropriate *balance* can be determined from a position of knowledge. The Approved Documents make it clear that a reasonable compromise on the energy efficiency targets may be acceptable in order to preserve *character and appearance* and to avoid technical risks.

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

They do this by specifically including some *exemptions* and circumstances where *special considerations* apply for historic buildings and those of traditional construction.

An understanding of what constitutes the special interest or significance of a historic building requires experience. Very often technical, philosophical and aesthetic conflicts will need to be resolved and on occasion highly creative solutions to problems will be necessary. In such circumstances there is no substitute for the knowledge, skill and judgement of a qualified and experienced professional advisor such as an architect or surveyor experienced with historic buildings. Such people have both the technical ability and wide working knowledge of historic buildings in their maintenance and adaptation, and their advice can thus prevent damage and unnecessary expense and heartache.

In each case the *appropriate balance* should be discussed early in the design process by consultation between the local authority's Building Control Officer or Approved Inspector and the Conservation Officer.

Introduction

WHAT IS THE PURPOSE OF THIS GUIDANCE?

The guidance has been produced to help prevent conflicts between energy efficiency requirements in Part L of the Building Regulations and the conservation of historic and traditionally constructed buildings. Much of the advice will also be relevant where thermal upgrading is planned without the specific need to comply with these regulations.

This advice also acts as ‘second tier’ supporting guidance in the interpretation of the Building Regulations (referred to in paragraph 3.10 of the Approved Documents) that should be taken into account when determining appropriate energy performance standards for works to historic buildings.

This guidance supersedes English Heritage’s previous publication *Building Regulations and Historic Buildings an interim guidance note on the application of part L* which was prepared in support of the 2002 Regulations (revised in 2004).

WHO IS THIS GUIDANCE FOR?

- **Building owners and occupiers** who are considering what action they need to take to improve energy performance, and to meet or surpass a range of statutory requirements
- **Architects, surveyors and similar professionals** who are preparing proposals for work on *traditional or historic buildings*, and who need to make an appropriate professional response to requirements which can often be in conflict
- **Building contractors, materials and component suppliers** who need to understand the implications of decisions they make in carrying out their work, or of the technical advice they give to their customers
- Officials, such as **conservation and planning officers, building control surveyors, approved inspectors, environmental health officers and housing officers**, who will be experts in one area (for example building conservation, general legislation or energy performance), but may be less familiar with the balances that need to be struck in reaching reasonable solutions that suit all parties.

WHAT ARE BUILDING REGULATIONS?

The Building Regulations set standards for how buildings must be constructed to achieve a minimum level of acceptable performance. They typically cover health, safety, energy performance and accessibility requirements for buildings. The regulations apply mainly to new buildings and there is no general requirement for all existing buildings to be upgraded to meet these standards. However, certain changes, such as the use of the

building, can trigger the need for existing buildings to comply with the Building Regulations.

WHAT IS PART L OF THE BUILDING REGULATIONS?

Part L of the Building Regulation covers the conservation of fuel and power.

Although the Building Regulations themselves only state general requirements, they are supported by *Approved Documents* which set practical guidance as a response to these requirements. The Approved Document (Part L) for energy efficiency is in four sections:

- New dwellings (L1A),
- Work to existing dwellings (L1B),
- New buildings that are not dwellings (L2A)
- Existing buildings that are not dwellings (L2B).

The Approved Documents are not the regulations but are intended to provide guidance for complying with the more common forms of building construction. Applicants are under no obligation to adopt any particular solution from an Approved Document if they prefer to meet the relevant requirement in some other way. Approved Documents Parts L1B and L2B also make clear that the characteristics of historic and traditionally constructed buildings warrant some exemptions and special consideration in reaching appropriate solutions. These are covered in detail later in this document.

OTHER RELEVANT DOCUMENTS

OTHER BUILDING REGULATIONS THAT MAY BE RELEVANT

Since the physical factors controlling energy efficiency also affect other aspects of an individual building's environmental performance, the guidance contained in this document is also likely to be relevant to the interpretation of other Approved Documents when applied to historic and traditionally constructed buildings.

The most relevant of these are likely to be:

- **Approved Document C:** Site preparation and resistance to moisture
- **Approved Document F:** Ventilation
- **Approved Document J:** Combustion appliances and fuel storage systems
- **Approved Document to support Regulation 7:** Materials and workmanship

ADDITIONAL ENGLISH HERITAGE GUIDANCE

Energy Efficiency in Historic Buildings

This series of guidance provides advice on the principles, risks, materials and methods for improving the energy efficiency of roofs, walls, floors and includes the following titles:

- Insulating pitched roofs/warm roofs
- Insulating at ceiling level/cold roofs
- Insulating flat roofs
- Insulating thatched roofs
- Chimneys and flues
- Insulation of dormers
- Insulation of timber framed walls
- Insulation of solid walls
- Early cavity walls
- Draught-proofing windows and doors
- Secondary glazing
- Insulation of suspended ground floors
- Insulation of solid floors

The documents will be updated from time to time, and new ones will be added when needed. The latest versions can be downloaded from:
www.climatechangeandyourhome.org.uk

1.0

Background to the legislation: The need to reduce greenhouse gas emissions

CARBON EMISSIONS FROM BUILDINGS

Energy used in running buildings is responsible for nearly half of this country's total carbon dioxide emissions. About 27% of these emissions are produced by domestic buildings and around 22% by public and commercial buildings.

In England, of these domestic buildings around 4 million or 20% were constructed before 1919. Almost a further 20% were constructed between 1920 and 1939.

Seventy five per cent of carbon emissions produced by dwellings come from space and water heating with the remainder coming largely from lighting and appliances.

SUSTAINABILITY AND HISTORIC BUILDINGS

Sustainability is broadly divided into three overlapping aspects, covering environmental, social and economic requirements and the need to bring them all into harmony. All of these are relevant to older buildings, but for the purposes of Part L of the Building Regulations the greatest emphasis must lie on the environmental aspect, specifically the use of fossil energy. This is closely allied to the generation of carbon dioxide both from the production of buildings and from their daily use.

When they were first built and inhabited, all pre-industrial buildings were, by definition, sustainable and zero-carbon in both construction and use. The primary energy sources available for the conversion and transport of building materials were human and animal power, and the biomass of available locally grown timber. Building, heating and cooking were almost entirely fuelled by sustainably sourced biomass. However, where water and wind power were available they could be used, for instance, for the conversion of timber or the transport of materials by water, and in areas where peat was available it was a popular heating and cooking fuel.

There is no inherent conflict between the retention of older buildings and the principles of sustainability.

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

In environment terms, the continued use of existing building stock...coupled with measures to improve energy efficiency is a global priority.

Replacing an existing building with a new one requires a considerable investment of 'embodied' energy in materials, transport and construction – typically equivalent to five or ten years of building. In global environmental terms, the balance of advantage strongly favours the retention of existing building stock, particularly when performance in terms of energy consumption in use can be improved

(BS 7913: 1998 The principles of the conservation of historic buildings)

The retention of older buildings, either in their entirety, or simply be re-using components in-situ and allowing for their thermal upgrading in benign and sympathetic ways, can provide excellent finished results which are fully in accordance with the principles of building conservation and sustainability. In many cases, the process of careful adaptation and re-use can produce new buildings and spaces of the highest architectural quality.

GOVERNMENT POLICY AND AGREEMENTS

The most recent, exhaustive and wide-ranging assessment of the overall likelihood and effects of global warming is that contained in the Fourth Assessment Report (AR4) of the *Intergovernmental Panel on Climate Change* (IPCC), published in 2007. This report is likely to remain the most definitive information available to policymakers until the IPCC publishes its Fifth Assessment Report, currently scheduled for 2014.

THE KYOTO PROTOCOL 1997

This Protocol which came into force on 16 February 2005 set legally binding emissions reduction targets on all developed and developing countries which ratified it. The UK was one of those countries.

CLIMATE CHANGE ACT 2008

In 2008 the Government passed the Climate Change Act. This is a general piece of legislation, not specific to buildings, intended to improve carbon management and help the transition towards a low carbon economy in the UK, and to demonstrate strong UK leadership internationally. The Act established the *Committee on Climate Change*, an expert body advising the Government through the Department of Energy and Climate Change (DECC). The Government also committed itself to meeting legally binding reductions in carbon dioxide emissions of at least 26% by 2020, and of all greenhouse gases by 80% by 2050, both measured against a 1990 baseline.

COPENHAGEN 2009

A major meeting of the *United Nations Framework Convention on Climate Change* took place in December 2009 at Copenhagen. It was anticipated that at this meeting the international community would decide further targets for global reductions of greenhouse gases from 2012 onwards. However, no effective internationally-binding agreement was achieved.

THE ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE

As a member nation of the EU, the UK is also subject to the European Energy Performance of *Buildings Directive (Directive 2002/92/EC)*, (EPBD) which is seen as another essential part of the European Union's response to the Kyoto Protocol. To comply with the Directive member states must implement the following requirements (although under the principle of subsidiarity individual nations may decide for themselves the means by which they achieve this).

- The application of minimum requirements on the energy performance of new buildings;
- The application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
- Energy performance certification of buildings;
- Regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old;
- Requirements for experts and inspectors for the certification of buildings, the drafting of the accompanying recommendations and the inspection of boilers and air-conditioning systems.

2.0

Part L of the Building Regulations and existing buildings

Although new building construction is well covered by the Building Regulations, existing buildings present a rather more complex picture. The majority of buildings expected to be in use within England for the foreseeable future, already exist. Current estimates suggest that of all buildings expected to be in use in 2025 around 80% are currently occupied, and that at least 70% of the housing stock likely to exist in the England in 2050 has already been built. Around three quarters of these houses were constructed before 1975. Existing buildings will come under even closer scrutiny as the standards for new buildings approach zero carbon in 2016.

WHAT TRIGGERS THE PART L REQUIREMENTS?

Approved Documents L1B and L2B (2010 Edition) contain the requirements for conservation of fuel and power for all existing domestic and non-domestic buildings respectively. What though are the circumstances which trigger the need to take action to upgrade the thermal performance of existing buildings?

Generally for existing buildings energy conservation upgrading is only required for elements which are to be substantially replaced or renovated or where there is a change of use. The requirements do not apply to normal maintenance and repair work.

The requirements apply in the following circumstances:

WHEN CERTAIN CHANGES OR RENOVATIONS ARE MADE TO THERMAL ELEMENTS.

A thermal element is a wall, floor or roof that separates internal space from the external environment.

WHEN AN EXTENSION OR CONSERVATORY IS TO BE ADDED.

Conservatories should be kept thermally separate from the main building. Extensions over a certain size on non-domestic buildings should be treated as new buildings.

WHEN THE BUILDING IS TO BE SUBJECTED TO A CHANGE OF USE OR A CHANGE OF ENERGY STATUS.

A change of use or energy status occurs when a new dwelling is created, or an existing dwelling is changed to certain other uses.

WHEN CHANGES ARE TO BE MADE TO CONTROLLED FITTINGS OR SERVICES.

Controlled fittings are windows, external doors, rooflights and roof windows. Controlled services are space heating and hot water systems, mechanical ventilation and cooling, and fixed artificial lighting.

WHEN CONSEQUENTIAL IMPROVEMENTS ARE REQUIRED.

Consequential improvements are required when an existing building over 1000m² is extended, or its capacity for heating or cooling per m² is increased.

NOTE:

This list is a simplified presentation, included here primarily as an introduction for convenience. For all projects reference should be made directly to the Approved Documents themselves where definitions of key terms italicised above will also be found

Several of these items are interdependent, and that works to comply with one category can trigger the need to comply with another:

PART L STATUTORY REQUIREMENTS

The *energy efficiency requirements* in the Building Regulations are defined in the regulations below and in Schedule 1-Part L:

[Note: the numbering has been amended by the *Statutory Instrument no 2214 Building Regulations 2010*. The numbers in brackets are as they appear in the Approved Documents]

23 [4A] *Requirement relating to thermal elements*

This covers work to renovate or replace a thermal element

26 [17C] this regulation only applies to new buildings

28 [17D] *Consequential improvements to energy*

This applies to an existing building with a total useful floor area over 1000m² where the proposed building work consists of or includes- an extension, the initial provision of fixed building services or an increase to the installed capacity of any fixed building services

29 [17E] *Energy performance certificates*

The energy efficiency requirements relevant to *existing dwellings* are in regulations 23, 28 and 29 and Part L of Schedule 1

Schedule 1- Part L Conservation of fuel and power

L1. Reasonable provision shall be made for the conservation of fuel and power in buildings by:

- (a)** limiting heat gains and losses-
through thermal elements and other parts of the building fabric; and
from pipes, ducts and vessels used for space heating, space cooling and hot water services;
- (b)** providing fixed building services which-
are energy efficient;
have effective controls; and
are commissioned by testing and adjusting as necessary to ensure they use no more fuel and power than is reasonable in the circumstances; and
- (c)** providing to the owner sufficient information about the building, the fixed building services and their maintenance requirements so that the building can be operated in such a manner as to use no more fuel and power than is reasonable in the circumstances.

WAYS OF COMPLYING WITH PART L

The following actions are included in Approved Documents L1B and L2B as ways of demonstrating compliance with Part L.

PROPOSE CONSEQUENTIAL IMPROVEMENTS WHERE REQUIRED.

This applies to all buildings. Consequential improvements may include improving the insulation of thermal elements, upgrading old services systems, or adding on-site zero-carbon energy generating equipment. This requirement is, however, limited to those improvements which can demonstrate economic payback within a set number of years, and, in the case of extensions, to no more than a set percentage of the value of the principal works.

ENSURE U-VALUES AND AREAS OF OPENINGS COMPLY.

U-values of thermal elements and controlled fittings should meet the minimum required in the Approved Documents for any particular

circumstance. For dwellings this is a basic but inflexible method of achieving compliance, but may be modified subject to certain criteria.

SHOW COMPLIANCE USING AREA-WEIGHTED U-VALUE CALCULATION.

An area-weighted U-value allows the value for all elements of a particular type to be averaged, thus enhancing flexibility over basic U-value calculations. This can be used both for dwellings and other buildings, but absolute minimum values also apply.

SHOW COMPLIANCE USING APPROVED COMPUTER MODELLING PROCESS.

This is potentially the most sophisticated and flexible way of achieving compliance. Dwellings should demonstrate compliance using the Standard Assessment Procedure (SAP). Other buildings should use the Simplified Building Energy Model (SBEM) or other approved software which conforms to the National Calculation Method (NCM). (Note, however, that these methods do not at present make proper allowance for the specific requirements of historic buildings or traditional 'breathing' construction.)

CONFIRM COMPLIANCE OF THERMAL BRIDGES AND MINIMISE AIR LEAKAGE.

This only applies where new thermal elements are provided. However, it is good practice that all upgraded insulating elements are checked to avoid cold bridges causing condensation, and all controlled fittings are checked to ensure they meet calculated standards of airtightness.

JUSTIFY REDUCED STANDARDS USING SET PERIOD PAYBACK CRITERIA.

This applies to upgraded or renovated existing thermal elements as part of a change of use, or a renovation, or when an existing internal element becomes part of the thermal envelope. Work which will only give an economic payback in excess of a set number of years need not be carried out. This is subject to other conditions, and to a particular calculation method.

**SPECIFY EFFICIENT BOILERS, PIPE-WORK AND CONTROLS.
SPECIFY ENERGY-EFFICIENT LIGHTING.**

These provisions apply when new or upgraded services are being installed. Provisions for non-domestic buildings are more extensive and complicated than for dwellings.

UNDERTAKE DUCT LEAKAGE AND FAN PERFORMANCE TESTING.

This applies to non-domestic services installations where appropriate.

PROVIDE FOR ENERGY METERING.

This only applies to new plant installations in non-domestic buildings, but includes for differential monitoring between systems (dwellings are excluded as they are normally adequately metered).

PROVIDE INSTRUCTION MANUAL FOR HEATING, COOLING, VENTILATION AND LIGHTING SYSTEMS.

To enable building users to realise the optimum levels of energy efficiency to which their buildings are designed.

Note: *This list is a simplified presentation, included here primarily as an introduction for convenience. For all actual projects reference should be made directly to the Approved Documents themselves.*

Whilst the recommended actions above are effective ways of complying with the Regulations, many of them will require particular care when being applied to historic buildings.

The two principal areas of risk when upgrading these buildings to meet the requirements are:

- Causing unacceptable damage to the *character and appearance of historic buildings*, and
- Causing damaging technical conflicts between existing *traditional construction* and changes to improve energy efficiency.

In order to allow appropriate actions to be taken to mitigate both of the above risks, Approved Documents L1B and L2B (2010 edition) contain some *exemptions* for historic buildings, as well as circumstances where *special considerations* should apply.

BUILDINGS WHICH ARE ‘EXEMPT’ FROM THE REQUIREMENTS

Certain classes of *historic buildings* are expressly exempted from the need to comply with the energy efficiency requirements of the Regulations where compliance with the energy efficiency requirements would unacceptably alter their character and appearance. These are listed in Regulation 21(2),(c) and Regulation 21(3), and comprise buildings which are:

LISTED BUILDINGS at Grades I, II* and II

“Listed in accordance with section 1 of the Planning (Listed Buildings and Conservation Areas) Act 1990”

Listed buildings are those included on the statutory List of Buildings of Special Architectural or Historic Interest. Controls apply and Listed Building Consent is required for any works of alteration or extension – both external and internal – which would affect a building's character. Fixtures and curtilage buildings – any objects or structures which are fixed to the building, or are within the curtilage (and have been so since before July 1948) – are

treated as part of the listed building. The same controls apply whatever the grade of listing.

BUILDINGS IN CONSERVATION AREAS

“In a conservation area designated in accordance with section 69 of that Act”

Conservation areas are ‘any areas of special architectural or historic interest, the character or appearance of which it is desirable to preserve or enhance’. Conservation area designation encourages authorities to implement conservation policies over these sensitive areas.

In a conservation area, the main emphasis is on external appearance, with surface materials (walls and roofs) and the details of windows, doors, and roof-lights being extremely important. Changes to these may need planning permission, especially if they are subject to an *Article 4 direction* under the Town and Country Planning Acts. Consent is usually needed for the demolition of buildings in a conservation area. Planning permission is not needed for internal alterations to unlisted buildings.

While not all buildings in a conservation area will be of historic interest, many have original internal and external features which contribute to the significance of the conservation area as a whole, and therefore removing such features could have an adverse impact on its overall character.

SCHEDULED ANCIENT MONUMENTS

“Included in the schedule of monuments maintained under section 1 of the Ancient Monuments and Archaeological Areas Act 1979”

Scheduling refers to the legal system for protecting nationally important monuments and archaeological remains in England. Not all scheduled monuments are ancient. Monuments and archaeological remains of all dates can be given the protection of scheduling.

Scheduled Monument Consent is required for any works that will affect a scheduled monument whether above or below ground level.

“For these buildings the exemption applies only to the extent that compliance with the energy efficiency requirements would unacceptably alter their character or appearance”

It should be noted from the above statement that this exemption is **not unconditional**. The regulations therefore require that these buildings should be upgraded in accordance with the *energy efficiency requirements* set out in Approved Documents L1B and L2B up to, but not necessarily beyond, the point at which the relevant alterations would become *unacceptable*.

The definition of this point requires both an understanding of what qualities of character and appearance are significant in each case, as well as an

effective assessment of the degree to which alterations to these qualities will be unacceptable.

For all the above designations, where consent is required, the local authority is required to assess proposals for any impacts on the significance of the heritage asset using the criteria set out in *Planning Policy Statement 5, Planning for the Historic Environment*.

BUILDINGS WHERE ‘SPECIAL CONSIDERATIONS’ APPLY

Paragraph 3.8 in both Approved Documents L1B and L2B lists three further classes of buildings where *special considerations* apply in making reasonable provision for the conservation of fuel or power:

LOCALLY LISTED BUILDINGS

“Buildings which are of architectural and historical interest and which are referred to as a material consideration in a local authority’s development plan or local development framework”

This category includes a local authority’s ‘local list’ or ‘supplementary list’ of historic buildings, which has been included in their unitary or local plan (known as the development plan). Inclusion within the plan means that any list of this kind has been subject to public consultation and is a material planning consideration in the determination of applications under the Town and Country Planning Acts.

Most buildings on these lists are good examples of a particular design or style of construction, e.g. buildings of the Arts and Crafts movement of the late 19th and early 20th centuries, the work of a noted local architect, or a building associated with a local historical figure. They could well become the listed buildings of the future.

These buildings have no statutory protection unless they are within a conservation area. Nonetheless, if they are to retain their significance it is often essential that original features and fabric are preserved in any schemes of alteration or extension.

BUILDINGS IN NATIONAL PARKS AND OTHER HISTORIC AREAS

“buildings which are of architectural and historical interest within national parks, areas of outstanding natural beauty, registered historic parks and gardens, registered battlefields, the curtilages of scheduled ancient monuments, and world heritage sites”

Buildings often help to create the townscape and landscape qualities which were amongst the original reasons why an area or a site achieved its designation. They use local materials and highlight vernacular traditions; roofs, windows, rooflights and doors typify their period, age and style. While these designated areas do provide slightly more control over ‘permitted developments’ than elsewhere, many important features on unlisted buildings make a contribution to the historic significance of statutorily designated heritage assets but are not safeguarded, and improvements to

energy efficiency must avoid harming them. Other buildings in these areas may be relatively modern or much altered, and may accommodate energy-saving upgrading more easily.

TRADITIONALLY CONSTRUCTED BUILDINGS

“Buildings of traditional construction with permeable fabric that both absorbs and readily allows the evaporation of moisture”

Most *traditional buildings* were designed and built before the development of reliable and cost-effective impermeable membranes or moisture barriers. They rely instead on their ability to allow such moisture to evaporate rapidly away, and thus prevent the damaging build-up of damp and resulting physical decay. Whilst the majority of *historic buildings* are traditional, there are many thousands of *traditional buildings* which are not legally protected or designated.

This category includes nearly all buildings constructed prior to 1919, as well as a significant proportion of those built before 1945. It is essential that adaptations made to improve the energy efficiency of these structures should take into account the traditional technology and characteristic behaviour of the building fabric, otherwise very real damage can be caused. Well-meaning attempts to keep moisture out of these buildings using modern methods tend to have the unfortunate effect of preventing the vital evaporation, and thus causing or accelerating moisture-related decay to the fabric.

The Approved Documents states:

3.9 *When undertaking work on or in connection with a building that falls within one of the classes listed [in paragraph 3.8] above, the aim should be to improve energy efficiency as far as is reasonably practical. The work should not prejudice the character of the host building or increase the risk of long-term deterioration of the building fabric or fittings.*

Although the wording is different, the provisions in this paragraph are very similar in their practical effects to the partial exemption accorded to *listed buildings, buildings in conservation areas and scheduled ancient monuments*.

That is, the energy efficiency of the building should be improved as well as it can be, but not beyond the point where there is a risk that unacceptable damage to the *character and appearance* or the long-term durability of the physical fabric will occur.

The Approved Documents then state:

- 3.10** *The guidance given by English Heritage should be taken into account in determining appropriate energy performance standards for building work in historic buildings.*

The ‘*guidance*’ mentioned in this paragraph comprises this document and the other supporting documents mentioned in the introduction.

NEW EXTENSIONS TO EXISTING BUILDINGS

An extension will normally be able to accommodate a higher standard of thermal performance than the host building. An exception would be where the extension was designed to be a true facsimile of a previous structure or where certain planning requirements generated the need for elements to complement the historic building in terms of construction and detailing.

Sometimes an extension, such as a conservatory, can improve the thermal performance of the whole building, for example by reducing heat loss through the surface to which it is attached and enhancing solar gain. However, care needs to be taken in the design and integration of such structures:

- If unheated and isolated (for example, by doors which are usually kept closed in winter), a conservatory will normally be warmer than outside and reduce heat losses from the building to which it is attached.
- However, if heated – or unheated but left open to the adjacent building – the whole building’s heating requirements could be significantly increased.

The Approved Document states:

- 3.11** *In general, new extensions to historic or traditional dwellings [or buildings in L2B] should comply with the standards of energy efficiency as set out in this Approved Document. The only exception would be where there is a particular need to match the external appearance or character of the extension to that of the host building.*

Again, a newly-constructed extension should comply fully with the *energy efficiency requirements*. However, the energy efficiency requirements should not be applied beyond the point at which they would unacceptably compromise the *character and significance* of the host building.

An example might be where windows need to match those in the host building and as a result might be single glazed. In these circumstances improved thermal performance could be met by draught-proofing or secondary glazing.

ISSUES THAT WARRANT SYMPATHETIC TREATMENT

The Approved Documents also makes provision for ‘special considerations’ being applied as follows:

- 3.12** *Particular issues relating to work in historic buildings that warrant sympathetic treatment and where advice from others could therefore be beneficial include:*
- a. restoring the historic character of a building that has been subject to previous inappropriate alteration, e.g. replacement windows, doors and rooflights;*
 - b. rebuilding a former historic building (e.g. following a fire or filling a gap site in a terrace);*
 - c. making provisions enabling the fabric of historic buildings to ‘breathe’ to control moisture and potential long-term decay problems.*

This is clearly indicative and is not an exhaustive list. It should be noted that items ‘a’ and ‘b’ both make provision for reinstating key parts of a building which can enhance its character which have been previously lost. Item ‘c’ is rather different in that this clause relates to maintaining the historic building’s technical performance where this is of a traditional ‘breathable’ construction.

- 3.13** *In assessing reasonable provision for energy efficiency improvements for historic buildings of the sort described in [the above] paragraphs..., it is important that the BCB [Building Control Body] takes into account the advice of the local authority’s conservation officer. The views of the conservation officer are particularly important where building work requires planning permission and/or listed building consent.*

‘EXEMPTIONS’ AND ‘SPECIAL CONSIDERATIONS’

Buildings which are **exempt** from the energy efficiency requirements are clearly defined in the Regulations, as is the extent to which their conditional exemption actually applies.

However, buildings where **special conditions** may apply are not specifically mentioned in the legislation itself and, although they are clearly identified in the Approved Documents, the provisions which apply to them, and when they might apply, are not as clearly defined.

The difference in legal status between **historic buildings** which are **exempted** from the energy efficiency requirements and those which may be accorded **special considerations** reflects simply the degree of *significance*

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

which applies to any particular building. It does not signify any material difference in the overall process or method which should be used to achieve compliance.

Special considerations can be summarised as follows:

- a. the application of the energy *efficiency requirements* in accordance with the provisions of Approved Documents L1B and L2B up to, but not beyond, the point at which:
 - i. unacceptable alteration to the *character and appearance of historic buildings* will be likely to occur,
 - ii. the ability of *traditional buildings* to ‘breathe’ to control moisture and potential long-term decay problems is likely to be unacceptably impaired,
- b. the local relaxation of the energy *efficiency requirements* to enable:
 - i. the restoration in their original form of previously lost elements of a building which are important to its overall *character*,
 - ii. the removal of later modifications which restrict the ability of *traditional construction* to ‘breathe’ to control moisture and potential long-term decay problems.
 - iii. the design of external details of an extension to a *historic building* in a manner which minimises unacceptable alteration to the character of the host building,

PLACES OF WORSHIP

Paragraph 3.6 of Approved Document L2B also notes that *special considerations* apply to

“buildings used primarily or solely as places of worship”.

This provision is further expanded as follows:

3.14 *For the purposes of the energy efficiency requirements, places of worship are taken to mean those buildings or parts of a building that are used for formal public worship, including adjoining spaces whose function is directly linked to that use. Such parts of buildings of this type often have traditional, religious or cultural constraints that mean that compliance with the energy efficiency requirements would not be possible. Other parts of the building that are designed to be used separately, such as offices, catering facilities, day centres and meeting halls are not exempt.*

In the majority of cases these buildings will be designated and therefore covered by the exemptions, but this particular paragraph indicates that the definition of *significance* can be drawn more widely when applied to places

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

of worship, and may therefore include aspects of religious significance which are not specifically historic.

These special *considerations* also recognise that large internal volumes used only occasionally can never be heated efficiently, and that carrying out all the alterations necessary to achieve energy efficiency would be both disproportionately expensive and potentially damaging to their character and significance.

3.0

Understanding the building before carrying out upgrading works

When proposing any works to modify an older building it is important that it should first be properly understood. This means understanding its construction, condition and the way it performs. It also means understanding the building's qualities. In many cases far more damage has been caused to historic buildings by hasty ill-informed alterations than by simple neglect. If a building is properly understood, works can be targeted to the places where they are most needed, or, in the case of major changes, the places where they will do least harm. Not only is such a targeted approach better for the building, it can also be more cost-effective.

The qualities that need to be understood in any historic building are those which make it special such as original windows, doors and joinery. A building's qualities in some cases are not always physical, but they will provide the underlying reasons why particular parts of a building or place are significant, and thus worthy of protection or designation.

Very few historic buildings or places survive as originally built. The majority will be made up of works from different periods, derived from and expressing different values. When simple modifications are proposed to individual building elements such as walls, windows and floors, the significance may well seem obvious and uncomplicated. This may well be so, but caution is still recommended, as things are not always what they may seem at first sight and the full consequences of proposed changes may be more extensive and potentially damaging than first anticipated. There is also a danger that a range of small individual modifications, each of which may be quite tolerable in its own right, can together cause unacceptable damage.

MAINTAINING CHARACTER AND SIGNIFICANCE

SENSITIVITY OF HISTORIC BUILDINGS

A historic building in its townscape or landscape setting, complete with its interior decoration, fixtures and fittings, can be regarded as a composite work of art and document of history. Historic buildings vary greatly in the extent to which they can accommodate change without loss of their special interest. Some are sensitive to even slight alterations, particularly externally, and where they retain important interiors, fixtures, fittings and details. Others may have changed significantly and restoration is not considered feasible or sensible. These considerations will influence the extent of change that is appropriate to improve energy efficiency.

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

When alterations for energy conservation are proposed, regard should be given to:

- Ensuring that the building is well understood, to avoid damage
- Minimising disturbance to existing fabric
- Reversing the changes easily without damaging the existing fabric (especially changes to services)
- Appreciating that some buildings or parts of buildings are of such quality, importance or completeness that they should not be altered at all save in the most exceptional circumstances.

BS 7913:1998 *The principles of the conservation of historic buildings* expands on these principles.

The significance of historic buildings clearly encompasses the more obvious architectural and aesthetic values, but it also includes less tangible issues such as associations with historic people and events, examples of technological innovations, aspects of social history and links with a building's setting and other heritage assets.

English Heritage's ***Conservation Principles, Policies and Guidance*** (2008) lists four primary categories of heritage value:

Evidential value derives from the potential of a place to yield evidence about past human activity. This aspect is of particular relevance in places where there may be archaeological remains, but the archaeology within the structure of a building, whilst less familiar, may be every bit as important.

Historical value derives from the ways in which past people, events and aspects of life can be connected through a place to the present. This may be illustrative, by demonstrating important aspects of past lives and assisting the interpretation of the historic environment, or it may be associative, through being linked to a notable historical person or event.

Aesthetic value derives from the ways in which people draw sensory and intellectual stimulation from a place. This will include both the fortuitous qualities which have evolved naturally in a place over time, as well as the design values attached to a deliberately created building, group of buildings or landscape.

Communal value derives from the meanings of a place for the people who relate to it, or for whom it figures in their collective experience or memory. This can cover commemorative and symbolic values important to collective memory, *social* values which contribute to people's identification with particular places, or the *spiritual* values people associate with special buildings and places, whether attached to organised religions or not

ASSESSMENT OF SIGNIFICANCE

The actual assessment of significance is a key task in the process of upgrading historic buildings for thermal efficiency and should be carried out and documented prior to the design or preparation of any proposals. An assessment of significance should not be required retrospectively, for instance as a condition attached to the granting of Listed Building Consent: it should always take place as close to the beginning of the process as possible.

Assessments of significance can vary considerably in scope and detail, from the large and complex to the quick and easy. The degree of understanding, and the care and complexity of the assessment required should be decided from the size, overall significance and complexity of the building or place in question. In each case, from the largest to the smallest, a suitably proportionate approach is encouraged.

Where only local, small-scale changes are anticipated, such as the upgrading of an individual thermal element in a simple building such as a window, an assessment of significance need not be an onerous task: if the matter can be adequately documented with perhaps a photograph and a paragraph or two of text, there need be no requirement to make the process any more complicated. Once this is established and agreed, the design and development of upgrading proposals may proceed directly.

On the other hand, at the highest level, and for the most complex sites and buildings, the optimum way of assessing significance is through the preparation of a statement of significance and conservation plan, of which the assessment of significance will form the pivotal part. This can be a large, complex and inevitably expensive process, but will normally have been carried out at the outset of the project, before obtaining relevant consents. The methodology for a plan's preparation is a widely accepted process for the understanding and long-term management of historic buildings and places, but it will normally need to be prepared by suitably qualified and experienced historic buildings specialists, possibly from a variety of different fields.

For less complex listed buildings the preparation of a conservation statement is normally sufficient which, whilst generally following the format of a conservation plan, will normally require less depth of research. Non-specialists may well be able to do this, although greater expertise will probably be needed on more complex issues.

Within conservation areas, local authorities are obliged to prepare and publish conservation area appraisals to identify the character of the place, and the physical features which contribute to the character. These appraisals will often contain sufficient information to enable an assessment of significance to be a simple and straightforward exercise. Similarly, world heritage sites, registered parks and gardens, and areas of outstanding natural beauty should have adopted management plans which will already include, or directly refer to, much of the relevant information.

Many aspects of historic buildings will be significant by nature of their environmental performance. Obvious amongst these will be chimneys and fireplaces, early heating and ventilation systems and remnants of other obsolete building services installations. Although now surplus to technical requirements these will often be significant features to be recognised, understood and retained.

IDENTIFYING THE SPECIAL ELEMENTS

Before considering any alteration, it is essential to assess the elements that make up the special character and interest of the building, including:

- *External features*
such as a decorative façade, windows and doors
- *The spaces and internal layout*
the plan of a building is one of its most important characteristics. Interior plans should be respected and left unaltered as far as possible.
- *Internal features*
of interest such as decorated plaster surfaces, panelling, floors, window shutters, doors and door-cases.
- *Details*
such as mouldings, stucco-work, wall and ceiling decorations can be just as valuable in simple vernacular and functional buildings as in grander architecture, and can be a building's most important features.

Besides the historical or aesthetic importance of a building and its fixtures, the archaeological or technological interest of the surviving structure and surfaces may also be significant.

PRINCIPLES OF ALTERATION

The stock of historic buildings is finite and every loss or major alteration to fabric is significant. Therefore a conservative approach is needed with knowledge and experience to determine what is important and how changes can be made with the least effect on the character of the building.

English Heritage's *Conservation Principles* refers to the following issues to be taken into account when alterations are being considered:

- There is sufficient information comprehensively to understand the impacts of the proposal on the significance of the place
- The proposal would not materially harm the values of the place, which, where appropriate would be reinforced or further revealed
- The proposals aspire to a quality of design and execution which may be valued now and in the future
- The long-term consequences of the proposals can, from experience, be demonstrated to be benign, or the proposals are designed not to prejudice alternative solutions in the future

Conservative repair

This principle was pioneered by the Society for the Protection of Ancient Buildings (SPAB) from its foundation in 1877. Broadly, speaking, *conservative repair* is a coherent philosophy in itself which calls for the following:

- Respect for the age and character of the building, and for the physical evidence of its history,
- The preservation of as much original fabric as possible in the repair process
- That repairs should be carried out with materials and craft techniques as close as possible to the originals
- That new work should always be subservient to the old, both practically and aesthetically,
- That all new work should be carried out honestly, without pretending to be older or of a different type than it is
- That repairs done now should not preclude later repairs when they become necessary

Although the broader field of conservation philosophy has developed and expanded considerably since 1877, and for certain buildings and situations a modified approach may now be preferred, this principle still offers extremely valuable guidance in the first instance, and should not normally be departed from without expert guidance.

Minimum intervention

The principle of minimum intervention applies at all scales, from an individual brick to works of significant alteration. If all works are kept to the minimum absolutely necessary, the maximum historic fabric will be preserved, and thus the significance which it embodies.

Compatibility

All changes, whether small-scale repairs or larger alterations, should be made using materials and techniques which are compatible with the historic fabric. Modern materials tend to be harder, less flexible, and less moisture permeable than traditional ones, and when used in direct conjunction with historic fabric they can greatly accelerate decay in the original work.

It is generally best practice for all new work placed directly adjacent to historic fabric to be slightly weaker and more permeable, to ensure that it will weather preferentially to the more significant older work.

Reversibility

Where changes which may be detrimental to the significance of a building are unavoidable, they should wherever possible be made to be fully reversible. Adopting this principle means that even if the significance is obscured, the valuable historic fabric can be returned to its original state without damage after the lifetime of the relevant addition has expired. This principle can also be applied at the full range of scales, from individual localised repairs to major building extensions.

Authenticity

The principle of authenticity requires that the history and fabric of the building should be respected as essential to its significance. This implies the following:

- That all new work should appear as of its time (but it is nevertheless recommended that it should be subservient to the old),
- That all past phases of the building's history should be allowed to be clearly read,
- That speculative restoration should be avoided (although it may be justified where clear documentary and/or physical evidence of previous form is available).
- That nothing important to the significance should be removed.

As above, this principle can also be applied at all scales.

MAINTENANCE

A basic principle of building conservation is to ensure that significant buildings are maintained as well as possible in order to prevent decay damaging their fabric. Traditionally constructed buildings are generally capable of lasting indefinitely with moderate amounts of regular maintenance,

Basic maintenance should include regular inspections so that defects can be discovered whilst still small and easily fixable. This has the advantage of limiting the need for major works (which could trigger the need to comply with part L), preserving historic fabric, as well as minimising cost and disruption to the building's owners and users.

Colloquial use of the word 'restoration' is often indicative of the assumption that all historic buildings need periodic campaigns of significant work to return them to an ideal state. In reality, however, the need for such restoration usually results from a consistent long-term lack of regular maintenance.

Regular maintenance is also effective in maintaining the building's originally-intended environmental performance. Damp and significant draughts are

more often the result of inadequate maintenance or ill-considered changes, rather than original defects in the design and construction of the building.

UNDERSTANDING THE BUILDING AS AN ENVIRONMENTAL SYSTEM

Whilst the principle of understanding what is important about an historic building before altering it is generally well established, there is also an equivalent need to understand the physical behaviour of traditionally constructed buildings before carrying out any thermal upgrading. The purpose of this type of understanding is to minimise the risk of causing damage to the physical fabric of the building rather than its character and appearance.

Buildings have always been designed and constructed specifically in order to filter the extremes of the external environment and provide more benign internal conditions. This is a fundamental function of all habitable buildings except, perhaps, those which have a primarily religious purpose. This environmental filtration is provided in the first instance by the entire external envelope (walls, roofs, windows, doors), which keeps out rain, snow and wind; keeps in warmth, and moderates the entry of both light and air.

The internal environment of most buildings of traditional construction is also moderated by internal characteristics and features such as chimney stacks, cellular room plans, draught lobbies and the like which provide additional thermal mass, and limit heat loss through air infiltration.

Whilst this environmental performance cannot compare in efficiency with that available from modern materials and services, it was nevertheless often effective in its day, and may still be able to make a valuable contribution. It can also be an inherent part of a building's significance.

Therefore, when consideration is given to upgrading the energy efficiency of a historic building, it is recommended that its originally-intended environmental performance should be researched and understood as a vital part of both its potential performance. This will enable upgrading proposals to be developed which will be as far as possible naturally compatible with the existing fabric.

This understanding needs to encompass:

- *The large scale*, the performance of the whole building must be assessed in a holistic approach to heating, ventilation, insulation and energy efficiency.
- *The medium scale*, it is necessary to review how the conditions vary from place to place around the building.
- *The smaller scale*, it can be difficult and sometimes impossible, to make satisfactory junctions between various elements and construction details with different types and levels of insulation, so these must be carefully examined.

MOST HISTORIC BUILDINGS NEED TO BREATHE

As already discussed, traditional buildings are characterised and for the purposes of Part L defined, by the widespread use of “breathable”, moisture-permeable materials which allow moisture within the building fabric to evaporate freely away. This is particularly pertinent to the widespread use of solid masonry external walls (whether of brick or stone), but is also very relevant to earth buildings, infill panels in timber-framed construction, solid ground floors, plastering and rendering, and internal and external decorative finishes.

Whilst ‘breathability’ may seem to be a simple matter, the actual behaviour of liquid water and water vapour, and their effects on other aspects of the performance of both the building envelope and the internal environment, can in reality be very complex.

There are a particular range of physical effects which need to be borne in mind, amongst the chief of which are:

Sources of moisture

There are four principal sources of moisture which are likely to affect a traditional building:

- *Rain*

Most traditional buildings are capable of resisting rain effectively if they are kept in good order. Generally it will be absorbed into the outer layers of permeable material, and will then safely evaporate back out again when the weather changes. Particular problems may arise, however, if wall heads and similar details are less well protected than was originally intended.

- *Rising damp*

Traditional buildings are normally also capable of dealing with rising damp surprisingly well. However, this is achieved mainly by balancing the capillary water ingress with suitable evaporation to keep overall moisture levels within tolerable limits. Problems tend to occur when circumstances change, particularly if ground levels are raised, impermeable materials such as cement renders are added, or a building is converted to a more intensive use.

- *Internal moisture vapour*

Building occupants can generate a considerable amount of moisture through breathing, cooking, washing. This is initially carried as vapour in the internal air, which itself is normally warmer than the external environment. This moisture can condense on cold surfaces or, in permeable construction, within the body of a wall or similar. This is not normally a problem if the water taken up by the wall is adequately balanced by suitable evaporation over time.

- *Damaged services*

Water from damaged pipe-work is a self-evident problem which can and should be resolved by normal maintenance.

Hygro-thermal behaviour

The behaviour of water vapour is directly linked to temperature, as warmer air can carry considerably more moisture than cold air. This is generally expressed as *relative humidity*, which is the amount of water vapour in air quantified as a percentage value of the total amount which air at that particular temperature could carry. This is an excellent practical indicator of useful physical effects as it shows the potential for evaporation to take place not just from building materials and surfaces, but also the potential for evaporation from the human body. Therefore, RH affects not just the health of a building and its occupants but also their comfort.

Pores and capillarity

Moisture is taken up into, and evaporated from the pores in permeable materials, but the pore sizes can be very variable. In larger pores the water is absorbed as in a sponge, and it can move out again relatively easily. However, water is absorbed into small pores by capillary action, which is a function of surface tension. With capillary action, water moves from large pores into smaller ones, but not the other way. This means that water in the smallest pores can be surprisingly difficult to remove, usually requiring a considerable amount of energy.

Dynamic behaviour

The liquid water within permeable building materials is rarely static, but moves around in response to changing conditions, and during both daily and seasonal cycles. Often, the moisture level can vary through the thickness of a wall, for instance, with relatively dry materials close to the surfaces, from where evaporation is relatively easy, to quite damp in the middle. This zone of dampness will often move inwards and outwards in response to changing internal and external environmental conditions.

This movement is often characterised by a process of constant evaporation and condensation, with movement taking place towards the side where condensation is greater than evaporation, and away from the side where the opposite applies. The pores within the wall need not be completely filled for this process to take place, and, in a healthy building, they rarely will be.

Moisture vapour can diffuse through the unfilled pores to contribute to this process, although, as moisture vapour movement is driven by differences in vapour pressure, whereas liquid water movement is driven by differences in relative humidity, these can actually happen in different directions at the same time.

Generally speaking, within a healthy traditional building the moisture flows will maintain a balance between evaporation and condensation which keeps

the overall level of moisture held in the material within tolerable limits that cause no harm.

Latent heat

Not only does temperature affect the amount of water present (as in relative humidity), but the evaporation and condensation of water has effects on material temperature through the effects of latent heat. It takes around 540 times the amount of energy to evaporate a given amount of water as it does to simply raise the temperature of that water by 1°C. This energy must be obtained from somewhere, and is typically taken from the body of the permeable material the water is evaporating from, thus cooling it. Conversely, when that water then condenses on a surface, that latent energy is released back into that material. The energy transferred can be enough to have a significant effect on the temperature of both the fabric of a building and its internal environment.

Understanding permeability

The permeability of the external surfaces of traditional building materials is perhaps the most important aspect of this phenomenon and the one with which most people are familiar. It applies to traditional bricks, building stones (except perhaps slate and granite), traditional mortars, plasters and renders, unglazed tiles, cob, earth and early concretes. It also applies to timber, although the linear, cellular nature of wood makes its response directional: very permeable in the end grain, but less so to the sides. Reed and thatch tend to behave similarly to timber. Traditional lime washes, distempers and similar finishes are also permeable.

Permeability is a variable quality, not an absolute one. Many materials (particularly modern ones) state that they are permeable, but their actual permeability is considerably less than that which is optimally required when repairing traditional buildings. Traditional materials can also vary considerably in their permeability, and this can also be modified in use, such as in the degree of polish which might be applied to a lime plaster or render.

When permeable materials are wetted by rain, a proportion of the rain soaks into the surface. The depth of penetration can vary considerably with the material and the exposure, but experience over hundreds of years in most parts of the UK has generally developed effective techniques to deal with the prevailing local conditions and materials. When excess damp penetration does occur, it is more often due to a lack of maintenance rather than faulty original construction. For instance, open joints in masonry can encourage considerable water ingress which is effectively resolved by normal maintenance.

The permeability of the outer surface of these materials allows the moisture absorbed in poor weather to evaporate out again rapidly when the rain stops. This two-way flow is vital for the health of the building, as it ensures that the overall moisture load never reaches a high enough level to cause damage to the building fabric. However, not all materials have equal permeability; brick and stone rely heavily on the more permeable nature of lime mortars to increase the overall amount of evaporation. In addition, the

greater the evaporative area available, the drier any particular part of a building will tend to be.

For many years it has been assumed that permeable walling and other surfaces should be sealed in some way to prevent the water getting in. However, such treatments, including cement rendering, silicone (and other) sealants and plastic paints, etc. are rarely fully effective. In most cases some water will be absorbed through the finish into the permeable material behind, often through cracks or decayed patches (these treatments often have limited lives), but it will be unable to freely evaporate out again. The result is a build-up of moisture in the wall thickness which is detrimental both the health of the building and its' thermal performance.

The absorbency of the permeable materials also has the beneficial side effect of reducing run-off from the face of the building during rain. This significantly reduces the wetting of lower parts of the building, including details, flashings and so on. If an area of permeable walling is treated or re-finished to make it impervious it can often trigger rapid erosion and failure of parts of the building below which were never intended to carry this degree of run-off.

Permeability within the construction

Permeability within the construction is a less well recognised aspect of permeability in general, although it can be extremely important to the overall health of traditional buildings. The use of highly permeable materials allows moisture to disperse through a mixed construction both by diffusion and capillary action. The effect is to spread water widely and evenly through the structure, avoiding any concentrations which may cause damage.

It is this facility more than any other which allows timber and masonry to co-exist safely without separating membranes in traditional buildings. Joist ends and bonding timbers built into brick walls, although theoretically vulnerable, can survive happily for hundreds of years if the permeable masonry around them is properly maintained. However, old timber framed buildings can be very rapidly damaged by concentrated and trapped damp if their masonry fill panels are replaced or rendered over with hard cement.

Internal permeability

The permeability of the internal surfaces in traditional buildings is perhaps the least well recognised aspect of this quality, probably because it has less effect on the physical health of traditional buildings themselves. However, permeable fabric internally also has the ability to absorb quite large quantities of moisture from the internal environment, and to store it for release later.

This process of 'moisture buffering' can be extremely beneficial in the control of internal humidity. It becomes very important when the air change rate with the exterior is significantly reduced (as may be the case when a traditional building is draught-proofed), as moisture build-up under such circumstances can cause considerable discomfort for occupants. Many will respond by turning the heating up (as this will allow the internal air to carry more moisture), but this will increase the rate of heat loss through the external

envelope. On the other hand, if internal humidity is adequately buffered, an interior can be comfortable for the occupants at a cooler temperature.

However, it is important to recognise that very little of this moisture will disperse effectively right through even a highly permeable wall. In reality, the moisture is typically taken into the surface of the wall a certain distance whilst humidity is high, and the greater part then re-evaporates back into the space when it is no longer being used. It can then dissipate safely through natural ventilation.

MOISTURE BARRIERS

As the movement and evaporation of moisture is such an important part of the way traditional buildings perform, any intervention in this process, however well meaning, can have significantly detrimental effects on the building fabric. It is for this reason that great care must be taken when considering adding modern, impermeable materials to traditional construction.

External moisture barriers

The danger of applying impervious treatments to the outside face of permeable construction has already been mentioned. Rainwater which would otherwise be partially absorbed and then evaporate harmlessly away can be trapped behind such treatments in large quantities over time. The impervious treatment tends to actually exaggerate the absorption through cracks because of the water pressure caused by the surface run-off. Fully saturated walls can easily result.

This will be highly detrimental to the health of the fabric by causing rot in built-in timbers and holding water in places where it can both mobilise soluble salts and freeze. In addition, dampness in walls causes increased heat loss through the fabric, and prevents moisture buffering in internal spaces, making buildings feel cold and clammy. The normal (and entirely understandable) human response is to turn up the heating, thus seriously compromising the energy efficiency of the building.

External moisture barriers also effectively trap condensation from the internal environment within the building envelope. Whilst the majority of internal condensation is buffered and released back to internal spaces later, a proportion can easily build up within the fabric over time to levels which cause damage. Allowing this to also evaporate away from the external face can be very helpful in preserving both the building fabric and its performance.

Internal moisture barriers

Internal moisture barriers are commonly used to try to prevent this moisture vapour from the internal environment condensing within the building fabric, particularly when insulation is being added to the internal face of solid walls. In these cases they are termed vapour barriers, vapour checks or vapour control layers, and under the right circumstances they can be very effective.

However, in order to remain effective, vapour barriers need to be completely imperforate, as even small holes will allow water vapour through. This can seriously reduce the effectiveness of any added insulation, as well as potentially causing rot and other damage to the structure of the building.

Retrofitting vapour barriers into existing buildings is particularly difficult because of the existing structural connections, such as where floor joists are supported off internal walls. Where such junctions already exist it will be impossible to seal them adequately, and the gaps in the vapour barriers will be at the most vulnerable point in the construction.

The installation of vapour barriers into existing buildings of traditional construction is therefore rarely effective, and can actually cause increased damage by concentrating the moisture rather than dispersing it. Vapour barriers also restrict the advantages which might otherwise be gained from moisture buffering in the inner face of permeable construction.

Internal tanking for waterproofing, or to control rising damp, has also often been applied to traditional buildings which are perceived to have problems. Very often, however, these will simply direct the moisture in unpredictable ways to alternative places where it can then evaporate away. This might be at a higher level within the building, even an upper storey, or to a connected internal wall. Instances of damp like this are far better dealt with wherever possible by removing the moisture at source, and reinstating the original external evaporation surfaces to full health, before considering any kind of impervious intervention.

Moisture barriers within the fabric

Moisture barriers within the construction, such as damp proof membranes (DPMs), damp proof courses (DPCs) and localised separating membranes are also commonplace both in modern construction and in converted traditional buildings. However, these also need to be treated with care.

Traditional breathable solid ground floors have often been broken out and replaced with modern concrete constructions including a damp proof membrane. Whilst this is effective in producing a dry floor, the moisture which previously evaporated harmlessly from the old floor can be driven to the perimeter, and can rise up the walls, causing significantly increased concentrations of dampness here.

Rising damp up walls can, of course, be prevented by installing a damp proof course within them. This can also be effective, but it must be continuous if damp is not to be concentrated in any gaps. Physical DPCs are difficult to insert, but are the most durable. Injected chemical DPCs unfortunately tend to have relatively short service lives.

It is worth remembering that most traditional buildings were constructed to be healthy and durable in the first instance. If there is a problem with damp it is very often a result of the situation of the building having changed through time, such as a raised ground level, a later building or road surface adjacent, or revised patterns of land drainage. Restoring the building's original circumstances as well as possible will often limit the moisture effectively at source.

The specification of local moisture barriers in construction, such as around built-in timbers or against otherwise vulnerable components is also

commonplace in repairs to traditional buildings. These are often added as a way of 'playing safe' in case the moisture diffusion with traditional materials is ineffective. The reason these rarely cause problems with moisture concentration is because they are small components within a much larger mass of permeable material, so their effect on moisture flows is minimal. It is therefore important not to over-specify in these situations.

VENTILATION REQUIREMENTS

Owing to the factors discussed above, historic buildings usually need more ventilation than modern ones. In the past, they were often more ventilated than strictly necessary because of loose-fitting doors, windows and other openings. In addition, open fires created generous rates of exhaust ventilation through chimneys at times when condensation risk might otherwise have been high.

However, if ventilation of a historic building is reduced too much, condensation, mould and fungal growth may occur, leading to deterioration of the fabric and contents, and possibly health problems for occupants. Great care is therefore required in selecting an appropriate ventilation rate for a historic building. A rule of thumb used by some designers is 'twice as much as required', though the actual amount needed varies with context, and particularly with the amount of evaporation occurring from the fabric.

THERMAL BRIDGING

If the thermal performance of one element is improved by adding insulation while an adjacent area is not insulated, a local cold spot – known as a thermal or cold bridge – is created. For example:

- it may be possible to place insulation over a ceiling but not at the head of the adjacent wall at the eaves, which will remain cold
- a wall may be internally lined but not the window reveal – so here the exposed edge of the newly-insulated wall actually becomes colder, and at greater risk of condensation.

Cold bridging becomes more severe when the insulation value of the main body of a construction element is high. This means that adding more and more insulation, although apparently desirable, can increase the risk of localised damp and construction failures in less-insulated components which bridge this layer. The same effect applies wherever the insulation thickness is reduced, such as at window and door reveals, and comparable construction details.

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

MATERIAL COMPATIBILITY

Paragraph 3.9 in the Approved Documents also includes a requirement that work should not:

“increase the risk of long-term deterioration to the building fabric or fittings”.

In addition, Regulation 7 of the Building Regulations Materials and Workmanship states that:

“Building work shall be carried out..... with adequate and proper materials which..... Are appropriate for the circumstances in which they are used”.

All interventions to upgrade the energy efficiency of historic buildings must therefore be technically compatible with the existing structure, particularly with the need for permeable fabric to ‘breathe’. It is important to remember that it is a fundamental objective of the Building Regulations to ensure that technical risks are not introduced.

It is accepted best practice to use materials which match the original fabric as closely as possible. This will ensure visual harmony, both in the short term and as the building weathers over time, but it also ensures that no detrimental effects are introduced into the permeable fabric. This is because material which match the originals visually and technically can normally be expected to have the same degree of breathability under equivalent conditions.

Many historic buildings include soft, weak or permeable materials; for example, mortars, plasters, renders and paints. These cause the fabric to respond in fundamentally different ways to air, moisture and structural movement from the hard, strong, impervious materials and membranes widely used in modern construction. Before any work is carried out, it is therefore important that a building’s form of construction and the way in which this might have changed over time is understood – and that alterations are compatible.

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 cement based mixes for plasters, renders and pointing where, for example, incompatibilities in flexural strength, permeability and porosity can lead to disastrous salt migration and damage.

Preserving breathability is clearly also key to ensuring the optimum performance and durability of all traditional buildings. It is therefore important to ensure that new materials have permeability which is appropriate to the existing breathable construction to which they are being added.

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

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

Many material manufacturers now quote permeability figures in their literature, and this is to be encouraged, but there is a shortage of corresponding data for traditional materials already in buildings. This is because it is difficult to test materials outside a laboratory, and there has generally been no economic reason to do so. It is hoped that this situation will improve over the coming decades, but for the moment this means that simple human judgement and experience are the principal tools available to assess the matter. Under these circumstances caution is recommended. It is probably better to err on the side of extra breathability in most cases, on the understanding that it is easier to increase the resistance of most materials after installation than to add breathability once building works are complete.

As a general rule it is also preferable to increase breathability progressively from the interior of a traditional building to its exterior. This may be counter-intuitive, but in a traditional building in good order, in the English climate, the water vapour generated internally has more difficulty evaporating from the fabric than rain falling on the external surfaces. It is only in areas of exceptionally high exposure, and often only on the sides of buildings facing severe prevailing weather, that this rule will not normally apply. Damp problems in traditional buildings caused by external moisture are most usually a result of poor maintenance, such as damaged or blocked gutters and drainpipes, missing flashings or raised external ground levels.

Natural insulation materials

When adding insulation to traditional buildings, the use of insulation materials based on natural fibres can be very beneficial. Typical amongst these are wool, hemp, flax and recycled newspaper (cellulose). These materials are not only breathable, allowing transpiration of moisture through their air spaces, but the fibres themselves are able to absorb and then release moisture by evaporation. Synthetic insulation materials, even glass fibre and rock wool, do not have these attributes.

These natural insulation materials allow moisture vapour to balance itself across the insulation layer, allowing any condensation to evaporate away, but they can take up and disperse moisture from vulnerable materials in which they are in contact, such as when installed between timber frame components. Typically this means that a given amount of water condensing in a space is no longer forced into the timber alone, but is dispersed through both the timber and the insulation, allowing local relative humidity levels to remain low, and easing the evaporation when conditions change.

ESTABLISHING EXISTING PERFORMANCE

Before carrying out any upgrading works it is first necessary to establish how well the building is performing so improvements can be targeted to those areas where the biggest return can be made with the minimum risk

There are a range of non-destructive tests which are available which may give useful information to help guide proposals for upgrading the energy efficiency of traditional buildings. Chief amongst these are the following:

Air pressurisation testing

This process uses a fan set temporarily into a doorway of the building to measure how much air is escaping. It gives a very useful assessment of the overall degree of air infiltration that a building suffers from, which may well be the most severe type of heat loss which is occurring. Depending on circumstances this may also be used in conjunction with smoke generation to show where the air is actually escaping and entering. This is essentially the same test required for new buildings, and there are a number of companies who carry out this work.

Infra-red thermography

This involves a survey of the external envelope of a building using an infra-red camera, and gives an excellent visual indication of where heat may be escaping from. It must be done when a good heat gradient exists through the wall preferably after dark in winter when the building is heated.

Dampness measurement

Dampness can be measured in a range of ways by specialists, although in the majority of cases the removal of small samples will be required for accuracy. It should be noted in particular that electrical dampness meters should not be used on masonry or plasterwork, as the presence of soluble salts will give extremely misleading readings. (Many unscrupulous installers use this technique as it makes damp look far more severe than it may be in reality.)

In-situ U-value measurement

This is a highly valuable technique for assessing the actual thermal performance of building elements. Again, however, it should be carried out in the winter, and the actual testing equipment needs to remain in place for some time. The U-values resulting are not necessarily comparable with those obtained by conventional calculation methods, but will in many cases be more accurate.

Borescope/CCTV investigations

These are visual techniques for examining small voids within structures, as well as flues and drains, generally without opening up. They are very useful and cost-effective ways of assessing whether damage has occurred in hidden areas of a construction, and whether upgrading is likely to be possible or worthwhile.

Monitoring energy consumption

This may be as simple a matter as comparing fuel bills year on year, which can give very useful information over time. However, smart meters and similar equipment can provide equally useful information over real time, rather than having to wait a year for comparative figures.

Environmental data logging

This is a more sophisticated form of monitoring, often used in the most valuable buildings and in museums etc., although it can be very useful elsewhere. This usually involves the monitoring and logging of temperature and relative humidity in interior spaces, but a range of even more sophisticated techniques can be added, including measurement of humidity within constructions, surface temperatures and similar. The degree of monitoring can be tailored to the task in hand. Data is usually recorded constantly and plotted against time to give a very detailed chart of the environmental behaviour within a space. This can show both daily and seasonal fluctuations in considerable detail.

4.0

Upgrading energy efficiency- meeting the requirements of part L

Once there is an understanding of the character and significance of a building and its environmental performance then it is possible to design upgrading proposals which can achieve an appropriate balance between these and the energy efficiency requirements set out in Approved Documents (L1B and L2B).

In the majority of cases a range of priorities can be established that can be applied in order of:

- Degree of impact on the original historic fabric
- Amount of benefit they can offer and payback period
- Ease of installation

The process of upgrading existing traditional buildings to improve their energy efficiency can also be considered in a series of logical stages which are explored in more detail in this section.

They can be summarised as follows:

- Repair the building using compatible materials and techniques to reinstate its optimum original performance. Consider removing damaging alterations and additions which compromise the building's permeability
- Look at benign enhancement- improving heating strategies, controls and equipment
- Control draughts to reduce air infiltration throughout the building
- Consider stage one insulation possibilities.
- Consider stage two insulation but look carefully at the potential impact
- Consider carbon neutral energy supply from micro-generation where practically possible

THE ADVANTAGE OF EARLY CONSULTATION

Early consultation with the building control body can help to ensure that upgrades are appropriate to the original performance of the building in question, and that breathable performance is not adversely affected through compliance with the energy efficiency requirements. However, as the

majority of historic buildings will also be of traditional construction, it is highly likely that the local authority's conservation officer may be able to offer useful practical advice.

It may sometimes be appropriate to allow upgrading works which present a small risk of technical incompatibility if the energy efficiency benefits are significant, but only where the new work and any old work it may affect can be adequately monitored for long-term deterioration.

In small works, such as the localised upgrading or renovation of a single building element, the overall provisions set out here may seem exceptionally onerous. Under these circumstances it is recommended that all parties seek to reach agreement, particularly with the conservation officer and the building control body, before proceeding with actual building work. Such agreement should ideally be documented for the records of all parties.

HEATING STRATEGIES

Where conflicts between energy efficiency and older buildings do occur, the problem may be less to do with poor construction and insulation standards than with the incompatibility between the fabric of a building and the heating strategy in place.

The energy efficiency standards invoked for new buildings generally assume that central heating will be installed throughout to achieve constant internal temperatures of, say, 20°C in winter. This heating strategy has become the norm over, perhaps, the past 50 years and is now rarely questioned. The levels of insulation and restrictions on ventilation required by the Approved Documents for new buildings are calculated to minimise heat loss through the fabric under such heating regimes. Indeed, insulation levels in new housing in particular are capable of maintaining such internal air temperatures with very little actual energy input indeed.

Older buildings, however, generally predate the introduction of central heating and therefore evolved their forms and details to suit entirely different regimes of energy use.

Examples of typical differences are:

- The practice of heating primarily those rooms in use, rather than the whole building;
- Continual occupation of the building, rather than just in the mornings and evenings throughout the week
- The use of the thermal mass of the structure (particularly chimney breasts) to retain heat from fires and to release it slowly over a longer time frame, thus evening out overall fluctuations;
- Greater use of traditional methods of retaining heat such as closing internal doors, closing heavy curtains and shutters at night.
- Wearing more clothing indoors in winter

Rather than assuming that answers to the problems of energy inefficiency in older buildings lie purely in upgrading the insulation value of the structure and reducing ventilation rates, with all the problems of technical compatibility which this can cause, it is often useful to also consider revising the heating regime to suit the inherent qualities of the building fabric itself. This need not mean returning to coal fires, smoke and ashes, but the introduction of more sophisticated and responsive heating controls, for which suitable technology is now beginning to become available. Such modifications have the potential to usefully reduce energy consumption whilst also minimising the need to upgrade the physical fabric of the building itself.

RESTORATION OF ORIGINAL PERFORMANCE- MAINTENANCE AND REPAIRS

Because traditional buildings made from permeable materials work differently to modern ones, it is necessary to consider carefully the process of optimising their performance in dealing with moisture and heat. Both traditional and modern buildings can be highly effective in keeping out the weather and creating benign internal environments, but they do so using methods which are incompatible with each other. In practical terms this means that mixing these contrasting technologies is usually inappropriate, and will give reduced performance compared to that which each can achieve on its own.

Some traditional buildings have inevitably become damaged and worn over time so that they are cold, damp and draughty. It should be remembered that human physiology has not changed over centuries, and what is uncomfortable for us would, by and large, have been equally uncomfortable for our predecessors. In reality, they would have used as many of the means at their disposal as possible to produce comfortable environments. Historically, therefore, new, unworn buildings would have been carefully constructed to be capable of delivering sufficient protection and comfort for the English climate.

In addition, a large proportion of traditional buildings will also have been adapted or repaired over the years with the best of intentions, but using inappropriate materials, such as hard cement mortars and renders, plastic paints, synthetic waterproofing treatments, etc. These reduce the building's breathability and give a detrimental impression of both its durability and its ability to provide a comfortable internal environment.

REMOVAL OF DAMAGING ALTERATIONS

Whilst it is often beneficial to remove damaging later alterations which reduce the breathability of traditional buildings, it has to be recognised that this is not always practically possible. Certain materials, such as hard cement mortars, can adhere so strongly to traditional permeable materials that all attempts to remove them will damage the older, softer substrate. Synthetic waterproofing treatments are inherently irreversible. Under such circumstances a mixture of technologies will have already been inflicted on the building, and the consequences, although undesirable, may simply have to be accepted.

When serious damage will ensue it may therefore be preferable to retain the later materials. However, it needs to be recognised that this will mean that the traditional construction cannot breathe as well as it once did, and steps to mitigate the effects may well be necessary. These might include introducing membranes to protect vulnerable elements of the structure from trapped moisture, or finding alternative ways of allowing evaporation. The building's thermal performance is likely to be reduced, and techniques to compensate may be necessary, although these will need to be specified and installed with care.

REPAIRS

It is also highly desirable to repair a building which has become worn and decayed through centuries of use in order to restore its original hygro-thermal performance. Fortunately, this is usually easier and less contentious than the removal of damaging interventions. The correct and sympathetic repair of traditional buildings brings the technical performance back to their most appropriate level, and provides a sound basis onto which upgrading proposals can then be developed.

Old windows and doors have a reputation for being draughty, but would originally have been made as accurately as the considerable skills of a traditional joiner would allow, whilst cracked joints and voids in masonry allow liquid water to penetrate where sound mortar would effectively keep it out. Conservative repair of such decay using materials which match the originals as closely as possible, particularly in their technical characteristics, will always be beneficial, and will greatly enhance both the performance and the durability of the building.

BENIGN ENHANCEMENT – BUILDING ‘NEUTRAL’ WORKS

Modern technology can offer distinct enhancements to the thermal performance of older buildings whatever their construction and age. For example, condensing boilers are highly efficient and with effective controls and programming can make heating systems work in ways which are relatively harmonious with traditional construction.

Modern electronic control systems offer effective zoned controls and monitoring which allow heating systems to be accurately tailored for optimum use to suit a variety of layouts and forms of construction.

Conventional domestic heating systems are often set with timer clocks which set the heating to come on for a period in the morning, and then again in the evening. This is appropriate for a building with low thermal mass, as it will equate to the times when the occupants will be at home. However, this is not necessarily an efficient heating regime for a traditional building with relatively small amounts of insulation and high thermal mass. Here, much of the warmth will be taken up by the structure, and then re-radiated at times when the building is not occupied, making the heating wasteful.

In traditional buildings which have a high heat storage capacity in solid walls it is often more economical to change the heating regime to suit the natural thermal response time of the building. In some cases a suitable regime

might actually be to keep the heating on constantly at a relatively low level (say 12-15°C, or even lower) and then use local heating to warm a single room to full comfort temperature when it is being occupied, remembering, of course, to close the door. However, it is difficult to give general recommendations for such heating regimes as all buildings are different, but experimentation is very likely to be worthwhile. This can be greatly facilitated by the installation of smart meters or similar, as it will then be possible to get accurate measurements of energy use in real time, without waiting for the next quarterly bill.

The use of energy-efficient lighting and appliances is always recommended,

DRAUGHT-PROOFING

The control of draughts or air infiltration is the first step to take in preparing proposals for upgrading the energy efficiency of older buildings. This is because large amounts of energy can be lost through gaps in construction, and this route of heat loss has the ability to undo any valuable upgrading work which might have been carried out elsewhere on a building. For instance, heat lost by air infiltration through gaps will simply by-pass any insulation which might be added to the fabric, and energy gained through local, sustainable micro-generation will be used inefficiently if a significant proportion of it is simply heating the external air.

The following are instances where the control of air infiltration is likely to be relatively easy and will give significant performance benefits:

- The repair of cracks and holes in the construction.
- The plugging of holes in the construction caused by later modifications and services installations.
- The introduction of removable register plates to limit air movement up chimneys in winter.
- The installation of draught-stripping to external doors and windows. *English Heritage research (see section 5: Upgrading building elements, Windows) has demonstrated that upgrading original windows can match the air infiltration standards of new factory-made windows at a relatively modest cost.*
- The restoration of window shutters to full operation. *These are normally only used at night, but it is during this period when external temperatures are lowest, and heat loss therefore greatest.*
- The installation of heavy curtains and pelmets. *Also normally only used at night, but highly effective. Pelmets restrict convection currents behind curtains.*
- The laying of heavy carpets, particularly on suspended ground floors. *Note, however, that synthetic fibre carpets with impervious rubber backings will heavily restrict the breathability of floors over which they are laid.*
- The installation of secondary glazing.

The majority of these improvements can be carried out at relatively low cost, and with limited disruption. They will also normally be found to significantly enhance the comfort of the building for its users, and can reasonably be expected to offer significant savings on fuel bills.

At the same time care should be taken to provide an adequate amount of ventilation to control internally generated moisture.

ADDING INSULATION

STAGE ONE

Stage one upgrading works should be those which create minimum damage to the building, where possible by using existing voids and largely reversible techniques and detailing. The use of insulation materials which are highly compatible with traditional permeable construction will also minimise risks.

The following are examples of stage one installations which will offer significant thermal benefits:

- *Loft space insulation*

Insulation can be installed either at ceiling level or below the roof itself, although the detailing in each case will need to be different. A ventilation path above the insulation should be retained in the majority of cases in order to carry away any condensation which might affect roof or ceiling timbers.

- *Insulation of suspended timber floors*

This can be installed between the floor joists which in most cases will require lifting and replacement of the flooring. A ventilation path should be maintained below the insulation to control any condensation.

- *Insulation of cavity walls*

Many of the earliest cavity walls will be unsuitable for cavity fill insulation, but if it is possible it can be highly beneficial. It is important to use materials certified specifically for this purpose.

- *Insulation of timber framed construction*

Particularly in between timber frame members where original historic construction has been replaced with unsuitable later construction such as concrete blockwork or cement renders.

- *Installation of insulating shutters*

These can be highly effective in limiting heat losses through windows at night

- *Installation of secondary glazing*

This can insulate effectively whilst also limiting draughts (air infiltration). If well designed it can also be both discreet and reversible and is cited in Part L as an effective way of meeting the target U value.

- *Installation of double glazing.*

In many cases this will mean replacing the existing window, particularly where windows have narrow fine glazing bars that are unable to accommodate the thickness of the double glazing unit. It is sometimes possible to incorporate the thinner double glazing systems into existing frames particularly timber or metal casements. If fitting into double hung sash windows the extra weight has to be allowed for.

Rather than replace the window, secondary glazing can be used to enhance the thermal performance.

These upgrading works can all be applied with little difficulty in the majority of older buildings, and the energy savings they offer can give very good value for money with reasonable payback times. They should also have a minimal impact on the character and appearance of the building.

STAGE TWO

Stage two upgrading works might be considered once stage one works have been explored or implemented. The areas likely to be relevant are solid elements of the external envelope, particularly masonry or brick walls. Insulation of these areas can improve energy efficiency considerably, with results that may even rival new construction

However, it is very difficult to insulate these elements without some very obvious impacts on character and appearance which in many cases may be an unacceptable alteration. Such work can also give rise to a range of potential technical problems which may significantly limit the desirability of carrying out any work in this category at all or make stage two insulation a low priority in most instances. Much of this type of work will also have significantly longer pay-back periods.

These issues are covered in more detail in *Section 5 Upgrading building elements, Walls*.

ENERGY SOURCES: MICRO-GENERATION

As an adjunct to the installation of efficient heating and environmental controls, the installation of micro-generation equipment can be very beneficial for the overall energy performance of older buildings. These systems tend to be technically complementary but considerable ingenuity may be needed to avoid unacceptable impacts on character and appearance.

Most commonly-available micro-generation equipment tends to either provide hot water or electricity, either through solar panels (hot water or photovoltaic) or from wind generators. However, these are generally useful and well-proven types of equipment, and can make valuable contributions to overall energy use. Wherever the opportunity arises, small-scale hydro-power schemes can also be highly viable. Small-scale combined heat and power systems which have recently come on to the market have great promise.

Of more direct relevance to space heating are ground and air source heat pumps. Heat pumps tend to deliver their heat at lower absolute temperatures than conventional heating systems, but can be fully integrated with them. This low-level heat is particularly beneficial in constant heating regimes in buildings of high thermal mass, where the highly efficient energy production keeps the thermal mass “topped-up” to the benefit of both the building and its occupants. Less efficient local heaters can be used to raise the temperature in inhabited rooms only.

Biomass-fuelled heating systems are very appealing, but they inevitably rely on quite large tracts of land to produce the fuel. They are therefore most appropriate to farms, country estates and similar, and are generally less so in urban or suburban locations.

CALCULATION AND MODELLING

U-VALUE CALCULATIONS

The standard methods for simple U-value calculation which are generally required by the Approved Documents and associated methodologies are not usually suitable for the evaluation of the thermal conductivity of permeable materials. This is primarily because they use steady-state models based on data acquired from standardised hot box testing.

These methods are not generally capable of taking into account the dynamic effects of both heat and moisture flows, and their interrelationships over time. The ability of thermal masses to store heat and then re-release it is not well covered, and the effects of moisture on the thermal properties of the materials are disregarded.

Dynamic calculation programmes for the assessment of hygro-thermal behaviour over time do exist, but are currently not well tested for use on existing buildings. For this reason considerable caution should be exercised when interpreting quoted U-value figures for existing buildings. In many cases the actual thermal performance of permeable materials will be noticeably better than the calculated figures would suggest, giving rise to excessive pressure to upgrade in inappropriate ways. If doubt exists in critical situations it is recommended that an in-situ measurement of the actual heat flow through a thermal element should be used as a basis for upgrading proposals instead of calculations based on standardised material data.

DEW-POINT CALCULATIONS

Standardised simple computer programmes are also available to assess condensation and dew-point risk within various forms of construction. These are usually based on US *ASHRAE* profiling or German “*Glaser*” diagrams (these are variants of the same method). These can give useful guidance, but they are in many cases too simple to reflect the actual situation in complex permeable materials, and considerable caution in their interpretation is therefore required.

In particular, they usually rely on standardised generic tables of moisture permeability data, and on thermal conductivity data based on the hot box tests discussed with reference to U-value calculations above. The actual characteristics of natural materials in particular can be far more variable than these tables usually suggest.

In addition, they do not take into account the complex evaporation and condensations processes which are normally constantly in motion within permeable constructions, nor do they allow for the ability of permeable materials to disperse moisture through themselves to limit concentrations. Again, dynamic calculation programmes which can deal with these issues do exist, but are relatively untested at present, and should really only be used by specialists who can understand the variables and interpret the results appropriately. It is hoped that such methods will be proved robust in the near future.

COMPUTER MODELLING

Unlike the provisions for new buildings, which require assessment of whole building performance against theoretical target buildings using approved computer software, the standards for existing buildings remain primarily element-based, as was usual under earlier incarnations of the Regulations. This means that individual parts of buildings, such as walls or roof slopes, are assessed for compliance without inherent reference to adjoining construction. It also means that prediction of the behaviour of the building as a whole is neither required, nor strongly encouraged.

Whole building analysis is *permitted* within the Approved Documents by the use of the same tools as for equivalent new buildings: SAP analysis for dwellings and SBEM analysis for others. These tools, however, do not specifically allow for the particular requirements of historic and traditional buildings for the following reasons:

- They are not sufficiently able to take into account the particular behaviour of moisture-permeable, ‘breathing’ construction,
- Whole building analysis must be based on a quantified analysis of the performance of the existing building in order to understand the behaviour of proposed modifications: there are no agreed or standardised test methods currently available to enable such analysis to be properly carried out,

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

- Unlike with modern materials, where manufacturers are required to provide performance specifications, there is at present little available quantitative data on the thermal and moisture behaviour of historical and traditional materials.

These drawbacks mean that with the currently established modelling methods there is a real danger that inappropriate modifications and interventions to historic traditional constructions will be applied if the standard methods are adopted without extensive adaptations and additional expertise.

It does not follow, however, that this will always be the case. There is no inherent reason why suitably sophisticated computer modelling tools cannot be developed in the near future, and the establishment of appropriate testing methods for existing structures and historic materials are also well within the bounds of possibility.

When suitable tools can be made available for computer modelling to be reasonably appropriate, such methods should become standardised for the analysis of both existing and new buildings, wherever the scale of the project will justify it. It is also hoped that future editions of the regulations and Approved Documents can be formulated to take this properly into account. This will offer the significant benefits of more accurate understanding of historic and traditional construction, better-targeted and more appropriate interventions and the thorough analysis of existing and new constructions, both in parallel and as combined entities. In each case, however, it will be necessary to ensure that upgraded buildings where computer modelling has been used as the principle design tool are carefully monitored for their performance after completion.

5.0

Upgrading building elements

This section provides guidance on specific issues relating to upgrading individual building elements such as windows, walls and floors.

Many of the issues are covered in more detail in a series of supporting English Heritage guidance documents covering the following:

- Insulating pitched roofs/warm roofs
- Insulating at ceiling level/cold roofs
- Insulating flat roofs
- Insulating thatched roofs
- Chimneys and flues
- Insulation of dormers
- Insulation of timber framed walls
- Insulation of solid walls
- Early cavity walls
- Draught-proofing windows and doors
- Secondary glazing
- Insulation of suspended ground floors
- Insulation of solid floors

WINDOWS

THE IMPORTANCE OF WINDOWS IN OLDER BUILDINGS

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 of historical significance 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. Replacing traditional single glazed sash windows with double glazed PVCu windows can be highly damaging to the special character and appearance of the building. 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 a sparkle that today's flat sheets with their uniform reflections don't have. Where it survives, it should be retained and alternative means of thermal improvement considered.

Many historic windows, frames and glazing, have fallen victim to inappropriate replacements, but over the past decade, there has developed a greater appreciation of their value. However, many windows are still threatened and Part L must not become the agent for their thoughtless destruction. While listed buildings enjoy some protection, unlisted buildings are at high risk – even where they are in Conservation Areas, National Parks, Areas of Outstanding Natural Beauty and World Heritage Sites.

WINDOW TYPES AND MATERIALS

England has a rich tradition of different window designs and materials from various periods of history. Most historic windows are timber-framed. Oak joinery (either fixed or in casements) predominated until the late 17th century, when, with the advent of the sash window, softwood was imported from Scandinavia and the Baltic States. This slow-grown, high-quality, naturally durable timber continued to be widely used until the early 20th century. Later inferior species started to be used which needed chemical preservatives to provide some degree of longevity. Historic timber is therefore not a renewable resource and it is very difficult to source timber of this quality and durability today. Where possible windows should be repaired and continue to be used.

Iron frames had been used in medieval times, and by the 16th century metal-framed glass windows were beginning to appear in secular homes. By the middle of the 18th century metal sash windows were being cast and even copper was being set in wooden frames, usually oak. 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 windows which were strong, slim and non-combustible. All these windows are important historically and should be conserved.

VENTILATING AND DRAUGHT-PROOFING

Most modern windows accommodate trickle ventilators for controllable background ventilation, to meet the Requirements of Part F of the Building Regulations. Older buildings often have considerable air infiltration through floors, airbricks, etc and may well not need more. Indeed, air infiltration through old windows is often excessive, so draught-proofing and weather stripping can be very effective in reducing not only heating bills but also reducing levels of noise and dust too. 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

Several forms of draught-proofing are available, which operate in different ways:

- Some types simply act as gap fillers, and are applied as mastic or foam.
- Other forms keep out the weather by means of a snug, slightly oversized fitting, comprising silicone rubber tubes, polypropylene and nylon-filled pile brushes, or with rubber, polyester, or sprung-metal 'Z' and 'V' fins.

For steel and timber casements, a self-curing silicone rubber sealant can be injected into the gap between the window and the frame. The window is first cleaned, and overhauled so that hinges and catches operate easily. The opening edge of the casement is temporarily coated with a non-stick gel. The silicone is then injected and sticks to the non-treated frame, but not to the coated casement edge.

A good draught-strip should insulate, be durable and inconspicuous. A number of firms now provide an effective specialist installation and refurbishment service for existing windows. According to one leading company, 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 and tests have shown this can reduce heat loss by nearly 90%.

IMPROVING WINDOW INSULATION

New 'facsimile' double glazed windows have been developed with sealed units and low emissivity glass. In most cases these fail to provide an adequate visual match to the original patterns owing to the glazing bar thickness required to accommodate the glazing cavity. It is impossible to replicate most original glazing bars in double glazing even with the thinnest systems. The aim should be to improve thermal performance whilst retaining the existing windows by investigating the following options:

- *Draught-proofing*
is the most cost-effective and least intrusive method.
- *Secondary glazing*
improves insulation, draught-proofing and noise control. If carefully designed, it can be relatively unobtrusive (with divisions in the glazed panels hidden behind meeting rails or glazing bars). However, not all windows are suitable for secondary glazing, owing to the narrowness of the internal sill or reveals; the difficulty of accommodating the new panes within an oddly-shaped or unduly protruding architrave; or clashes with internal shutters.
- *Shutters*
are important features and often contribute to the design of an elevation. Repairing and using external and internal shutters can minimise heat loss at night and when rooms are unused, as well as reducing unwanted solar

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

Traditional means of minimising heat loss are still effective, such as heavy lined curtains. Modern alternatives include insulated curtains and reflective and/or insulated internal blinds.

WINDOWS RESEARCH

With the increasing pressure to replace traditional windows to improve thermal performance, English Heritage recently commissioned research to look at the actual performance of traditional sash windows on the basis that:

- Traditional windows can be very durable: many original Georgian and Victorian windows are still in place, whereas modern windows tend to be designed to have very much shorter lives
- Current calculation methods may be pessimistic about performance of traditional windows and the opportunities for improvement
- Window replacement can easily destroy the character of a traditional buildings as has been widely demonstrated over the past 30 to 40 years in nearly every part of the UK

Using a traditional 2 x 2 double hung vertical sliding sash window the research looked at:

- Heat transfer through the window
- Heat loss through the glass and frames
- Heat loss by air leakage
- The combined effects of conduction and air leakage
- Providing ventilation and avoiding condensation

The research concluded:

- Simple repairs to mend cracks and eliminate gaps can significantly reduce the amount of air infiltration or draughts. On the window that was tested, air infiltration was reduced by one third
- Air infiltration through a sash window in good condition can be reduced by as much as 86% by adding draught-proofing
- Heat loss through contact with the glass and frames can be significantly reduced by adopting simple measures like closing thick curtains and plain roller blinds. In the test heat loss was reduced by 41% and 38% respectively
- More elaborate measures reduce heat loss even more and can improve windows to meet modern Building Regulations, which target a U value for windows of 2 or below. In a test with good quality secondary glazing, this value was 1.7. Well-fitted closed shutters, also produce similarly good results. The best result is when the two methods are used together, resulting in a 62% reduction in heat loss and a U-value of 1.6

ROOFLIGHTS

Most old rooflights are single-glazed, set in cast iron or timber frames, or sometimes as unframed sheets of glass replacing slates or plain tiles. Frames are often ill-fitting, and draught-proofing may improve this. Where replacement is essential, double-glazed copies of original rooflights are available which can be acceptable in historic buildings.

DOORS

TYPICAL CONSTRUCTION

Most external doors on historic buildings were made of timber, many in hardwood frames. Depending on their age and design they were usually morticed and tenoned together, either in a flat plane, or with panels fitted between stiles, and muntins and rails. Doors which are original or of historical interest should be retained wherever possible, and repaired as necessary.

THERMAL PROPERTIES

Solid doors often have reasonable insulating properties. Most of the heat loss usually occurs by infiltration around the perimeter of the door or where gaps have developed around panels, at the junction with the door closer and through locks. Repairs and draught-proofing may be helpful. Where space permits, an internal draught lobby with a well-fitting (and if necessary well-insulated) inner door may be a practical solution.

GLAZED DOORS

Existing glazed doors should be retained, and all original or historically important glass kept. Often the easiest option to improve thermal performance will be with draught-proofing, thick insulated curtains or a draught lobby, if these can be fitted without detriment to other historic or architectural features.

WALLS

EXTERNAL APPEARANCE

Historic buildings display a wide range of materials and forms of construction, ranging from thick stone or earth walls, to timber-framed buildings with comparatively thin and lightweight wattle-and-daub infill panels. The appearance of the external walls is usually one of the most important aspects of a historic building, while the materials give the building

its unique and often local character. Other than repairs or re-pointing, they are unlikely to tolerate much change without exacerbating decay problems and detrimentally affecting their special interest and appearance.

THE USE OF POROUS MATERIALS IN WALLS

Most historic buildings in this country have solid walls constructed in porous materials, with internal finishes such as lime plaster. This porosity has helped to keep many buildings in good condition.

- On the outside, it acts as a thick overcoat, absorbing rainwater, and allowing it to run down, drain out and later to evaporate.
- On the inside, it helps to stabilise moisture levels in rooms and often averts surface condensation, for example in crowded conditions or when cooking.
- Moisture can also pass through the wall and evaporate both externally and internally as conditions allow, as can any dampness rising from the earth.

This approach differs greatly from most modern buildings, which rely on:

- Impervious or rain-screen systems externally
- Internal construction which is completely protected from moisture – at least in theory – by cavities, damp-proof membranes, and vapour control layers.

THE IMPORTANCE OF PERMEABILITY

Where walls need to transpire moisture and vapour effectively, new materials intended to form barriers to unwanted moisture or water vapour can impede the very processes which help a historic wall to survive in good condition.

Examples are commonplace, including:

- Hard cement mortar pointing which catches rainwater and diverts it into a wall, by-passing the overcoat effect
- Hard external rendering, intended to keep the rain out, which also stops moisture evaporating and causes the wall to become damper. When cracked, it also traps rainwater, making things even worse.
- Modern impervious paints which cause previously sound plaster to break down, because rising and penetrating damp can no longer evaporate
- Other impervious materials applied internally which cause moisture to accumulate. This in turn leads to decay of embedded materials (such as timber) which are hidden from sight until deterioration has become severe. The impervious layers can lead to a build-up of salts in the underlying substrate. The salts then crystallise and rupture the original construction.

Many insulation products lose their insulating qualities when wet, so moisture from damp walls or interstitial condensation can make them almost useless. Other products, including some natural materials, are less affected. However, care must be taken in selecting appropriate materials that do not result in new problems such as insect infestation.

IMPROVING INSULATION EXTERNALLY

The opportunity to improve the thermal performance of walls externally will often be limited in a historic building because of the impact external insulation has on the appearance of the building: notably on its proportions, and on details such as quoins, window reveals, cills, thresholds etc – all likely to be unacceptable in terms of planning and Listed Building Consent. However, there may be opportunities to insulate externally, for example where tile hanging or weatherboarding has to be removed and replaced. Panels in timber frame buildings might have been in-filled with unsuitable materials such as concrete blockwork, which would benefit from replacement with an insulated more compatible material. Another possible exception is where rendering requires complete replacement.

From a purely technical point of view the installation of *external insulation* is perhaps more desirable, but this presents a range of particular issues that need to be considered before proceeding:

- *Rain screening*

Most insulation materials used externally will need to be screened from rainfall effectively and preferably using techniques which allow the insulation and the wall behind to breathe to vent condensation.

Whilst a render which is thermally more effective might be used, the main criterion is that repairs should be carried out on a like-for-like basis, which means adhering to the original mix of materials. This is also important where transpiration is required.

- *Vapour build-up*

If the external insulation, or any part of its associated construction, forms a barrier to vapour, there will be a possibility of condensation build-up from internal moisture vapour within the permeable wall behind.

- *Detailing*

External insulation will increase the wall thickness. This will require the design of effective details for all window and door surrounds, for roof overhangs and for the wall foot, and for junctions with adjoining construction. These will often significantly increase the expense of the overall work.

- *Warming of original fabric*

The external insulation will, however, offer the advantage of warming the internal fabric. This will often improve both its durability and the internal environment of the building to a useful degree.

It is recommended that a condensation risk assessment should be carried out before installing external insulation, although this can normally be expected to give more satisfactory results.

Against the possibility of insulating solid external construction, however, should also be set the possibility that the majority of generic U-value calculations on permeable construction tend to over-estimate the actual heat loss which will in reality occur. Given the problems which may arise with all insulation proposals, it may well be of value to explore the fact that solid external walls may actually behave significantly better in reality than is often assumed even by those who have significant experience in the field.

IMPROVING INSULATION INTERNALLY

It is important to ensure that internal walls are always investigated with care in advance of any changes, in case ancient or interesting features – such as early plaster and paint schemes – are hidden in the plaster or behind panelling or other coverings. Timber panelling, plaster mouldings or enriched decorations are all-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:

- The dimensional changes may be unacceptable at window and door openings and where original surface details such as dados or cornices, or skirting boards survive.
- The loss of space may also be unacceptable.

Particular technical matters which should also be considered:

- *Resistance to condensation*

If insulation is installed internally there will be a reduction in temperature towards the outside, reaching a dew point at which internal moisture vapour will condense. If this happens near to the insulation it can render it ineffective and cause rot and decay within both old and new construction. This is theoretically controllable with vapour barriers, but these are not always effective.

- *Effectiveness and durability of vapour barriers.*

Vapour barriers are easily punctured, allowing vapour through, and in existing buildings, particularly those of vapour-permeable construction, can rarely be adequately sealed at their perimeters. As a result they tend to lose their effectiveness markedly over time.

- *Detailing*

All internal insulation installations will need to be carefully detailed around the edges of window and door openings. This will usually mean reducing the insulation thickness, possibly give rise to cold bridging and condensation.

- Cold bridging.

Breaks in all insulation layers, including studwork construction to hold internal finishes, are potential cold bridges which can lead to condensation and rot.

- *Loss of thermal mass*

If a solid wall is insulated internally its thermal mass will no longer be available to moderate the internal temperature of the rooms inside.

- *Cooling of external fabric*

Internal insulation means the external fabric will be maintained at a consistently reduced temperature. This can lead it to becoming wetter for longer, especially if it has been repointed in hard cement mortar increasing dangers of rot and decay within the wall thickness and frost damage on the surface.

Because of all these issues it is vitally important to calculate the condensation risk prior to installing internal insulation. This will often be done in a simple way free of charge by insulation manufacturers, but the calculations resulting may be based on very approximate estimates of the performance of traditional materials. It is also necessary to interpret such calculations, and to take a very careful view of the likely effects of changes to moisture and heat flows through the construction, details as well as the body of the wall, and the practicality and durability of any mitigating techniques which may be suggested.

FLOORS

FLOORING GENERALLY

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 also 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

Solid floors, such as those laid with stone, brick, early concrete, plaster or lime ash, cannot be insulated without first excavating them. Generally this

should be avoided, unless it is the only way to remedy some destructive defect. In reconstruction, damp-proof membranes will usually be incorporated both as normal practice and to protect the insulation. However, membranes can cause more problems by driving moisture up walls and columns and are sometimes unnecessary with permeable materials.

SUSPENDED FLOORS

Floorboards can often be lifted and insulation installed with comparative ease. However, care should be taken if:

- The floorboards have a structural function-acting as a plate membrane in early 18th-century construction: houses have been known to collapse when all the floorboards on one level were removed at once
- Early wide hardwood boards (usually oak or elm) are used, particularly if these have been undisturbed and cannot be lifted without causing damage to the boards or joists
- There are historic examples of sound-deadening or fireproofing between joists: these should be preserved.

Suspended timber floors are, or should be ventilated underneath. This is usually intended to be cross-ventilation between under-floor openings or air bricks on opposite sides of the building. However, research has shown that air flow is very erratic and sometimes can be harmful as it introduces more damp. In practice, air often comes in through external openings and then passes between the floorboards before rising up within the building or into flues. Adding insulation (or floor coverings) can reduce this airflow and increase moisture levels both under the floor and in the building. Conditions below the floors should be checked before any work is done. If there are no signs of damp or decay then it is best to avoid making changes. It would be wise to check the situation after insulation has been installed.

ROOFS

EXTERNAL APPEARANCE

The roof of a historic building is often its most striking feature. Most have survived in a remarkably unchanged condition for many centuries. With stone, slate or tile, re-covering becomes necessary when the fixings fail, though much of the covering material is often re-used on the same building. With thatch, shingles, lead and other metals, failure is more often attributable to the natural life of the covering material itself.

ROOF STRUCTURE

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 roof-spaces. Even though a historic building may generate a lot of moisture internally, some of which finds its way into 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

Proposals to improve the thermal performance of the roof-space have to be considered in relation to the use and performance of the rest of the building.

For example:

- Modern living tends to introduce more moisture into buildings and roof-spaces
- Ventilation rates are often reduced, exacerbating the problem
- The air and vapour control layers (AVCLs) often used in modern construction are virtually impossible to install in existing ceilings with any degree of effectiveness
- Added insulation tends to cause roof-space 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 roof-spaces. These are outlined in the following paragraphs.

PITCHED ROOFS WITH VENTILATED ROOF SPACES

For traditional roofs with 'cold' roof-spaces 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 below into the roof-space 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 roof-space colder than before, so the risk of dampness and condensation may increase, particularly if ventilation is limited or poorly distributed.

Sometimes additional roof-space 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 roof-space from the building below. In such circumstances it is essential to understand what is happening to the internal environment here, in order to determine the likely

effect of insulation and ventilation on the existing fabric; and not to introduce additional ventilation gratuitously.

PITCHED ROOF WITH INSULATION AT RAFTER LEVEL

Where there are rooms in the roof, a 50 mm ventilation path is recommended beneath the roof finish, insulation, vapour control layer and an internal lining (Stirling 2002). It is important to maintain the through flow of air when detailing new dormers or rooflights. Few historic buildings would be able to meet these requirements.

When upgrading utilitarian attic spaces, however, it may be sometimes be possible to adopt these modern details. Alternatively, improved insulation can still be provided and the extremes of driven rain or snow combated by traditional means. Such applications maximise the permeability of the structure effectively absorbing most of the increased moisture in the short term, and allowing it to disperse slowly.

FLAT AND LOW-PITCHED ROOFS

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 roof-space (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

These have always been problematic technically. According to Stirling (2002) 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 also 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 not be used if the structure spans between parapet or abutment walls.

In spite of the above, research has shown that even with little roof-space ventilation and no air and 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 roof-space. In winter, moisture from below is absorbed or buffered by the timber which then dries out thoroughly again in 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 some metal roof coverings by inducing corrosion on the underside.

FLAT ROOFS WITH WARM DECKS

To upgrade the insulation of a 'cold' flat roof, Stirling (2002) states that the preferred option is to convert it to 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.

ROOFING MATERIALS AND DETAILS

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,

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 the most popular; 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. Additional ridge ventilation can be unsightly.

Insulating foam (isocyanate) is sometimes sprayed directly onto the underside of slates and tiles, and 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 insulated 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 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.

6.0

Further information

GLOSSARY

THE CONSERVATION OFFICER

It is a primary responsibility of the conservation officer in a local authority (or other relevant agency) to ensure that the significance of any building or place is properly assessed at a relevant level, and at the appropriate time in the overall process. The conservation officer will also need to be satisfied that the proposals for upgrading are designed and implemented in such a way that the character and appearance of the building is established and adequately respected.

At the outset of any project, the conservation officer will be able to give advice about the appropriate level of understanding and assessment which may be required in each instance, and whether specialist advice will be needed. To ensure the optimum upgrading can be achieved without causing 'unacceptable' damage, the conservation officer may also be able to give guidance on achieving an appropriate balance between protecting the building's significance, and complying with the energy efficiency requirements of the regulations.

SIGNIFICANCE

'Significance' or '*cultural significance*' is an internationally-recognised concept for the aggregated valuable qualities found in historic buildings and places. Within UK primary legislation it is generally protected under the terms '*character and appearance*', or, in lesser cases, simply '*appearance*'. However, within national and local planning frameworks an assessment of historic significance is an explicit requirement when determining planning consent.

Use of the term '*character*' in addition to '*appearance*' is important, as it implies the inclusion of all relevant aspects of value which are not immediately visual or aesthetic. Significance can be defined very widely. Clearly it includes architectural and aesthetic values, but it may also include association with significant historic people or events, unusual historic technology, particular aspects of social history, or the part a structure plays within a wider field of value, such as a significant landscape, or the setting of a more valuable monument. It is likely to be different in every case, and degrees of listing or designation, whilst useful, will only ever give a rough indication of the total significance of any particular structure. In addition, such designations will not normally make any distinction between different

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

levels of significance which may be present within a particular building or place.

For this reason the assessment of significance to an appropriate level of detail is a vital part of the process of achieving compliance with the energy efficiency requirements without inflicting unacceptable damage. This may be a relatively simple and straightforward process, particularly in the lesser categories of value. However, at the higher levels and in more varied sites, it can be a complex and subtle matter, requiring careful investigation and background research, and a considerable degree of professional expertise and experience to interpret and evaluate appropriately.

ENERGY EFFICIENCY REQUIREMENTS

As defined in Approved Documents L1B and L2B, *energy efficiency requirements* means the requirements of regulations 23, 26, 28 and 29, and Part L of Schedule 1 to, the Building Regulations.

These requirements are expanded and interpreted within Approved Documents L1B and L2B, which are therefore first-tier guidance to their application. As noted above, these Approved Documents also contain a range of recommendations for achieving compliance.

HISTORIC BUILDINGS

For the purposes of the interpretation of the *energy efficiency requirements* of the Building Regulations, Approved Documents L1B and L2B, and this series of documents, *historic buildings* are defined as those which meet at least one of the following criteria:

- i. *listed in accordance with section 1 of the Planning (Listed Buildings and Conservation Areas) Act 1990* (generally referred to as **Listed Buildings**, and including all those at Grades I, II* and II);
- ii. *in a conservation area designated in accordance with section 69 of that Act* (generally referred to as **Buildings within Conservation Areas**); or
- iii. *included in the schedule of monuments maintained under section 1 of the Ancient Monuments and Archaeological Areas Act 1979* (generally referred to as **Scheduled Ancient Monuments**)
 - a. *buildings which are of architectural and historical interest and which are referred to as a material consideration in a local authority's development plan or local development framework* (generally referred to as **Locally Listed Buildings**);
 - b. *buildings which are of architectural and historical interest within national parks, areas of outstanding natural beauty, registered historic parks and gardens, registered battlefields, the curtilages of scheduled ancient monuments, and world heritage sites;*

All these categories of historic buildings are recognised and designated as such in order to protect either their inherent significance or their particular contribution to the wider significance of a place. It is this significance and its expression in the physical fabric of these buildings, which the specific legal designation is intended to protect.

Whilst the vast majority of *historic buildings* within the UK are also *traditional*, certain buildings, particularly from the twentieth century, are recognised and designated as *historic* because of their *significance* whilst being built using modern methods without *breathable* materials. Such buildings are therefore *historic* but not *traditional*.

SPECIAL CONSIDERATIONS

Special considerations are:

- a. the application of the *energy efficiency requirements* in accordance with the provisions of Approved Documents L1B and L2B up to, but not beyond, the point at which:
 - i. unacceptable alteration to the *significance* of *historic buildings* will be likely to occur,
 - ii. the ability of *traditional buildings* to ‘breathe’ to control moisture and potential long-term decay problems is likely to be unacceptably impaired,
- b. the local relaxation of the *energy efficiency requirements* to enable:
 - i. the restoration in their original form of previously lost elements of a building which are important to its overall *significance*,
 - ii. the removal of later modifications which restrict the ability of *traditional construction* to ‘breathe’ to control moisture and potential long-term decay problems.
 - iii. the design of external details of an extension to a *historic building* in a manner which minimises unacceptable alteration to the *significance* of the host building,

TRADITIONAL BUILDINGS

For the purposes of the interpretation of the *energy efficiency requirements* of the Regulations, Approved Documents L1B and L2B, and this series of documents, ‘*Traditional buildings*’ are defined in Paragraph 3.8 of both Approved Documents L1B and L2B as:

- c. *buildings of traditional construction with permeable fabric that both absorbs and readily allows the evaporation of moisture.*

This quality is often colloquially referred to as ‘*breathability*’. For simplicity these may also be referred to as ‘*traditional buildings*’.

ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

Most *traditional buildings* were designed and built before the invention of reliable and cost-effective impermeable membranes or moisture barriers, and they therefore use techniques for dealing with moisture which are very different from modern construction. Because they cannot provide complete, effective impermeable barriers to moisture ingress, they rely instead on their ability to allow such moisture to evaporate rapidly away, and thus prevent the damaging build-up of damp and resulting physical decay.

Whilst the majority of *historic buildings* are traditional, there are many thousands of *traditional buildings* throughout the United Kingdom which are not recognised as *historic*, meaning that their *significance*, whilst possibly present, is not considered to be sufficiently valuable to justify specific legal protection. This includes nearly all buildings constructed prior to 1918, as well a significant proportion of those built before 1945. It is essential that adaptations made to improve the energy efficiency of these structures should take into account the traditional technology and characteristic behaviour of the building fabric, otherwise very real damage can be caused. Well-meaning attempts to keep moisture out of these buildings using modern methods tend to have the unfortunate effect of preventing the vital re-evaporation, and thus causing or accelerating moisture-related decay to the fabric.

U- VALUES

U values are about thermal transmittance of materials. This is measured by how much heat will pass through one square metre of a structure when the air temperatures on either side differ by one degree. U values are expressed in units of Watts per square metre per degree of temperature difference (W/m² deg K)

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ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

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ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

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ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

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ENERGY
EFFICIENCY IN
HISTORIC
BUILDINGS –
APPLICATION OF
PART L OF THE
BUILDING
REGULATIONS TO
HISTORIC AND
TRADITIONALLY
CONSTRUCTED
BUILDINGS

English Heritage is the Government's statutory adviser on the historic environment. English Heritage provides expert advice to the Government about all matters relating to the historic environment and its conservation.

The Conservation Department promotes standards, provides specialist technical services and strategic leadership on all aspects of the repair, maintenance and management of the historic environment and its landscape.

This guidance has been prepared for English Heritage by David Pickles, Ian Brocklebank and Chris Wood.

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