Building environment and performance

Good practice guidance

September 2016

If you require a copy of this guidance in an alternative format (large print, Braille or audio version), or if your first language is not English, we can provide it in the appropriate format or language if you ask us. It is also available in Welsh.

Contents

1. Introduction

This guidance has been prepared to help you understand and control the risks that the physical changes brought about by your project might pose to the fabric of your building and its contents.

“Building environment” refers to environmental factors that have an impact on a building – such as water, light, heat and pollution. Sometimes the sources and the resulting problems are obvious, for example water leaks which can lead to crumbling plaster or mould growth or overheating, which can cause timber to crack. In other cases, environmental damage may be less obvious, this may be because it is associated with apparently harmless matters, such as the way the building is heated or through leaving doors open. Even though the rate of damage may be slower in such instances, it can still be serious and irreversible.

“Building performance” describes **how** the building responds to its environment and the conditions outlined above i.e. by moderating the temperature due to its thick masonry walls. It is important to understand that this is different to the environmental sustainability issues associated with energy use and the building’s carbon footprint, although the two areas are related.

1.1 Why does building performance matter?

You may already be aware that the buildings you look after might be difficult to heat (thermally inefficient) and might sometimes be uncomfortable for users and visitors. You might be looking to change this and make the building more comfortable for the use of current and future generations. However, the measures that are commonly used to improve comfort levels for users and visitors can sometimes have unintended consequences for the building fabric and the contents, and may even cause severe and costly damage. Even positive changes such as increasing visitor numbers in fragile historic buildings can have damaging consequences unless the changes are carefully planned.

> Improving the performance of a historic building for visitor comfort can inadvertently cause severe and irreversible damage to the building fabric and its contents.

A typical example where changes to the original design can cause long-term problems is the installation of new heating systems which are expensive to run, produce minimal increased thermal comfort for those using the building and potentially dry out sensitive areas, causing damage to the stonework (from salts) and the cracking of timbers. Another example is the installation of kitchen facilities in rooms with insufficient ventilation. The water vapour from kettles and urns can cause condensation – leading timber to rot and mould to grow.

The key point to understand is that if you are trying to use your building in a different way from how it was used before this may bring significant risks that need to be addressed. However, we also know that historic buildings can be remarkably resilient. Traditional thick masonry walls can provide considerably more thermal buffering than modern insulated walls and porous limewash on lime plastered walls can control moisture levels in the air without the need for mechanical air conditioning. Helpfully, these methods of environmental control are passive and can be achieved at little or no cost and if these inbuilt characteristics are used well they can also help to reduce the building's carbon footprint and allow it to perform well in environmental and financial terms over the long term.

Many traditionally-built historic buildings can provide benign environmental conditions for human comfort and also conserve the building fabric and contents in a way that is sustainable and reduces running costs. We simply need to understand the way that the building performs in order to use the structure and its inherent characteristics to our advantage.

This good practice guidance will:

- take you through the steps involved in understanding your building and its performance;
- help you think about how you can use the building to support your project aims;
- help you avoid the common problems that could lead to costly damage in the future.

1.2 How does the building environment work?

A building that has good environmental performance is one that modifies the external environmental conditions (the weather) in a way that is beneficial for the building, its contents and the people using it. For inhabited buildings the conditions produced by the building structure alone may not be sufficiently comfortable for human occupation and so artificial controls are often introduced, often by way of mechanical heating. Building performance is not an absolute measurement but one that is relevant to each particular case. For instance, the performance characteristics of a Victorian greenhouse will be very different to those of a medieval church or a twentieth century concrete-built house partly because they have been designed to address different functional needs but also because building techniques and user expectations have changed over time. When you are assessing the efficiency of your building, the first step is always to establish the intended performance standards and then assess whether they are being achieved.

1.3 How can we control the environmental conditions in an historic building?

Unlike modern buildings, where we attempt to separate internal and external conditions, the greatest influence on the internal environment of a historic building is the weather outside.

Many historic buildings are designed to buffer the conditions between inside and outside by passive means, often with thick walls and porous materials that allow the fabric to 'breathe'. Well-designed traditionally constructed buildings are capable of comfortable conditions for human use, though we have to remember that expectations of comfort have changed. Even though a building feels a little cold and uncomfortable it may be performing in the way that was intended. This is a very important concept to understand when considering a programme of building repair or a change of use.

Is your project trying to help the building achieve its original state or are you trying to make it do something that it has never done before?

In order to achieve conditions that are more comfortable for the modern user, changes are often made both to the building envelope (floors, walls, windows, doors and roofs) to increase the amount of buffering between the internal and external conditions. Changes are also made to building systems, such as heating and ventilation in order to modify the internal microclimate. Changes to the building envelope can be regarded as **passive**, as they simply increase the efficiency of the building's existing ability to act as a buffer, while changes to the building systems can be regarded as **active**.

1.4 Modern use of historic buildings

In many cases, the way that we use historic buildings has changed significantly from how they were originally intended to be used. In addition, our expectations for physical comfort have increased considerably, particularly over the last half century.

Changing uses and expectations are not unusual, as each successive generation has adapted its buildings to suit its needs. As an example most domestic buildings have included some form of heating throughout their history, but for many this was originally limited to fireplaces. Controlling heat loss was seen as an integral part of the process of keeping occupiers warm and so curtains, shutters, carpets and cushions were used for this purpose.

In recent decades we have begun to expect our historic buildings to feel more like our homes, with constant high temperatures. This is a difficult aim to achieve, particularly in situations where we want to achieve these domestic conditions at minimal cost when the buildings are occupied infrequently.

So, whilst achieving more comfortable conditions may, in overall terms, be beneficial as it can encourage greater use of our historic buildings, and generate the funds to maintain the building, the process brings with it considerable risks that need to be anticipated and controlled. It is therefore important that projects are carefully designed to ensure that they achieve the desired outcomes effectively but without causing long term and costly damage to the heritage that we are aiming to protect and sustain.

We now have far higher expectations of thermal comfort from our historic buildings than previous generations and risk damaging the buildings in our desire to be comfortable.

2. The risks to your project

Most projects that involve a change of use in a historic building will have an impact on the internal environmental conditions. These changes need not be damaging. In many cases a well-designed project can improve the environmental conditions as well as the condition of the building fabric. However, it is easy to make apparently minor building alterations that can have a disproportionate and negative impact on the building.

Historic structures and materials tend to perform best when the environmental conditions are stable. In contrast, sharp or periodic changes in the environment can cause considerable harm. This deterioration tends to occur slowly and may not become visible until the damage is severe and irreversible.

Apparently minor building alterations can have a negative impact on the environment and the building. The effect of this may often not be seen until the damage is severe and irreversible.

There are a number of key risks to consider when making changes in a building.

2.1 Salt activity

A common form of deterioration in materials such as stone, plaster and concrete is salt activity. All historic buildings are contaminated with a certain level of soluble and water-attracting (hygroscopic) salts. In their crystalline form or in solution these salts will cause little, if any, damage. However, as they undergo phase change i.e. changing from their dissolved state to their crystalline state and back again, they undergo a significant change in size, which can cause the surrounding stone or plaster to crumble and collapse.

The change from the crystalline to the dissolved state occurs when the humidity of the air changes. The level of humidity in a building is affected by the temperature. Salts can also change state through the addition or loss of water vapour. Unstable heating or the extensive use of kettles and urns can therefore cause changes in humidity that can therefore lead to salt damage.

Over time the repeated change from dissolved state to crystalline state can cause the erosion of not only small architectural details but entire building facades, sometimes leading to structural, as well as superficial failure.

Unstable levels of moisture in the building structure or excessive humidity in the air can activate salt activity leading to erosion and damage to materials such as stone and plaster.

2.2 Moisture

Another common problem is the way in which organic materials, such as wood, respond to changes in moisture content by moving in ways that develop cracking and structural failure. In addition, painted organic structures, such as decorated furniture or panel paintings, can suffer delamination and flaking as the response of the wood, or even the canvas, will be very different to that of the brittle paint layer.

Inappropriate or unstable humidity levels can cause structural movement and cracking in wooden objects and the flaking of painted surfaces.

Where humidity levels remain high for long periods or condensation occurs, microbiological growth can take place. This can produce unsightly cosmetic damage, for example mould patterns on walls, as well as physical damage. Some mould growths can be toxic and a risk to human health.

Changes to heating systems or the installation of kitchen facilities can therefore result in risks, unless appropriate control measures are put in place. Most of these problems can be avoided through careful planning and design. If you are developing a project that will involve varying the environment within your building, you need to understand how the existing structure may react to the changes and how best to avoid costly long-term damage, while still achieving the outcomes that you want from your project.

3. Strategies to avoid damage

3.1 Understanding the different requirements for people and buildings

People, like buildings, interact with the air around them. Warm air increases our temperature and dry air causes us to evaporate moisture. In the simplest scenario, if we make changes to the air conditions to benefit people, they will also affect the building. However, conditions that are comfortable for people may be damaging to the building. We must ensure that we understand the different effects on buildings and people and then create conditions that are comfortable, but will not unduly affect the historic fabric and collections.

Conditions that are comfortable for people may well be damaging to the building and its contents.

3.2 Managing the expectations of stakeholders and users

It is extremely important to understand the limitations of your building and to manage the expectations of those using it. While your project might be successful in making the building more comfortable for new activities, we have to recognise that not all buildings are capable of becoming an all-purpose space that can be used in exactly the same way year-round. It is important that this is understood both by the people who are developing the project and by those who will be using and visiting the building. For instance, it is almost impossible to achieve the high temperatures that we might expect in our homes in an historic building that is used infrequently without causing damage. Therefore, holding an educational activity in an old barn in the middle of winter may well be uncomfortable for the participants as it is unlikely that you will be able to install sufficient insulation or heating without putting the building fabric at risk.

Ensure that your users and stakeholders understand the limits within which your historic building can be used without putting the fabric at risk.

Similarly, while a historic parish church might feel more comfortable after an effective programme of fabric repairs and the introduction of a well-designed heating system, there will still be limitations on how the building can be used. Congregations and other user groups may still need to dress appropriately during the winter. It is important to be realistic about what you are likely to achieve through your project and to make sure that your intended users understand this.

3.3 Personal control

There are questions to be asked about whether the environment within a historic building should be controlled for human comfort or whether the individual should control their own, personal, environment. Some visitors may assume that your historic building will be heated to the same comfort levels as modern spaces (e.g. domestic homes) and expect to be able to wear lightweight clothing in an old town hall or a medieval parish church during the winter. . Previous generations would have expected to wear warm layers and an appropriate coat to attend a church service for example.

Over the last fifty years there has also been a trend towards removing soft furnishings such as the cushions and curtains that had previously been used to control draughts and protect users from cold surfaces.

Warm clothing and the use of simple methods to control personal heat loss – cushions or suitable floor coverings, for instance – can be used to achieve thermal comfort in some historic buildings during the coldest months of the year.

We must also consider how to accommodate user groups with different needs – a person who visits the building for a short time does not need the same comfort level as a school group taking part in a learning activity for a couple of hours.

3.4 Heating and ventilation

One common requirement of many historic building projects is the improvement of the thermal comfort of users, which is often focused on the question of heating. Heating systems can be one of the most costly elements of a project and, while they can offer considerable benefits, both in terms of the comfort of users and the conservation of the building they are also one of the most high risk elements. For this reason it is worth considering heating in some detail. We should also bear in mind that there can be confusion between the goal of improving thermal comfort for users and the assumption that the solution is to change the way that the building is heated. Heating a building is rarely the most efficient way of helping the users of the building feel warm So, although upgrading the heating system might contribute to achieving greater thermal comfort it is rarely, if ever, the whole solution.

Do you want to heat your building or do you want to make the users of the building feel warm? These are very different aims and require different approaches.

Achieving thermal comfort in an affordable manner, but without risking the building fabric, requires an understanding of where the heat is needed, how you will retain it in that location and for how long. Therefore, if you have a small group who use a small part of the building periodically, for example a small church congregation meeting in the side chapel for an hour each Sunday or a group who meet for a local history lecture in the evening in one room in the village hall, you are unlikely to want to heat all the air mass in the building to achieve a moderate and temporary increase in air temperature in the small occupied space. On the other hand, if you employ guides or custodians who will be in your building on a full-time basis you will need to think about the best way to make them feel comfortable. Both of these scenarios relate to thermal comfort but each has different solutions and cost implications.

4. Controlling heat loss from buildings

In broad terms thermal comfort is a matter of heat input and heat loss. If you are standing on a cold stone floor or sitting on a cold bench you will lose heat by thermal conduction. This can be addressed simply by adding insulation – a carpet or a cushion. If you are sitting next to a cold stone wall, you will lose heat by radiation. This can be solved either by adding insulation or taking a seat closer to centre of the space. In fact, with few exceptions, heat loss is a comparatively simple issue to deal with and costs little to control.

Heating is also expensive in terms of the financial cost (and is likely to continue to get more expensive as energy prices increase) as well as having an impact on your carbon footprint.

Tackling the challenge of improving the thermal comfort in a building offers a number of possibilities but it is often productive to start with a consideration of how unnecessary heat loss might be minimised. If there is an unnecessarily high level of air leakage around doors or roofs, not only will this reduce the thermal buffering capabilities of the building but it will also allow air movement, which will increase discomfort. This can often be solved by simple repairs or draught exclusion measures. Of course, the lowest cost approach is also the most obvious one. If you feel cold in an historic building in winter then part of the answer is to dress appropriately.

Balancing input and heat loss is a key element of any building heating project for thermal comfort as it improves efficiency and saves costs.

4.1 Water leaks, insulation and air leaks

If there are problems with excess moisture entering a historic building then it will lose heat quicker in cold weather than would otherwise be the case. Additionally, a wet wall will encourage evaporation, increasing problems with internal moisture levels, which may damage the building and make the air feel humid or damp, causing further discomfort to users.

It is also important to consider the building's level of insulation and the location of the heating system components. It is inefficient and costly to place a heating unit next to an uninsulated wall or a draughty window as this will simply allow the heat energy to escape. However, installing inappropriate insulation in historic buildings can also be inefficient and sometimes damaging. If insulation is installed incorrectly it can cause condensation to occur, which can lead to the deterioration of the building fabric. A careful evaluation is needed to find out if improving the thermal insulation of the structure will be of benefit to the building and whether it can be implemented without undue risk.

Air leakage is another key factor when evaluating building performance. The aim of the building envelope (floors, walls, doors, windows and roofs) is to separate internal and external conditions, so any holes in that envelope that allow air leakage will reduce the efficiency of the envelope and will limit the buffering that it can provide. Broken windows and ill-fitting doors therefore need to be repaired promptly in order to ensure that there is no unavoidable heat loss.

4.2 Heating systems (heat input)

There are three ways that heat can be transferred:

- convection – heating the air in order to indirectly heat the object or person within the space;
- conduction – direct transfer of heat energy by surface contact; and
- radiation – transfer of infrared heat energy between two surfaces that do not touch.

Convective heating

Many traditional heating systems, such as fires, achieve most of their warming effect through radiation and a little convection (the air in the room eventually warms, which, in turn, warms the occupants at a distance). However, many of the heating systems employed in modern homes and historic buildings are largely convective, with some level of radiation. For example, a hot water radiator system generally aims to warm the air and then, indirectly, the person. However, if you sit next to the radiator, you also receive some radiant heat. This means that much of the expensive heat output is heating the unoccupied air. This is particularly extreme in a tall building, such as a barn or church, when the buoyant warm air rises to the top of the building so that the space above the users is heated to a far greater level than the occupied lower areas.

A variation on traditional heating of this type is the use of low level local convective heaters placed under or within the fixed seating (e.g. church pews). This type of heating warms the air in which the people are sitting and needs less heat input than would be the case if the whole building were being heated. While this is a commonly used approach, it relies on people using the fixed seating and may be inappropriate for many historic buildings if they need to be used in a more flexible way.

Radiant heating

Radiant systems can be far more efficient than convective heating as they transfer the heat directly to the person by infrared radiation. The practical difficulty is that there needs to be a radiant surface producing the heat close to the user. Overhead high temperature radiant heaters have been used for many years in this context. In faith buildings, radiant heaters are often placed under pews or low temperature pew back radiant panels are used.

In recent years there has been an increased use of under floor heating (UFH), which is often effective as the radiant heat is generated in exactly the location where it is needed. In addition, such systems include an element of convection, as the air in contact with the floor is warmed. However, UFH is expensive in terms of capital costs, is disruptive in archaeological terms during its installation and can result in the loss of historic floor finishes and details. Furthermore, the construction materials used to physically support the UFH system can themselves cause damage to the building by changing the pattern water movement in the ground below the floor if they are not carefully specified. So, although UFH can be highly effective, there are many situations where it is not an appropriate solution.

A variation on under floor heating is under carpet heating, which uses an electric element below, or woven into, carpet material. This can provide localised floor-level radiant heating with very low installation costs, but the technology is comparatively new and the impact of long-term use has yet to be seen. Nevertheless, if designed and controlled correctly, its use in defined areas e.g. in small chapels, seating areas for custodians, and children's play areas offers some possibilities.

Different heating systems provide warmth in different ways, with advantages and disadvantages for the user and the historic building. Convective heating warms the air indirectly, warming the person and the building fabric within the air. Radiant heating heats the surface of the person with limited effect on the air or the building.

4.3 Conservation heating

As well as providing thermal comfort, heating can also be used to control the relative humidity to benefit the conservation of the building and its contents. 'Conservation heating' is based on the use of relative humidity as the primary control factor for heating rather than temperature. This means that heating is controlled with a humidistat control rather than thermostat control. The system can be extremely effective in producing effective humidity conditions for the conservation of the building and its fragile contents. However, because of the way in which temperature and humidity interact, maintaining a stable humidity at the levels generally required in historic buildings means that the temperature can fall to uncomfortably low levels at some times of the year. Therefore in many cases, conservation heating is only used during unoccupied periods, while comfort heating is used during occupied periods. In such cases, control is provided by a combination of humidistats and thermostats. This approach can be particularly useful in historic buildings that are only used periodically.

4.4 Managing and maintaining heating systems

Whatever heating system is chosen, it is important that the system's resilience and sustainability is fully evaluated at the start of the project and that you consider how you will maintain and service the system without disruption to the building fabric or the building users in the future. It is also critical to consider running costs at current and future energy prices alongside capital costs.

Will your heating system be resilient or will it quickly become obsolete? Can you afford to run it at current and future energy prices?

Heating controls

The control strategies for heating systems are just as important as the heating units themselves, both in terms of the effectiveness of the heating and controlling energy costs. Ensuring that the heating is only turned on when it is needed and that enough time is allowed to heat up the building before it is being used is essential.

Of course, heating controls can always be tampered with and heating units can become a source of damage to the building fabric if incorrectly managed. Restrictions can be put on controls but, ultimately, it is essential that the people responsible for the day-to-day management of heating systems understand the approach that has been agreed. This may mean that training needs to be provided and a simple user manual prepared. The manual should explain not only the mechanics of the system, but how and why it is being used in this particular way. It is important that the manual is handed on to successive building managers as this person may change on a regular basis and that training is made available to everyone who needs it.

It is important to ensure that the people responsible for the day-to-day management of a heating system understand the methodology behind the heating controls and do not change them unnecessarily.

The key point to remember is that there is no single effective system of providing thermal comfort in an historic building. You will need to consider the needs of your individual building and its users and develop your approach accordingly.

4.5 Ongoing maintenance

Any measures that you put in place for controlling the environment in your building will require maintenance in the future. A single blocked gutter or a leaking drain can completely undermine the positive conditions that you have created, causing damage to your building and making users uncomfortable due to the presence of damp air. Faulty heating systems may cause uncomfortable conditions for users but can also cause severe damage to the building or the sensitive artefacts inside. You should therefore devise a clear and achievable plan for the ongoing maintenance of the building and its systems.

You will also need to think about who will carry out the maintenance, at what intervals and how it will be funded over the long term. Your plans for the ongoing management and maintenance of the site should be set out in a Management and Maintenance Plan, which should be submitted with your application. Management and Maintenance Plan Guidance is available on the HLF website.

5. Assessing building performance and the impact of your project

5.1 The aims of building performance assessment

Understanding the basic environmental performance of your historic building is a vital first step in determining whether your proposed project is viable. Therefore, at an early stage in the project development process you should carry out an assessment of your building's performance. The key aims of an assessment of this type are:

1) To examine the building's current environmental performance and establish benchmarks.

2) To identify and evaluate the risks to the building that might be created by the changes proposed as part of your project.

3) To determine whether there are any issues with the building and collection that might affect the outcomes of your project.

4) To determine whether your project will have the desired outcomes in terms of building conservation, user experience and comfort.

This assessment can be done at many levels; large and complex projects might benefit from a detailed and in depth study but for many smaller projects a much simpler approach will be sufficient. The key point is that the main elements of the project are questioned in order to identify any potential for unintended consequences so that measures can be put in place to avoid such problems.

This assessment should always be carried out at the start of the project, when the concept is still being developed and before time and funding has been spent on developing a fully detailed design brief. Questions about environmental conditions and building performance are often asked too late in the project's development and a considerable amount of work is then needed to address the problems.

Carry out a building performance assessment at the earliest stage of the design process to ensure that the project is viable and to discover whether any significant mitigation measures need to be included.

In many simple cases the assessment can be done by an informed individual with the correct questions. It is only when a project is complex that specialist professional support may be necessary.

5.2 Gathering data

The assessment and control of building performance starts with thinking about the possible impacts of your project on the building fabric, as well as considering the limitations that the building places on your project.

The first step is to gather as much existing data as you can about the current environmental conditions in the building. Some sources of useful information include:

- **Anecdotal evidence**: How do the people using the building feel? Are they hot or cold, comfortable or uncomfortable? Are some areas of the building more comfortable than others? Although such views may be subjective they can give a very good impression of where the building is working or not working from the point of view of the user.
- **Building reports and surveys**: Do you have any previous reports on the condition of the building written by an architect, surveyor, engineer or building manager? If so these may provide some indications of where the building is in good condition and where is it failing. A building with leaking drains will rarely produce environmental conditions that are good for the conservation of the fabric or the comfort of those using it.
- **Utility bills and energy monitors**: These will tell you how much energy the building is currently using. Will you be able to afford this in the future? If you plot the figures for successive years on a graph you will be able to see if there are any seasonal patterns. You will also be able to see how your energy use compares to other similar buildings.
- **Use patterns**: If you keep a diary or a spreadsheet showing who uses the building, which areas and when, this will provide information about which areas of the building you need to heat for comfort and which areas might need only limited heating to keep the building in good order.

Having gathered all this information you will be able to move on to considering a simple element/risk/control approach for each of the proposed changes to your building:

1. **Element**: Which elements of the project might have an impact on the building environment (heating, drainage, building use etc.)?
2. **Risk**: What are the risks that this may create for the building and its contents?
3. **Control**: How can these risks can be controlled i.e. by removing them or mitigating them?

The variety of buildings and projects means that there are numerous variations to the risks, so the questions below only offer a general guide to common issues. It is important that you make an individual assessment of your project to identify where the relevant risk may occur and then design your own set of questions using the element/risk/control approach discussed above. The document that you produce should be a practical tool to aid the project design and should develop alongside the project itself.

However, the following questions are likely to be common to almost all historic building projects:

A. **Element:** Has your project addressed any existing building defects?

> **Risk**: Unless the building envelope and rainwater disposal systems are in good condition and functioning correctly, any measures to improve the environment for the conservation of the building itself or the comfort of users will be undermined.
>
> **Control**: Identify any damage or defects in the building envelope and rainwater disposal systems (including underground drainage) and ensure that repair measures are included at an early stage of the project.

Example: Water penetrating the building from leaking gutters or damaged walls and windows will not only cause damage to the historic fabric but will reduce the thermal buffering provided by the building, resulting in uncomfortable conditions for the users.

B. **Element:** Does your project involve modifying the building envelope (floors, walls, doors, windows and roofs)?

Risk: Could the proposed changes affect the ability of the building to effectively mediate between external and internal conditions, for example by requiring doors to be open for prolonged periods or through insulating roofs or introducing new windows?

Control: Identify measures that can be put in place to minimise any negative effects e.g. curtains at entrances, automatic door closers, seeking appropriate advice on suitable types of insulation.

Example: You want to make your building more welcoming by adding glazed outer doors so you can keep your inner solid doors open. Is there sufficient room to allow people to open and close both sets of doors independently? If visitor numbers are high is it possible that the doors will remain propped open allowing all of the heat to escape? If this is likely to happen does this mean that you actually need a larger glazed porch for this approach to work?

C. **Element:** Does your project involve modifying the rainwater disposal system?

Risk: Could the changes have an impact on the rainwater disposal system above or below ground, for example by changing flow volumes over roofs or down specific downpipes or by introducing additional water into below ground drains?

Control: Investigate alternative water disposal strategies or consider increasing the capacity and efficacy of the current system.

Example: The construction of a new extension to a building will increase the surface area of the roof and the volumes of rainwater that need to be taken away. If the rainwater is being transferred into the existing rainwater disposal system will the rainwater goods and the underground drainage systems have enough capacity to deal with this?

D. **Element:** Does your project involve changes to the way in which part or all of the building is used?

Risk: Will the project involve changes in activities that might change the environmental conditions, for example substantially increasing visitor numbers?

Control: Identify what impact the changes might have on environmentally sensitive elements of the building or artefacts and plan how these effects can be minimised.

Example: Creating a play area for children in a church may require greater localised heating for this area relative to other areas. If the play area is located next to sensitive monuments or historic furnishings there might be a risk that they could shrink or crack if overheated. The solution might therefore be to choose another less sensitive place to locate the play area.

E. **Element:** Does your project involve the installation of kitchens, serving areas or other activities that might generate heat and moisture?

Risk: Will the additional heat and moisture generating in the kitchen facility damage sensitive historic fabric?

Control: Identify mitigation measures that can be put in place to prevent such damage e.g. plan the location of kitchen facilities carefully and use the correct type of extraction fans.

Example: Most cooking and serving produces heat and water vapour, which can cause movement and cracking in historic furnishings or corrosion within lead roofs. These problems can be avoided by locating the catering facilities in a low risk area, limiting the amount of cooking and serving carried out and ensuring that heat and water vapour are correctly removed by air extraction. However, you need to remember that high volumes of air extraction may pull in external air causing other problems so this needs to be designed appropriately.

F. **Element:** Will the project involve any changes to the layout of the building (removal of walls or installation of walls or screens)?

Risk: Could the change of conditions in each of the spaces have a negative impact on the historic fabric in those areas?

Control: Identify measures that can be taken to avoid negative effects.

Example: A glazed or enclosed area within a large building can produce an attractive space that is simple and economic to heat. However, the enclosure may also concentrate any problems with heating or excess moisture arising from building defects, magnifying the damaging influence on the historic fabric.

G. **Element**: Does the project involve changes to services such as heating, lighting or ventilation?

Risk: Are elements of the building fabric vulnerable to damage from heating or ventilation, often as a result of the effect that this has on humidity e.g. timber panelling shrinking and cracking. Increasing lighting levels can cause sensitive materials (books, textiles etc.) to fade. Increasing external ventilation in an uncontrolled manner can lead to less stable environmental conditions, condensation and draughty airflow.

Control: Can the same benefits be achieved without the risks, for example using different lighting types, addressing heat loss issues, changing the position of heat emitters or using different types of heating system? Can controlled external ventilation or air exchange with an internal space achieve the same positive outcomes with lower risks?

<u>Example</u>*: Increased thermal comfort for the users can often be achieved by reducing air leakage to prevent uncomfortable draughts, increasing heat loss controls (floor coverings or cushions on seats) and changing the heating system from heating the entire air mass in the building to local surface heating. Such measures can limit the risk to the historic building and can result in lower energy costs too.*

The building performance assessment should be a practical document to allow you to examine the risks associated with each aspect of your project and help you design suitable mitigation measures.

5.3 Specialist support

When projects are complex or there is a high risk of serious problems arising if environmental issues are not properly addressed then it may be necessary to commission a specialist survey as part of the project. Depending on the type of building and the details of the project, statutory bodies may also require an independent specialist survey. For instance, if a new heating system is to be installed or major changes of use or layout are to take place in a sensitive historic building the risks will be high and specialist input is likely to be required. However, if minor repairs are to be carried out on a less sensitive building, and the overall use is to remain the same, then the self-assessment approach will be appropriate.

The approach taken by a specialist will vary from case to case, but can generally be separated into a basic or preliminary environmental survey, which will address the questions above, but in more detail than is possible for the non-specialist. Alternatively, if the specialist considers the project to be particularly complex or to be a high risk to the building, a detailed environmental study might be called for. This may include a scheme of environmental monitoring, thermal imaging or material analysis. In general, it is advisable to start with a preliminary survey that will swiftly answer the basic questions and then proceed to a detailed survey only if it is absolutely necessary.

A preliminary survey generally involves the specialist spending one or two days on site and a similar amount of time in assessing the results of data gathered on site and preparing the necessary reports and drawings. A full environmental survey may take up to twelve months if it involves environmental monitoring, as it is generally necessary to evaluate the building conditions over four seasons. It is important to make sure that the appropriate type of survey is commissioned in good time.

In all cases, the resulting reports should include practical recommendations for the measures necessary to control the various risks and, where possible, to allow the project to go ahead with as little disruption as possible.

5.4 Costs

In general, survey work of this type is regarded as part of the required development works for complex historic building projects and so the costs can be included within the development phase in the same way as other fees for building professionals, such as the architect or engineer.

5.5 Mistakes to avoid

In some cases applicants are tempted to carry out more complex surveys themselves using tools such as environmental monitors as the equipment is now comparatively affordable. While gathering data is easy, gathering the right data and undertaking the correct analysis and interpretation to answer the relevant questions, is not. Furthermore, statutory bodies are unlikely to accept data analysis and recommendations for building interventions from an individual who cannot demonstrate relevant qualifications and experience in this area. In such cases the work has to be repeated leading to delays and additional costs.

Do not attempt to undertake complex investigations by yourself unless you have the requisite qualifications and experience as this may delay your project.

5.6 Timing

To avoid unnecessary work and delays in the project process, timing is important. You should consider the basic questions at the earliest possible stage when the overall aims of your project are still being considered. Ideally, these issues should be part of any pre-application discussions and should certainly be considered before you make your round one application. It may also be sensible to seek initial advice from statutory advisory bodies such as Historic England, the national amenity societies, the local authority conservation officer or denominational bodies.

If you are successful in receiving a round one pass you will need to consider these issues further during the development stage and should undertake any necessary assessments, either by yourself or with professional help. This assessment should be carried out early in the development stage as the findings may influence other important aspects of the project, including the way that the building is used, visitor management and heating. By the time you are putting together your round two application, all of the questions that you need to address should have been answered so that you fully understand the implications of the work that you hope to be carrying out.

6. Summary

Many capital projects will increase the risk of damage to sensitive historic buildings and their contents due to the changes that they make to the building environment. However, many of these problems occur as a result of a lack of planning rather than the incompatibility of the project aims and the historic building fabric. Problems mostly occur because building performance issues are not identified at the outset and mitigation measures are not included from the design process as a result.

6.1 Building performance assessment

A building performance assessment should be carried out at the earliest stage of the design process, once the overall project aims begin to take shape. This assessment should answer the following key questions:

- What aspects of the building and collection are vulnerable to environmental damage?
- Which elements of the project might have an impact on the building environment?
- What are the risks that these may create for the building and its contents?
- What mitigation measures need to be taken to protect the building and its contents while allowing the project aims to be achieved?

In simple cases you will be able to carry out the assessment yourself while, in more complex cases specialist support will be required. The resulting report should be both a reference document and a practical tool in developing the detailed design for the project and should be developed and updated alongside the project design.

6.2 Developing a thermal comfort and heating strategy

In order to develop a plan to achieve good thermal comfort in an historic building it is essential to ask the following basic questions:

- Which groups of users are you trying to improve conditions for?
- Where will they be located in the building? Will different parts of the building be used in different ways?
- How long will each user group be in the building?
- Will users be active (walking around) or passive (sitting)?
- Are there any user groups who might be particularly sensitive to temperature for example children and the elderly?
- What factors will cause the users to lose heat? Will they be sitting on a cold pew or is there uncomfortable air movement from draughts?
- What factors will cause the building to lose heat? How well insulated is the structure and is there unnecessary air leakage?
- What types of heating systems are available?
- Do you need to use active heating to provide conservation conditions for the building or its contents?

- How much money are you willing to spend on capital works such as building repairs and heating systems?
- How much can you afford for the ongoing costs of fuel, servicing and maintenance?

At the outset of any project involving thermal comfort and heating, the project team should prepare a short document that addresses these questions. This document can then inform the brief for the building performance specification and the heating design.

6.3 Management and maintenance

Any measures that you put in place for controlling the environment in your building will require maintenance in the future. As the design develops you will need to think about how you will control the environmental conditions after the project ends. You should therefore draw up a clear and achievable plan for the maintenance of your building and its systems and include this in your Management and Maintenance Plan.