This section provides guidance on the principles of system design. Reference is made to relevant regulatory requirements and International Standard Organisation (ISO), European (EN) and British (BS) standards. It considers various principles from a building theory and practical perspective.

Fire
Fire performance includes fire resistance, fire protection and reaction to fire, which are relevant for compartmentation, structural steelwork and surface spread of flame respectively. British Gypsum only test solutions to the most up to date BS EN test standards. Our technical specifications, detailed drawings and technical advice is based on the latest BS EN test standards. BS 476 Parts 20-23, while accepted in AD-B for maintaining older buildings, is not recommended for new or future schemes. See page 2.3.

Acoustics
Building acoustics includes both sound insulation (airborne and impact) and sound absorption. A key design aspect is how the drylined building element interacts with the associated structure. If this is ignored, the performance of the element can be completely nullified. The key factors that are covered include gap sealing, why it is preferable to take the partition through to the structural soffit, and why it is important to design out flanking sound transmission. See page 2.7.

Thermal insulation
Thermal comfort within a building is primarily dictated by the thermal insulation (heat loss), air tightness, heating regime and ventilation, together with appropriate vapour control to reduce risk of condensation. Carbon dioxide performance and fabric energy efficiency are measures used to optimise the performance of a building. See page 2.37.

Robustness
Consideration needs to be given to the robustness of drylining systems, particularly if required to resist crowd pressure, impacts, abrasions and wind loading. The stiffness of a partition is critical to this and is therefore considered when determining the recommended maximum height. See page 2.25.

Service installations
Drylining elements need to be fully compatible with building services such as electrical, plumbing, heating and ventilation etc. This means that service installation should be fully assessed at the design stage to ensure that the layout of the services is compatible with the ceiling module or location of stud work. Furthermore, the weight of fixtures and fittings must be considered at the design stage to ensure that the appropriate system with correct detailing is specified. See page 2.29.
**Fire**

### System design principles

Legislation, guidance and insurance

**Building Regulations – Fire safety**

Building Regulations Approved Document B (AD B) and Technical Handbook – Fire (section 2) are a series of approved documents that provide practical guidance on meeting the fire safety requirements of the Building Regulations 2000 (England and Wales) and Building (Scotland) Regulations 2004 respectively.

The documents are divided into two parts, AD B Volume 1 and Technical Handbook – Domestic (Fire section 2) covers dwelling houses and AD B Volume 2 and Technical Handbook – Non-Domestic (Fire section 2) covers buildings other than dwelling houses.

The documents classify the use of a building into purpose groups and specify minimum periods of fire resistance to be achieved by the building elements. The periods of fire resistance vary according to the use and the size of building. The greater the fire hazard a building presents, the greater the period of fire resistance required to protect the elements within the building. The materials used to form the internal surfaces of the building are also controlled to reduce the risk of fire growth and internal fire spread.

**Healthcare buildings**

Hospitals and healthcare environments by their very nature contain people who are at risk from fire. Health Technical Memorandum (HTM) 05 series (England and Wales) and Scottish Health Technical Memorandum (SHTM) 81 series documents cover the fire safety design of healthcare facilities. These documents provide guidance on the standards of fire safety expected in healthcare facilities and include recommened fire spread, elements of structure, compartmentation, fire hazard areas, hospital streets, penetrations, protected shafts, ceiling membranes, cavity barriers and fire-stopping.

**Educational buildings**

The design of fire safety in schools is covered by Building Bulletin 100 (England and Wales) and Fire Safety in Schools (Scotland). The Building Regulations will typically be satisfied where the safety guidance in these documents is followed.

**Loss Prevention Council (LPC) Design Guide for the Protection of Buildings – Commercial and Industrial**

Provides guidance on the general principles of passive fire protection - contribution to fire growth, fire resistance, compartmentation and external fire spread. It also provides guidance on ‘active’ fire protection such as sprinklers and fire alarms. It presents insurers with standards of fire protection for industrial and commercial buildings. It is intended to assist building designers and other professional advisors in reconciling the provisions of national legislation standards with the recommendations of the insurance industry. It also gives guidance regarding how fire protection measures can be used to augment passive protection.

**Fire protection for structural steel in buildings, Association for Specialist Fire Protection (ASFP) Yellow Book**

Publication prepared by the ASFP. Presenting the theory behind, and methods for, fire protection of structural steelwork to comply with Building Regulations. It provides a comprehensive guide to proprietary materials and systems, all of which are manufactured, marketed by members of ASFP.

**Principles of fire performance**

**Fire growth**

The choice of materials for walls and ceilings can significantly affect the spread of fire and its rate of growth, even though they are not likely to be the materials first ignited. The specification of linings is particularly important in circulation spaces where surfaces may offer the main means by which fire spreads, and where rapid spread is most likely to prevent occupants from escaping.

Two properties of lining materials that influence fire spread are:

- The rate of flame spread over the surface when it is subject to intense radiant heating
- The rate at which the lining material gives off heat when burning

**Compartmentation**

The spread of fire within a building can be restricted by sub-dividing it into compartments separated from one another by walls and/or floors of fire resisting construction.

The two key objectives are:

- To prevent rapid fire spread, which could trap occupants within the building
- To reduce the chance of fires becoming large, which are more dangerous - not only to occupants and fire service personnel, but also to people in the vicinity of the building

The appropriate degree of sub-division depends on:

- The use and fire loading of the building, which affects the potential for fire growth and its severity, as well as the ease of evacuation
- The height to the floor of the top storey in the building, which is an indication of the ease of evacuation and the ability of the fire service to intervene effectively

### Structural fire precautions

Premature failure of the structure can be prevented by fire protection to loadbearing elements.

The purpose in providing the structure with fire resistance is:

- To minimise the risk to the occupants, some of whom may have to remain in the building for some time (particularly if the building is a large one), while evacuation proceeds
- To reduce the risk to fire fighters engaged on search and rescue operations
- To reduce the danger to people in the vicinity of the building who may be hurt by falling debris, or because of the impact of the collapsing structure on other buildings

**Fire limit state**

In structural design terms, fire is considered to be an accidental limit state, i.e. an accidental occurrence, and one for which the structure must not fail. Loads and their factors of safety used in design at the fire limit state reflect the low probability of occurrence.

Typically, structural members that are designed to be fully stressed under normal conditions would be subject to a load ratio of 0.5 to 0.8 under fire conditions. Within this book, loadbearing floors and partitions are quoted with respect to a stated load ratio. Many constructions have been tested at a conservative load ratio of 0.5 (200%) despite the fire state being an accidental load.

**Structural behaviour of timber in fire**

Timber has a low thermal expansion coefficient, which means that the possibility of protective layers and charred materials becoming displaced. It also has a low thermal conductivity, which means that undamaged timber retains its strength. Generally, it may be assumed that timber will char at a constant rate when subjected to the standard heating conditions of the test furnace. The rate of reduction in the size of structural timber can be taken as 15mm to 25mm (depending on species) in 30 minutes for each face exposed; different rates apply where all faces are exposed. The undamaged timber can be assessed for structural stability using standard design guides in conjunction with stress modification factors.

For partitions tested with high load ratios it should be noted that, as the timber is exposed to fire, the exposed face will shrink causing differential thermal movement. This can be important for axially loaded sections, as it introduces a degree of eccentricity, which may cause a loss of loadbearing capacity.

**Structural behaviour of steel in fire**

Steel generally begins to lose strength at temperatures above 300°C and eventually melts at about 1500°C. Important for design, the greatest rate of strength loss is in the range of 400°C to 600°C.

Using fire design codes such as the Structural Eurocodes EC3-1.2 and EC4-1.2 (designated BS EN 1993-1-2 and BS EN 1994-1-2), the load on the structure at the time of the fire can be calculated by treating it as an accidental limit state. If used, this will allow designers to specify for the fire protection contractor a limiting or failure temperature for a given structural section. The fire protection contractor will then be able to use the required thickness of material to ensure that the steel section does not exceed this temperature within the fire resistance period. This process could be simplified by the designer specifying a maximum steel temperature, based on the worst case, for all beams or columns on one floor level.

Buildings that are not primarily used for storage, e.g. offices, residential units, schools and hospitals, have a high percentage of non-permanent loads. For this type of building, the structural Eurocode BS EN 1991-1-1 assumes that a proportion of the design load will not be present at the time of the fire. Other types of buildings, such as warehouses and libraries, are primarily used for storage, so a high percentage of the load is permanent. The codes allow for no reduction in design load for the fire condition. The fire testing standards effectively base the failure criteria for loadbearing elements on strength. However, beams should be designed at the fire state limit as well as in the cold state limit.

Columns are frequently designed so that a single length will be two or three storeys high. The lowest storey will be loaded: the highest and the upper storey will be lightly loaded. In buildings with a degree of non-permanent load (in terms of duration and magnitude), the load ratio of the structural members is unlikely to be greater than 0.5. In storage buildings, where the majority of load is permanent, the load ratio would normally be higher, but it is unlikely to be greater than 0.65.

In steelwork encasement systems (Section 3), the thicknesses of protection required are specified for design temperatures of 550°C, unless otherwise stated. It is the responsibility of the design engineer to design using codes such as BS EN 1993-1-2, to specify the appropriate limiting steel temperatures.

The loss of strength of cold-formed steel at elevated temperatures exceeds that of hot-rolled steel by between 10% and 20%. Expert advice should be sought in determining the strength reduction factor at the limiting temperature.
Fire
System design principles

Why gypsum is so effective in fire

Our plasters, plasterboards and specialist boards provide good fire protection due to the unique behaviour of gypsum in fire. When gypsum protected building elements are exposed to fire, dehydration by heat (calcination) occurs at the exposed surface and proceeds gradually through the gypsum layer.

Calcined gypsum on the exposed faces adheres tenaciously to uncalcined material, retarding further calcination which slows as the thickness of calcined material increases. While this continues, materials adjacent to the unexposed side will not exceed 100°C, below the temperature at which most materials will ignite, and far below the critical temperatures for structural components. Once the gypsum layer is fully calcined, the residue acts as an insulating layer while it remains intact.

Gypsum products are excellent performers in terms of reaction to fire, as the endothermic hydration reaction requires energy to be taken from the fire, so gypsum is a negative calorific contributor.

Fire resistance test standards

Building Regulations and supporting documentation require elements of structure and other building elements to provide minimum periods of fire resistance, expressed in minutes, which are generally based on the occupancy and size of the building.

Fire resistance is defined in the ability of an element of building construction to withstand exposure to a standard temperature / time and pressure regime without loss of its integrity and insulation performance.

Fire resistance is defined in the ability of an element of building construction to withstand exposure to a standard temperature / time and pressure regime without loss of its integrity and insulation performance.

The fire separating function of a construction is defined as the ability of a separating element to remain intact.

Fire resistance test standards

Fire resistance methods used across Europe were similar but the severity of furnaces varied due to factors such as different fuel sources and furnace geometry. To improve consistency between different furnaces, plate thermometers were introduced to measure the heat flux to which samples are exposed. The use of plate thermometers means the EN fire resistance tests can be more severe than the superseded BS tests, especially in the first 30 minutes.

EN Fire resistance test standard also imposes strict rules governing the use of tests to cover specific and use scenarios (field of application). This restricted field of application has most effect on partitions that are built with heights above 4m, as they may need to have enhanced levels of fire protection.

To claim up to 3m, the partition has to be tested at a height of 3m in the fire resistance test. To claim up to 1m above the 3m tested height the partition has to pass the test with partition height equal or greater than 3m and not deflect laterally by more than 100mm during the test.

To claim an increase in height greater than 1m, an extended application can be conducted following the design rules given in BS EN 1524-3. The standard permits either an engineering appraisal; where to claim up to 4m, the partition has to pass the test with a partition test height of 3m and not deflect laterally by more than 100mm during the test; or an increase height provided certain criteria given in the relevant section (of the standard) are satisfied. Where an extended application is not permissible the only alternative is to conduct a test at the height under consideration.

We have conducted an extensive series of EN Fire resistance tests on partitions with heights up to 6m. Data from these tests are used within the performance tables. Insulation materials, such as glass and stone mineral wool, can affect the fire resistance of a partition. These materials can provide additional insulation / integrity performance but can also increase the thermal bow of the partition and therefore reduce the partition height that can be claimed.

Consequently, there are instances where the partition height is reduced when a quilt is included within the cavity of the partition. It cannot be assumed that adding a quilt to a partition specification will not impact on its fire resistance.

EN fire resistance test standards

The Construction Products Regulation (CPR) within European legislation is designed to enable free trade across Europe in construction products. To enable free trade, harmonised test standards for technical performance are required. The area of technical performance most affected by this requirement is fire performance.

Fire resistance test standards

Fire resistance test standards

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EN fire resistance and its application to British Gypsum systems

The EN fire resistance periods claimed for systems in this document are evaluated in accordance with the relevant EN fire resistance test standards.

- BS EN 1564-1 specifies a method for determining the fire resistance of non-loadbearing walls.
- BS EN 1565-1 specifies a method for determining the fire resistance of loadbearing walls.
- BS EN 1565-2 specifies a method for determining the fire resistance of loadbearing floors and roofs.
- BS EN 1564-2 specifies a method for determining the fire resistance of non-loadbearing ceilings.
- BS EN 13181-1 Test methods for determining the contribution to the fire resistance of structural members: Applied protection to steel members.
- BS EN 13181-1 specifies a method for determining the contribution to the fire resistance of structural members: Applied protection to steel members.
- BS EN 13181-2 Test methods for determining the contribution to the fire resistance of structural members: Vertical protective membranes.
- BS EN 13181-2 specifies a method for determining the contribution to the fire resistance of structural members: Vertical protective membranes.
- BS EN 1524-3 Extended application of results from fire resistance tests: Non-loadbearing walls - Light-weight partitions.

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**Acoustics**

**System design principles**

**Principles of building acoustics**

Building acoustics is the science of controlling noise in buildings, including the minimisation of noise transmission from one space to another, and the control of noise levels and characteristics within a space.

Noise can be defined as sound that is undesirable, but it can be subjective and depends on the reactions of the individual. When a noise is troublesome, it can reduce comfort and efficiency. If a person is subjected to noise for long periods, it can result in physical discomfort or mental distress. Within homes, a noisy neighbour can be one of the main problems experienced in attached housing. It’s estimated that up to 4 million people in Britain have had their lives disturbed by noisy neighbours.

The best defence against noise is to ensure that proper precautions are taken at the design stage and during construction of the building. The correct acoustic climate must be provided in each space, and noise transmission levels should be compatible with the building’s usage. Retrofitted remedial measures taken after occupation can be expensive and inconvenient.

The term ‘building acoustics’ covers both sound insulation and sound absorption.

**Sound insulation**

Sound insulation is the term describing the reduction of sound that passes between two spaces separated by a dividing element.

In transmitting between two spaces, the sound energy may pass through the dividing element (direct transmission) and through the surrounding structure (indirect or flanking transmission). When designing for optimum sound insulation, it’s important to consider both methods of transmission. The walls or floors, which flank the sound insulation, it’s important to consider both methods of transmission. The walls or floors, which flank the sound reducing element, have to be given to a superior standard of sound insulation. When the background noise is low, consideration may be given to the ceiling. Small openings such as gaps, cracks or holes will occur, particularly when boards are lifted tight. These include speech, musical instruments, loudspeakers and other sounds that originate in the air. In most cases, floors must also resist the transmission of impact sounds, such as heavy footsteps and the movement of furniture.

**Indirect paths (flanking transmission)**

Flanking sound is defined as sound from a source room that is not transmitted via the separating building element. It is transmitted indirectly via paths such as windows, external walls and internal corridors. Refer to figure 1 (page 2.8).

It is imperative that flanking transmission is considered at the design stage and construction detailing is specified so as to eliminate or at least to minimise any downgrading of the acoustic performance. The sound insulation values quoted in system performance tables are laboratory values and the practicalities of construction will mean that actual performances measured in the laboratory will be difficult to achieve on site.

One of the main reasons for this difference is the loss of acoustic performance via flanking transmission paths. Good detailing at the design stage will minimise this effect and optimise the overall levels of acoustic privacy achieved.

If designing for residential units, design advice on flanking details must be followed to maximise the possibility of achieving the specified acoustic performance. It is imperative that the design advice is followed, otherwise site sound insulation values may not meet the minimum standards required by Building Regulations and expensive remedial treatment will be required.

Small openings such as gaps, cracks or holes will conduct airborne sounds and can significantly reduce the sound insulation of a construction. For optimum sound insulation a construction must be airtight. Within masonry construction, most gaps can be sealed at the finishing stage using Gyproc SoundCoat Plus, Thistle plaster or Gyproc jointing compounds. At the base of the partition, deflection heads, by definition, must be able to move and, therefore, achieving an airtight seal is very difficult without incorporating sophisticated components and techniques. Air leakage at the partition heads will have a detrimental effect on acoustic performance of any partition.

Other factors, such as flanking transmission through the structural soffit, can significantly affect the overall level of sound insulation. Therefore, other measures may need to be taken.

In any existing sound insulation problem, it is essential to identify the weakest parts of the composite construction.

The Building Regulation requirements regarding the sound insulation of walls and partitions only relate to the transmission of airborne sounds. These include speech, musical instruments, loudspeakers and other sounds that originate in the air. In most cases, floors must also resist the transmission of impact sounds, such as heavy footsteps and the movement of furniture.

**Acoustic performance of deflection head details**

Deflection heads, by definition, must be able to move and, therefore, achieving an airtight seal is very difficult without incorporating sophisticated components and techniques. Air leakage at the partition heads will have a detrimental effect on acoustic performance of any partition.

Other factors, such as flanking transmission through the structural soffit, can significantly affect the overall level of sound insulation. Therefore, other measures may need to be taken.

In non-fire rated applications, a suspended ceiling installed on both sides of the partition may provide a similar cladding effect to that of steel angles.

- In non-fire rated applications, a suspended ceiling installed on both sides of the partition may provide a similar cladding effect to that of steel angles.

- Gyproc ceiling incorporating imperforate plasterboard can deliver a similar reduction in air leakage at the partition head. A tight fit between the ceiling perimeter and the surface of the partition lining board is important, although mechanically fixed perimeter are not essential.

Ceilings with recessed light fittings may be less effective and if these cannot be sealed in some way, the installation of cladding angles at the partition head should be considered. A suspended ceiling may also reduce the level of sound flanking transmission via the soffit.
Acoustics

System design principles

Partition to structural steelwork junctions

When designing the layout of rooms requiring separation by sound insulating walls abutting structural steelwork, consideration should be given to the potential loss of sound insulation performance through the steelwork.

Figures 2 to 5 (pages 2.9 to 2.11) are example details relating to a typical scenario where a partition is specified against a requirement of $R_{w50}$dB. Although these details refer to structural steel column abutments, similar principles apply when abutting structural steel beams. We recommend that these details are checked by an Acoustic Consultant, in particular the performance via the flanking structure.

Sound by-passing a partition via the void above a suspended ceiling

This is a common source of sound transmission, particularly where the ceiling is absorbent to sound. Sound can easily travel through a perforated tile, or lightweight suspended ceiling, and over the top of a partition where it abuts the underside of the suspended ceiling. Where sound insulation is important, partitions should, wherever possible, continue through the ceiling to the structural soffit, and be sealed at the perimeter junctions. Gyproc plasterboard suspended ceilings offer better insulation where partitions must stop at ceiling level to provide a continuous plenum. In this instance, a cavity barrier can be incorporated above the ceiling line.

2. Exposed or painted steel column

3. Encased steel column

4. Encased steel column with additional plasterboard lining
Acoustics

System design principles

5. Encased steel column with additional framing, insulation and plasterboard lining

Composite construction
A common mistake made when designing a building is to specify a high performance element and then incorporate a lower performing element within; for example, a door within a partition.

Where the difference between insulation is relatively small (7dB or less), there needs to be a comparatively large area of the lower insulation element before the overall sound insulation is significantly affected. However, where there is a greater difference in sound insulation performance between the two elements, this would normally result in a greater reduction of overall sound insulation performance.

Table 1 shows the acoustic effect of various door types and gives a guide to sound insulation levels in the same table.

Ambient noise levels
Along with acoustic privacy, the acceptable level of sound within a room should be assessed. Factors that affect the ambient noise level of a space are:

- The level of external noise
- The level of sound insulation designed into the surrounding structure
- The amount and type of sound absorbing surfaces within the room
- The noise generated by building services

Reverberant energy
Reverberation is the persistence of sound in a particular space after the original sound is removed. A reverberator, or reverber, is created when a sound is produced in an enclosed space causing a large number of echoes to build up and then slowly decay as the sound is absorbed by the walls, ceilings, floor and air. The length of this sound decay is known as reverberation time and can be controlled using sound absorbing materials. The appropriate reverberation time for a space will be dependent on the size and function of the space. Examples of typical reverberation times are given in Table 5.
**Acoustics**

**System design principles**

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### Table 3 – Recommended maximum noise rating for various types of room function

<table>
<thead>
<tr>
<th>Situation</th>
<th>NR* criteria (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound studios</td>
<td>15</td>
</tr>
<tr>
<td>Concert halls, large theatres, opera houses</td>
<td>20</td>
</tr>
<tr>
<td>Large auditoria, large conference rooms, TV</td>
<td>25</td>
</tr>
<tr>
<td>studios, hospital wards, private bedrooms, music</td>
<td>30</td>
</tr>
<tr>
<td>practice rooms</td>
<td></td>
</tr>
<tr>
<td>Libraries, hotel rooms, courtrooms, churches,</td>
<td>35</td>
</tr>
<tr>
<td>cinemas, medium-sized conference rooms</td>
<td></td>
</tr>
<tr>
<td>Classrooms, small conference rooms, open-plan</td>
<td>40</td>
</tr>
<tr>
<td>offices, restaurants, public rooms, operating</td>
<td></td>
</tr>
<tr>
<td>theatres, nightclubs</td>
<td></td>
</tr>
<tr>
<td>Sports halls, swimming pools, cafeteria, large</td>
<td>45</td>
</tr>
<tr>
<td>shops, circulation areas</td>
<td></td>
</tr>
</tbody>
</table>

* Refer to ‘Ambient noise levels’ section on the previous page for explanations of NR.

---

### Table 4 – Example on-site sound insulation matrix (D_tr, w dB)

<table>
<thead>
<tr>
<th>Privacy</th>
<th>Activity noise of source room</th>
<th>Noise sensitivity of receiving room</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Confidential</td>
<td>Very high</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Typical</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>42</td>
</tr>
<tr>
<td>Moderate</td>
<td>Very high</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Typical</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>No rating</td>
</tr>
<tr>
<td>Not private</td>
<td>Very high</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Typical</td>
<td>No rating</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>No rating</td>
</tr>
</tbody>
</table>

**D_tr, w** refers to the sound insulation performance of a separating floor tested in isolation, in the absence of any flanking paths. With impact sound insulation tests, the lower the figure the better the performance.

---

### Table 5 – Recommended maximum noise rating for various types of room function

<table>
<thead>
<tr>
<th>Situation</th>
<th>Maximum noise rating (dB)</th>
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<tr>
<td>studios, hospital wards, private bedrooms, music</td>
<td>30</td>
</tr>
<tr>
<td>practice rooms</td>
<td></td>
</tr>
<tr>
<td>Libraries, hotel rooms, courtrooms, cinemas,</td>
<td>35</td>
</tr>
<tr>
<td>theaters, medium-sized conference rooms</td>
<td></td>
</tr>
<tr>
<td>Classrooms, small conference rooms, open-plan</td>
<td>40</td>
</tr>
<tr>
<td>offices, restaurants, public rooms, operating</td>
<td></td>
</tr>
<tr>
<td>theatres, nightclubs</td>
<td></td>
</tr>
<tr>
<td>Sports halls, swimming pools, cafeteria, large</td>
<td>45</td>
</tr>
<tr>
<td>shops, circulation areas</td>
<td></td>
</tr>
</tbody>
</table>

---

### Sound insulation rating methods

The sound insulation rating methods that follow are defined in BS EN ISO 717: Part 1: 2013 (airborne) and BS EN ISO 717: Part 2: 2013 (impact).

**R_p**
- This single figure rating method is used for laboratory airborne sound insulation tests. The figure indicates the amount of sound being stopped by a separating building element when tested in isolation in the absence of any flanking paths.

**D_tr, w**
- This single figure rating method gives the airborne sound insulation performance between two adjacent rooms within a building as measured on site. The result achieved is affected not only by the separating element, but also by the surrounding structure and junction details.

**C_w**
- The C_w adaptation term is a correction that can be added to either the R_p (laboratory) or D_tr, w (site) airborne rating.

---

### Speech clarity

Speech clarity (intelligibility) is now recognised as essential in helping pupils in an educational environment to achieve their full potential.

Research has shown that pupils who cannot understand clearly what the teacher is saying have a tendency to ‘switch off’ - limiting their own educational opportunities and creating additional stress for teachers. In a typical classroom with the teacher at one end, sound reaches the pupils both directly from the teacher and via reflections from the ceiling, walls and floor. Refer to figure 6 (page 214).

Pupils at the front will generally be able to understand what the teacher is saying, whilst pupils at the back and sides of the room receive a mixture of both direct speech and reflected sound, making it difficult to identify the teacher’s words.

Reverberation time alone cannot be relied upon to deliver a suitable environment for good speech intelligibility. In any situation where speech communication is critical, e.g. conference room, lecture theatre or classroom, it is necessary to design the space appropriately using a mixture of sound reflective and sound absorbing surfaces.

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### 6. Sound transmission in a typical classroom

Consequently, within separating constructions, British Gypsum can offer enhanced specifications that meet the low frequency performance of the C_w rating whilst also offering good mid and high frequency sound insulation.

---

**Table 5 – Typical reverberation times**

<table>
<thead>
<tr>
<th>Type of room/activity</th>
<th>Reverberation time (mid frequency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swimming pool</td>
<td>&lt;2.0 seconds</td>
</tr>
<tr>
<td>Dance studio</td>
<td>&lt;1.2 seconds</td>
</tr>
<tr>
<td>Large lecture theatre</td>
<td>&lt;1.0 seconds</td>
</tr>
<tr>
<td>Small lecture room</td>
<td>&lt;0.8 seconds</td>
</tr>
<tr>
<td>Primary school playroom</td>
<td>&lt;0.6 seconds</td>
</tr>
<tr>
<td>Classroom for hearing impaired</td>
<td>&lt;0.4 seconds</td>
</tr>
</tbody>
</table>
Sound absorption rating methods

The following ratings are calculated in accordance with BS 4142:1977

**Sound absorption coefficient, α**

Individual sound absorption figures quoted in one-third octave frequency bands are used within advanced modelling techniques to accurately predict the acoustic characteristics of a space. The coefficient ranges from 0 (total reflection) through to 1 (total absorption).

**Practical sound absorption coefficient, αₚ**

A convenient octave-based expression of the sound absorption coefficient, commonly used by Acoustic Consultants when performing calculations of reverberation times within a building space.

**Sound absorption rating, αₚ**

A single figure rating used to describe the performance of a material. The single figure rating can have a modifier added to indicate if the spectral shape is dominated by a particular frequency range.

- **L** - absorption is predominantly in the low frequency region
- **M** - absorption is predominantly in the mid frequency region
- **H** - absorption is predominantly in the high frequency region

The absence of a letter following the rating indicates that the absorber has no distinct area of sound absorption and has an essentially flat spectral shape.

**Noise Reduction Coefficient, NRC**

Whilst the sound absorption performance of a ceiling system can be expressed as an NRC, this does not always accurately reflect the product performance. An NRC value is the arithmetic mean of the absorption coefficients across a limited frequency range; this means that it will hide extremes in performance. For instance, a ceiling tile may be a very efficient absorber at high frequencies but very poor at low frequencies, and the NRC value will not reflect this.

To optimise the room acoustics the more accurate sound absorption rating, αₚ, should be used.

**Principles of lightweight construction**

Typically the average sound insulation of a material forming a solid partition is governed by its mass; the heavier the material, the greater its resistance to sound transmission. To increase the sound insulation of a solid partition by approximately 4dB, the mass must be doubled. This is known as the empirical mass law.

For example, a 100mm solid block wall of average mass 100kg/m² will have an approximate Rₚ value of 40dB, whereas a 200mm solid wall of the same material would have an Rₚ value of 44dB.

Increasing mass is a very inefficient way of achieving sound insulation and one of the advantages of using lightweight cavity partitions and walls is that better than predicted sound reduction values can be achieved. This is why this construction is commonly used in auditoria, e.g. GypWall Twin Frame Audio. Lightweight systems versus the mass law shows how lightweight systems consistently exceed mass law predictions. This demonstrates that adding mass is not always the best method to satisfy acoustic design requirements and that, lightweight systems, if correctly designed, can provide very effective acoustic solutions. Refer to figure 7 (page 2.36).

Acoustic performance is commonly expressed as a decibel (dB) value. The logarithmic scale of decibels provides a simple way to cover a large range of values and show them as a convenient number. Unfortunately the decibel scale can create confusion especially when comparing alternative systems as the difference in acoustic performance can appear to be quite small. In reality an increase of 6dB is equivalent to a doubling of the acoustic performance of the system.

A simple stud partition, for example, can have an Rₚ rating of 6dB better than predicted by the mass law. In this case, the maximum sound insulation obtainable will be governed by the transmission of energy through the stud frame. The use of other frame types, or configurations, can result in even better insulation. If Gyproc plasterboard or Glasroc specialist boards are fixed to a timber stud frame using a flexible mounting system, such as Gypframe RB1 Resilient Bar, or a more flexible frame is used, for example, Gypframe studs and channels, sound transmission through the frame is minimised and performance significantly better than the mass law prediction can be achieved.

The use of two completely separate stud frames can produce even better results. In this case, the maximum energy transmission is through the cavity between the plasterboard linings. The air in the cavity can be considered as a spring connecting the linings, which allows the passage of energy. The spring will have some inherent damping, which can be significantly increased by the introduction of a sound absorbing material (such as mineral wool) positioned in the cavity. The increased damping of the air-spring results in a reduced coupling between the plasterboard linings and a consequent decrease in sound transmission. Air-spring coupling becomes less significant as the cavity width increases. In practice, cavities should be as wide as possible to insulate against low frequency sounds.

### Table 6 – AD E sound insulation requirements (England and Wales)

<table>
<thead>
<tr>
<th>Where applicable</th>
<th>Minimum airborne sound insulation Dₚₗₜ&lt;w&gt; + Cₚₗₜ (&lt;site test result&gt;)</th>
<th>Maximum impact sound transmission Lₚₜ'Lₚₜ (&lt;site test result&gt;)</th>
<th>Minimum airborne sound transmission Rₚ &lt;(laboratory test result)&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separating walls between new homes</td>
<td>45dB</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Separating walls between purpose-built rooms for residential purposes</td>
<td>43dB</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Separating walls between rooms created by a change of use or conversion</td>
<td>43dB</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Separating floors between new homes and purpose-built rooms for residential purposes</td>
<td>45dB</td>
<td>62dB</td>
<td>–</td>
</tr>
<tr>
<td>Separating floors between rooms created by a change of use or conversion</td>
<td>45dB</td>
<td>64dB</td>
<td>–</td>
</tr>
<tr>
<td>Internal wall without a door between a bathroom, or WC, and a habitable room</td>
<td>–</td>
<td>40dB</td>
<td>–</td>
</tr>
<tr>
<td>Internal wall without a door between a bedroom and another room within the dwelling</td>
<td>–</td>
<td>40dB</td>
<td>–</td>
</tr>
<tr>
<td>Internal floor</td>
<td>–</td>
<td>40dB</td>
<td>–</td>
</tr>
</tbody>
</table>

### 8. Acoustic benefits of applying Thistle MultiFinish to certain GypWall partitions

**Acoustic benefits of applying Thistle MultiFinish to certain GypWall partition systems**

Applying 2mm Thistle MultiFinish to both sides of certain GypWall partitions has a positive affect on the sound insulation performance. This is effective on partitions that are limited by their high frequency performance (coincidence region).

The application of Thistle MultiFinish also adds mass to the partition which has a positive effect on the mid-frequency section of the spectrum.

Figure 8 (below) shows an example of a partition that will be positively affected by skim finish using Thistle MultiFinish.
Acoustics
System design principles

Refer to system sections within 'Partitions' where systems positively affected by the application of Thistle MultiFinish are shown. Systems with additional performance will show two acoustic figures in the tables – Sound insulation performance for partitions finished using jointing or plaster skim and sound insulation performance for partitions with a 2mm skim finish of Thistle MultiFinish.

Legislation and guidance
Building Regulations Approved Document E – Residential Buildings
Approved Document E (AD E) gives guidance on how to provide reasonable standards of sound insulation in dwellings and other residential buildings. It covers both new-build and refurbishment or conversion, and includes minimum standards of performance. The standards in Table 6 have applied for all new-build homes and purpose-built rooms for residential purposes since July 2004.

Complying with the regulations
In England and Wales, housebuilders and residential developers can follow one of two routes to demonstrate compliance of separating walls and floors for new-build houses and apartments:
- Using ‘Robust Detail’ constructions
- Using manufacturers’ proprietary systems or AD E ‘Guidance Constructions’ and verifying by Pre-Completion Testing

Robust Details
To avoid Pre-Completion Testing for new-build houses and flats, the Home Builders Federation (HBIF) developed a series of Robust Details. These forms of construction have been designed and site tested to ensure that they deliver a standard of sound insulation on site to meet the minimum requirements of AD E. The Building Regulations have been amended to allow Robust Details to be used as an alternative to Pre-Completion Testing. If you are following the Robust Detail route, you must register each plot, with the details you intend to use, and pay a fee. You will then be given a registration certificate to hand to your building control authority before work starts. Robust Details Ltd administers the scheme. Further details are available from the Robust Details Ltd website robustdetails.com

If you are building to either the Code for Sustainable Homes, or EcoHomes, Robust Details may entitle you to additional credits under the Health and Wellbeing category – check the Robust Details Handbook for the most up-to-date details.

Sound Absorption
Section E3 of AD E covers reverberation noise in the common internal parts of buildings containing flats or rooms for residential purposes. The regulations state that the common internal parts of buildings which contain flats or rooms for residential purposes shall be designed and constructed in such a way as to prevent more reverberation around the common parts than is reasonable.

The regulations give two methods of calculating the amount of absorption required in any communal areas. The two methods are referred to as ‘Method A’ and ‘Method B’. AD E specifies sound absorption in terms of a class of absorber. There are five classes (A through to E) with Class A signifying the products with the highest level of sound absorption. However, to comply with AD E using method A, only Class C or D is required. The values ascribed to the different classes are given in Table 7.

For more information, refer to Building Regulations Approved Document E, section 7. Reverberation in the common internal parts of buildings containing flats or rooms for residential purposes.

The Building Standards - Scotland (Technical Handbook Section 5)
AD E applies to England and Wales only. In Scotland, Technical Handbook Section 5 is the approved document covering the resistance to the transmission of sound.

A new version of the Domestic Technical Handbook Section 5 was published in October 2010, which increased the standards of sound insulation. This was the first major review of standards for more than 20 years. Its aim is to limit sound transmission from differently occupied parts of a building, and from attached buildings, to a level that will not threaten the health of occupants.

The standards outlined in Table 8 now apply in new build or converted homes and ‘traditional buildings’.

Complying with the regulations
Since January 2012, housebuilders and developers in Scotland have been able to use one of three routes to comply with Section 5 performance standards of separating walls and floors for new build houses and apartments.
- Using ‘Robust Detail’ constructions
- Using ‘Example’ constructions and verifying by Post-Completion Testing
- Using ‘Other’ constructions and verifying by Post-Completion Testing

The Post-Completion Testing route, however, remains the only means of compliance for purpose-built rooms for residential purposes and conversions.

Robust Detail constructions
Since 2012, certain Robust Detail (RD) constructions have been permitted for use in new houses and apartments as an alternative to Post-Completion Testing in Scotland. If you are following the RD route, you must register each plot, with details of the RD(s) you intend to use, and pay a fee. You will then be given a registration certificate to hand to your building control authority before work starts.

Example constructions
These are constructions developed to repeatedly achieve required design performance levels, if built correctly with correctly designed flanking details. Use of these constructions does not guarantee regulatory performance levels will be achieved, and the onus is therefore on the housebuilder to demonstrate compliance by Post-Completion Testing on site.

Table 7 – Absorption class

<table>
<thead>
<tr>
<th>Sound absorption class</th>
<th>$a_w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.90, 0.95, 1.00</td>
</tr>
<tr>
<td>B</td>
<td>0.80, 0.85</td>
</tr>
<tr>
<td>C</td>
<td>0.60, 0.65, 0.70, 0.75</td>
</tr>
<tr>
<td>D</td>
<td>0.30, 0.35, 0.40, 0.45, 0.50, 0.55</td>
</tr>
<tr>
<td>E</td>
<td>0.15, 0.20, 0.25</td>
</tr>
<tr>
<td>Unclassified</td>
<td>0.00, 0.05, 0.10</td>
</tr>
</tbody>
</table>

Table 8 – Section 5 sound insulation requirements (Scotland)

<table>
<thead>
<tr>
<th>Where applicable</th>
<th>Minimum airborne sound insulation $L_{pa}$ (site test result)</th>
<th>Maximum impact sound transmission $L_{in}$ (site test result)</th>
<th>Minimum airborne sound insulation $L_{pa}$ (laboratory test result)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separating walls between new homes, purpose-built rooms for residential purposes and conversions (not including traditional buildings*)</td>
<td>55dBa</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Separating walls between rooms created by a change of use or conversion (traditional buildings*)</td>
<td>53dB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Separating floors between new homes, purpose-built rooms for residential purposes and conversions (not including traditional buildings*)</td>
<td>56dB</td>
<td>56dB</td>
<td>-</td>
</tr>
<tr>
<td>Separating floors between rooms created by a change of use or conversion (traditional buildings*)</td>
<td>55dB</td>
<td>58dB</td>
<td>-</td>
</tr>
<tr>
<td>Internal wall forming a room in a dwelling, or a room in a residential building, which is capable of being used for sleeping</td>
<td>-</td>
<td>-</td>
<td>40dB</td>
</tr>
<tr>
<td>Internal floor forming a room in the dwelling, or a room in a residential building, which is capable of being used for sleeping</td>
<td>-</td>
<td>-</td>
<td>43dB</td>
</tr>
</tbody>
</table>

* Definition of traditional buildings – A building or part of a building of a type constructed before or around 1919:
  a) using construction techniques that were common in use before 1919
  b) with permeable components, in a way that promotes the dissipation of moisture from the building fabric.

Table 9 – Section 5 sound insulation requirements

<table>
<thead>
<tr>
<th>Type of construction</th>
<th>No. of attached dwellings</th>
<th>Number of tests for separating walls and floors (flats or maisonettes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New-build Using Example Constructions*</td>
<td>2-20</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>21-40</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Over 40</td>
<td>1 extra for every 20 flats or maisonettes (or part thereof)</td>
</tr>
<tr>
<td></td>
<td>New-build Using ‘Other’ Constructions*</td>
<td>2-10</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>21-30</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Over 30</td>
<td>1 extra for every 10 flats or maisonettes (or part thereof)</td>
</tr>
</tbody>
</table>

With correctly designed flanking details. Use of these constructions does not guarantee regulatory performance levels will be achieved, and the onus is therefore on the housebuilder to demonstrate compliance by Post-Completion Testing on site.
Acoustics
System design principles

Other constructions
These include manufacturers’ proprietary solutions and new, or innovative, constructions not considered to be “Examples of Construction.” Again, the onus is on the housebuilder to demonstrate compliance by post-completion testing.

Post-completion testing
Post-completion testing is carried out when the building is complete, with doors, access hatches and windows fitted. To achieve the required approval, homes should be tested as in Table 9.

If a test fails due to the construction of the separating floor or associated flanking elements, other untasted rooms may be affected. This will result in additional testing requirements, over and above those in the table above. It may be prudent to seek specialist advice to identify and remedy any problems.

The fundamental differences between Section 5 (Domestic) and AD E are as follows:

- Section 5 has an R₁₅dB requirement for mid-floors, which is also generally applicable for student accommodation.
- Section 5 has no requirement for sound absorption in corridors of the building.
- Section 5 measures site performance by way of a D₁₅dB measure only, whereas AD E also uses a Cₜ correction factor.
- Example construction and junction details are available in conjunction with Section 5.

Building Bulletin 93: Acoustic design of schools

Requirement E4 of the Building Regulations Approved Document E states that each room or other space in a school building shall be designed and constructed in such a way that it has the acoustic conditions and the insulation against disturbance by noise appropriate to its intended use.

To satisfy this requirement, it is recommended that buildings comply with the guidance given in Building Bulletin 93 (BB93): Acoustic design of schools, a design guide. BB93 was written by the Department for Children, Schools and Families (DCSF), formerly the Department for Education and Skills (DfES), and provides a regulatory framework for the acoustic design of schools; including sound insulation between spaces, ambient noise levels and optimum reverberation times for various spaces within educational buildings.

Health and Technical Memorandum

HTM 08-01 Acoustics – Healthcare Buildings

Good acoustic design is fundamental to the quality of healthcare buildings. The control of unwanted noise improves patient privacy, dignity and sleep patterns; all key conditions for healing. Good acoustic design also increases the morale and comfort of healthcare professionals.

HTM 08-01 covers the acoustic design criteria that are important for healthcare premises and contains a method of determining the level of sound insulation required between adjacent spaces in a healthcare environment. The document also gives recommended reverberation times for various types of space.

BS 8233 – Sound insulation and noise reduction for buildings

BS 8233 provides guidance on acoustic ratings appropriate to a variety of different building types. It is applicable to the design of new buildings, or refurbished buildings undergoing a change of use. It deals with control of noise from outside the building, noise from plant and services within it, and room acoustics for non-critical situations.

A full revision of the standard, launched in 2014, includes changes which reflect:

- Legislative framework revision since publication of the 1999 edition
- Revisions to Building Regulations Approved Document E
- The publication of specialist documents for specific sectors, such as healthcare and education
- The publication in England of the National Planning Policy Framework in March 2012, with the concurrent withdrawal of numerous individual planning guidance and policy statement documents, including those specifically relating to noise
- A reappraisal of the tabular content with respect to setting targets for various classes of living space in the light of research findings
- The need to transfer some of the more detailed information from the main text to annexes
- Requirements for offices

Designing for on-site performance

Achieving a D₅₂dB + Cₜ performance on site

The BS 8233:1999 method determines the sound insulation on the low frequency region of the spectrum. For lightweight construction this means a significant change in some of the design principles. For partitions, the cavity should be as large as possible and double layers of plasterboard should be used.

For masonry walls lined with lightweight panels, cavities with a depth of less than 60mm should be avoided. Two linings, with small, identical sized cavities either side of a solid masonry wall, should not be specified. These cavities can interact and cause a significant downgrade in the critical low frequency zone. If a small cavity is required, one side only should be lined with a double layer of plasterboard. Optimum performance is achieved by lining one side only and having a cavity depth of at least 85mm.

To increase the sound insulation of new or existing masonry walls, Gypliner wall lining systems can be used in conjunction with Isover insulation and Gyproc plasterboard. The cavity depth of the Gypliner lining should be as large as possible, and small, identical sized cavities to either side of the wall should be avoided.

For lightweight separating floors, partially de-coupling the plasterboard ceiling from the floor structure, using Gyfframe RB1 Resilient Bars, helps to achieve the required performance. Floating floor treatments, for example timber battens, should have a cavity depth of at least 70mm to avoid low frequency resonance effects in the critical low frequency zone. Performance can be further enhanced by specifying Gyproc Pank within the walking surface.

Floating floor and resilient wall ceiling systems should be tested in a UKAS laboratory to ensure good low frequency performance. The Robust Details handbook outlines a benchmarking procedure for this purpose (robustdetails.com) to support specification of such systems to meet the requirements for new-build residential construction.

A method of determining the achievable site D₅₂dB + C₅₂ performance is to refer to a laboratory R₁₅dB + C₅₂ rating. Depending on the wall specification, a minimum drop of 4dB is typical when comparing R₁₅dB + C₅₂ and D₅₂dB. However, we recommend that a safety margin of + 9dB should be used to reduce the risk of failure to comply with Building Regulations. This assumes all flanking paths are incorporated when designing to meet a D₅₂dB performance on site.

Achieving a D₅₂dB + Cₜ performance on site

A minimum reduction of 5dB is typical when comparing site performance, Lₕ₅₀ to laboratory performance, Lₕ₅₀. However, when designing separating floors to reduce the risk of impact sound flanking transmission, in particular between floors, the walking surface should be de-coupled from the joists, for example using GypFloor Silent or a floating floor system. This is in addition to the de-coupling of the ceiling, using GypCeiling MF ceiling or Gyfframe RB1 Resilient Bar, for example.

Therefore, in some cases the safety margin in the laboratory for timber joist separating floors is likely to be in the region of + 10dB, rather than the typical minimum + 5dB for concrete floors.

9. Optimum design of panel linings for Cₜ

For purpose-built homes for residential purposes requiring D₅₂dB + C₅₂dB performance on site, the realistic safety margin should be incorporated when designing to meet a D₅₂dB requirement, to reduce the risk of failure. We recommend a safety margin of + 7dB when comparing site performance, D₅₂dB, to laboratory performance, Rₜ₅₀.

For dwelling houses, flats and rooms for residential purposes formed by material change of use requiring D₅₂dB + C₅₂dB for separating walls, and Rₜ₅₀ + C₅₂dB for separating floors and stairs, we recommend the use of specifications that are capable of achieving Rₜ₅₀ + C₅₂dB. Refer to table 10 for more information.

Achieving a D₅₂dB + Cₜ performance on site

Similar to the principles of achieving a D₅₂dB + C₅₂dB performance on site, a realistic safety margin should be incorporated when designing to meet a D₅₂dB requirement, to reduce the risk of failure. We recommend a safety margin of + 7dB when comparing site performance, D₅₂dB, to laboratory performance, Rₜ₅₀.

For example, to comply with Scottish Technical Handbook Section 5 in Scotland for a requirement of D₅₂dB, a system capable of achieving Rₜ₅₀ + C₅₂dB under laboratory conditions should be specified. Refer to table 11 for more information.

Achieving a Lₕ₅₀ + Cₜ performance on site

A minimum reduction of 5dB is typical when comparing site performance, Lₕ₅₀ to laboratory performance, Lₕ₅₀. However, when designing separating floors to reduce the risk of impact sound flanking transmission, in particular between a wall and a floor, the walking surface should be de-coupled from the floor joists, for example using GypFloor Silent or a floating floor system. This is in addition to the de-coupling of the ceiling, using GypCeiling MF ceiling or Gyfframe RB1 Resilient Bar, for example.

Therefore, in some cases the safety margin in the laboratory for timber floor separating floors is likely to be in the region of + 10dB, rather than the typical minimum + 5dB for concrete floors.
**Acoustics**

### System design principles

#### Table 10 – Recommended laboratory performance to meet requirements of Building Regulations Approved Document E (England and Wales)

<table>
<thead>
<tr>
<th>Where applicable</th>
<th>Minimum airborne sound insulation $D_{n,w}$ (site test result)</th>
<th>Recommended performance $R_{w}$ (laboratory test result)</th>
<th>Maximum impact sound transmission $L'_{w,inc}$ (site test result)</th>
<th>Recommended performance $L_{w}$ (laboratory test result)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separating walls between new homes</td>
<td>45dB</td>
<td>54dB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Separating walls between purpose-built rooms for residential purposes</td>
<td>43dB</td>
<td>52dB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Separating walls between rooms created by a change of use or conversion</td>
<td>45dB</td>
<td>52dB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Separating floors between new homes and purpose-built rooms for residential purposes</td>
<td>45dB</td>
<td>54dB</td>
<td>62dB</td>
<td>57dB - 52dB (depending on test method)</td>
</tr>
<tr>
<td>Separating floors between rooms created by a change of use or conversion</td>
<td>43dB</td>
<td>52dB</td>
<td>64dB</td>
<td>53dB - 54dB (depending on test method)</td>
</tr>
</tbody>
</table>

#### Table 11 – Recommended laboratory performance to meet requirements of Technical Handbook Section 5 (Scotland)

<table>
<thead>
<tr>
<th>Where applicable</th>
<th>Minimum airborne sound insulation $D_{n,w}$ (site test result)</th>
<th>Recommended performance $R_{w}$ (laboratory test result)</th>
<th>Maximum impact sound transmission $L'_{w,inc}$ (site test result)</th>
<th>Minimum airborne sound transmission $L_{w}$ (laboratory test result)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separating walls between new homes, purpose-built rooms for residential purposes and conversions (not including traditional buildings)*</td>
<td>56dB</td>
<td>63dB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Separating walls between rooms created by a change of use or conversion (traditional buildings)*</td>
<td>53dB</td>
<td>60dB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Separating floors between new homes; purpose-built rooms for residential purposes and conversions (not including traditional buildings)*</td>
<td>56dB</td>
<td>63dB</td>
<td>56dB</td>
<td>51dB - 46dB (depending on test method)</td>
</tr>
<tr>
<td>Separating floors between rooms created by a change of use or conversion (traditional buildings)*</td>
<td>53dB</td>
<td>60dB</td>
<td>58dB</td>
<td>53dB - 48dB (depending on test method)</td>
</tr>
</tbody>
</table>

* Definition of traditional buildings: A building or part of a building of a type constructed before or around 1940:
  a) using construction techniques that were commonly in use before 1940; and
  b) with permeable components, in a way that promotes the dissipation of moisture from the building fabric.

The key points for consideration when designing to meet any acoustic performance requirement are below:

- Inappropriate detailing of flanking conditions can greatly reduce the level of performance of the system from that achieved in the laboratory. Refer to figures 2-5 (pages 2.9 to 2.11) for more information.
- For separating wall and floor constructions to be fully effective, care must be taken to correctly detail the junctions between the separating wall or floor and associated elements such as external walls, other separating elements and penetrations or door openings, etc.
- If junctions are incorrectly detailed then the acoustic performance will be limited and Building Regulations requirements will not be achieved in practice.
- Pre-Completion Testing exposes poor flanking details and inadequate separating wall and floor specifications. Good flanking detailing and specifications that provide a reasonable margin of safety on site are therefore essential.

Examples of practical solutions

**Gypframe AcouStuds**

Gypframe AcouStuds are metal stud sections optimised to give enhanced sound insulation performance. These unique shaped studs are used for increased acoustic performance. Gypframe AcouStuds can be used to upgrade the acoustic performance of 70mm, 92mm and 146mm wall systems.

Figure 10 (page 2.23) shows the performance improvement possible using acoustic stud technology compared with a standard ‘C’ stud of the same cavity dimension.

**GypWall Staggered**

GypWall Staggered features staggered studs that are located within a head and base channel by means of retaining clips. This arrangement means there is limited connection through the framework to the plasterboard face on the opposite side of the partition. The system design enables a higher level of sound insulation to be achieved with modest cavity sizes.

Figure 11 (page 2.23) shows the improvements possible using a staggered stud arrangement compared to a standard GypWall Single Frame ‘C’ stud partition with the same partition cavity size.

**GypWall Resilient**

GypWall Resilient utilises Gypframe RB1 Resilient Bars to partially de-couple the plasterboard linings from the partition stud frame, leading to enhanced levels of sound insulation.

Figure 12 (page 2.24) shows the improvements possible when including Gypframe RB1 Resilient Bar on one or both sides of a standard Gypframe 70mm ‘C’ Stud partition.

**GypWall Twin Frame Audio and GypWall Twin Frame Independent**

The most acoustically effective wall designs are twin frame walls. Minimal or no bridging between the plasterboard linings and the increased cavity size allows optimum performance from the wall.

Figure 13 (page 2.24) shows the difference achievable by using a twin framed wall approach as opposed to a standard GypWall Single Frame stud partition. The plasterboard linings and insulation are the same for both partitions and the key difference is the overall partition thickness – typically 211mm for the standard partition and 300mm for the twin framed option. With this type of design, further improvements in performance can be achieved by increasing the cavity size and/or increasing the board specification.

**Gypframe RB1 Resilient Bar (ceilings)**

Gypframe RB1 Resilient Bar is an engineered metal component used predominantly with lightweight separating floors to de-couple the ceiling from the floor structure and thereby improve the airborne sound insulation performance of the separating floor.

The value of this component is recognised in Robust Details, where all lightweight floor solutions feature resilient bars to partially de-couple the ceiling from the floor structure.

Figure 14 (page 2.24) shows the substantial performance improvements achievable for airborne sound insulation when Gypframe RB1 Resilient Bar is utilised instead of a directly fixed ceiling.

**Floating floor treatment**

Floating floor treatments are used with both lightweight and concrete separating floors to de-couple the walking surface from the floor structure and thereby improve both the airborne and impact sound insulation performance of a separating floor.

The value of this technique is recognised in Robust Details, and is currently featured in a number of separating floor solutions.
Acoustics
System design principles

Sound insulating dry linings
In designing for sound insulation, care should be taken to ensure that flanking transmission via the associated structure does not downgrade the performance of the partition or wall to a level below that required in use. This applies especially when a lightweight partition or wall is constructed in a masonry building. Care should therefore be taken to ensure the associated structure is able to achieve the level of sound insulation required.

The performance of sound resisting floors of timber joist or lightweight concrete construction, supported on or flanked by conventionally finished masonry walls, can be adversely affected by flanking transmission in the walls. This effect can be significantly reduced by the application of a GypLyner wall lining system, to the flanking walls.

Lining treatments can also be beneficial in refurbishment work when applied to flanking walls of new or existing sound resisting walls.

Refer to Section 6, wall linings.

10. Acoustic benefits of Gypframe AcouStuds

11. Acoustic benefits of staggered studs

12. Acoustic benefits of Gypframe RBI Resilient Bars (partition)

13. Acoustic benefits of twin stud framework

14. Airborne sound insulation benefit of Gypframe RBI Resilient Bars (ceiling)
Robustness
System design principles

Legislation and guidance

BS 5234 - Partition (including matching linings)

BS 5234 comprises two parts. Part 1 Code of practice for the design and installation, and Part 2 Specification for performance requirements for strength and robustness including methods of test in relation to end-use categories. The standard covers performance aspects such as stiffness, crowd pressure, impact resistance, anchorages and door slamming resistance.


This code of practice gives dead and minimum recommended imposed loads for use in designing buildings. Whilst our GypWall partition systems are non-loadbearing, they are able to provide resistance to levels of horizontal line load applied at a height of 1.2m as detailed within this standard for parapets, barriers and balustrades, etc.

Principles of robust design

Partition Duty Ratings

All our partition systems have a Duty Rating established in accordance with all the full requirements of BS 5234. This rating relates to the strength and robustness characteristics of the partition system against specific end-use applications. Table 13 gives details of the four duty categories.

A series of tests are used to assess the resistance to damage, both aesthetic and structural, from a range of impacts and load applications.

The tests are conducted at the maximum height for the partition system. BS 5234 itself does not have a method for establishing an acceptable maximum height, and the partition height must be established using a separate method. It is suggested within BS 5234 that the crowd pressure test may be suitable for evaluating heights up to 4200mm, but we would strongly advise against using this inconsistent approach and would never rely solely on BS 5234 for evaluating heights, especially above 4200mm. Tests within BS 5234-2 include:

- Partition stiffness
- Resistance to damage from a small hard body impactor
- Resistance to damage from a large soft body impactor
- Resistance to perforation from a small hard body impactor
- Resistance to structural damage from a large soft body impactor
- Resistance to damage from door slamming

BS 5234-2 does not identify specific points of contact on a partition that should be impacted. However, we understand that there are limiting points in terms of impact resistance. These are then subjected to the impact tests to ensure that the most onerous situation is assessed.

Optional tests are also detailed within the standard, but these are not used in the partition grading. These include:

- Resistance to damage from a crowd pressure load
- Lightweight anchorages pull down
- Lightweight anchorages pull out
- Heavyweight anchorages wall cupboard
- Heavyweight anchorages wash basin

Refer to Service installations within this section, for more information on fixing to drywall systems.

Important design considerations

To achieve Heavy Duty Rating or Severe Duty Rating, the door detail needs to be reinforced otherwise the door opening will undergo too much deflection and damage during the onerous door slamming test.

The level of deflection and strength performance required to achieve Light Duty Rating within BS 5234-2 is, in our opinion, unsuitable for any application. We do not offer any systems with a rating less than Medium Duty Rating.

Maximum partition heights

As stated previously, BS 5234-2 does not contain a consistent methodology for establishing the performance of a partition in terms of height. The UK has therefore adopted a methodology, which is based on the level of lateral deflection under a given uniformly distributed load (UDL). The criterion is that the maximum lateral deflection of the partition should not exceed L/240 (where L is the partition height) when the partition is uniformly loaded to 200Pa.

We utilise a UKAS accredited test laboratory to evaluate partition system heights against this performance criteria. The test evidence comes from a full-scale test procedure where the test specimen is subjected to a UDL and the induced lateral deflection recorded. From this procedure, it is possible to establish the maximum height for a range of partition systems.

When cutting Gypframe studs to suit the partition height, it is not good practice to cut the stud through the location of a service cut-out.

Important information

To claim a partition Duty Rating, all tests must achieve the designated performance level. It is not possible, for example, for a partition lined with a single layer of Gyproc WallBoard (12.5mm) to achieve a Duty Rating better than medium, because of the board’s performance in the hard body perforation test. In the majority of cases, the type of board used will determine the maximum partition Duty Rating. Table 14 shows the maximum rating available based on a single layer board lining. In all cases, a double layer lining achieves Severe Duty Rating.

### Table 12 – BS 5234-2 Duty Ratings

<table>
<thead>
<tr>
<th>Partition duty rating</th>
<th>Category</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>Adjacent space only accessible to persons with high incentive to exercise care; Small chance of accident occurring or misuse</td>
<td>Domestic accommodation</td>
</tr>
<tr>
<td>Medium</td>
<td>Adjacent space moderately used, primarily by persons with some incentive to exercise care. Some chance of accident occurring or misuse</td>
<td>Office accommodation</td>
</tr>
<tr>
<td>Heavy</td>
<td>Adjacent space frequently used by the public and others with little incentive to exercise care. Chance of accident occurring or misuse</td>
<td>Public circulation areas, industrial areas</td>
</tr>
<tr>
<td>Severe</td>
<td>Adjacent space intensively used by the public and others with little incentive to exercise care. Prone to vandalism and abnormal rough use</td>
<td>Major circulation areas, heavy industrial areas</td>
</tr>
</tbody>
</table>

### Table 13 – Board type required to achieve a given Duty Rating (single layer solutions)

<table>
<thead>
<tr>
<th>Board type</th>
<th>Maximum rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyproc WallBoard 12.5mm</td>
<td>Medium</td>
</tr>
<tr>
<td>Gyproc WallBoard 15mm</td>
<td>Medium</td>
</tr>
<tr>
<td>Gyproc SoundBloc 12.5mm</td>
<td>Medium</td>
</tr>
<tr>
<td>Gyproc SoundBloc 15mm</td>
<td>Medium</td>
</tr>
<tr>
<td>Gyproc FireLine 12.5mm</td>
<td>Medium</td>
</tr>
<tr>
<td>Glasroc H TileBacker 12.5mm</td>
<td>Medium</td>
</tr>
<tr>
<td>Gyproc FireLine 15mm</td>
<td>Heavy</td>
</tr>
<tr>
<td>Gyproc SoundBloc 15mm</td>
<td>Heavy*</td>
</tr>
<tr>
<td>Gyproc SoundBloc F 15mm</td>
<td>Heavy</td>
</tr>
<tr>
<td>Glasroc F MultiBoard 10mm</td>
<td>Heavy</td>
</tr>
<tr>
<td>Glasroc F MultiBoard 12.5mm</td>
<td>Severe</td>
</tr>
<tr>
<td>Gyproc DuraLine 15mm</td>
<td>Severe</td>
</tr>
<tr>
<td>Rigidur H 12.5mm / 15mm</td>
<td>Severe</td>
</tr>
</tbody>
</table>

* Minimum Gypframe 70mm Stud for Heavy Duty Rating.
System design principles

Assessing acoustic performance of GypWall Single Frame with reduced stud centres

Reducing the centres of the metal studs within GypWall partition systems can have a detrimental effect on the sound insulation performance of the system. The effect may vary depending on the precise specification, e.g. board type, number of board layers, stud size and type, insulation within stud cavity.

Where Thistle MultiFinish is specified to obtain a 1 or 2 dB uplift, this will be negated when closing down stud centres or changing stud profile.

If the partition system is also performing a fire compartmentation function to EN standards, the partition height in the fire area also needs to be established for the required duration. It should not be assumed that the cold state height is still valid in the fire state.

Movement

Deflection of upper floor and roof slabs can cause appreciable stress in partitions. Where such deflection is likely to occur, the partition to structural soft joint detail must be designed to accommodate movement, whilst still complying with any fire or acoustic performance requirements. Typical deflection head details for fire-rated GypWall partition systems are given in the relevant partition and wall system sections within this book. Additional attention to detailing will be required to optimise sound insulation performance.

Where linings (partitions, wall linings and ceilings) cross a movement joint in a structural wall, floor or roof joint, Gyproc Control Joint provides a suitable solution for movement up to 7mm. Gyproc Control Joint may also be required to relieve stresses induced by extreme environmental conditions. For example, consideration could be given to installing control joints at 10m centres in linings that are subjected to either extreme or variable temperatures.

Refer to this construction details in Gypsum Independent.

Environmental conditions

Temperature

Gypsum plasterboards, Glasroc specialist boards and Thistle plasters should not be used where the temperature will exceed 49°C. Prolonged exposure to high temperature, and/or multiple exposure for short periods, results in the gradual calcination of the gypsum and loss of its inherent properties. Gypsum plasterboards, Glasroc specialist boards and Thistle plasters (once fully dried) can be subjected to freezing conditions without risk of damage.

Moisture

Plasterboards have different levels of moisture performance designed for different applications or different construction stages. If a plasterboard is incorrectly specified for a particular application it could lead to non-performance and/or damage. If project timelines change, product choice may need to change.

Our products should not be used in continuously damp conditions or in buildings that are not weather tight. However, our Gyproc Moisture Resistant grade plasterboards and Glasroc specialist boards are suitable for use in intermittently damp conditions or sheltered external situations in conjunction with an appropriate decorative finish. This should take the form of ceramic tiling or other suitable moisture impervious coating by others. Glasroc H TileBacker can be used as a tiling substrate in high moisture applications.

Two coats of Gyproc Drywall Sealer applied to the face of standard grade plasterboards, with the edges adequately protected from moisture may also be suitable to receive a tile finish. The application of Gyproc Drywall Sealer provides surface water absorption resistance only, and does not meet the performance requirements for moisture resistant grade boards as defined in BS EN 520, type H1.

Relative humidity (RH)

In moderate humidity situations, i.e. 40% to 70% RH, no special precautions need to be taken when using Gyproc plasterboards, other than those necessary to prevent interstitial condensation. However, whenever the building's heating system is turned off, a rapid increase in the relative humidity can occur as the building cools down.

This could lead to the occurrence of potentially harmful surface condensation. Precautions to avoid this problem should be taken, e.g. by continuing to run the ventilation system after the heating is turned off.

Low humidity does not affect the plasterboards, but may lead to distortion of timber framing members as they dry to below their usual moisture content. Intermittently high relative humidity, i.e. above 70% RH, requires special treatment to the face of the plasterboards, and only moisture resistant grade plasterboards or Glasroc specialist boards should be used. Suitable surface treatments include ceramic tiling and water vapour resistant paint systems. Gyproc plasterboards are not considered suitable in continuously high humidity conditions. Certain British Gypsum ceiling products are suitable for use in environments above 70% RH.

Special environments – swimming pools and similar environments

Ceiling lining

Our products and systems are regularly specified for ceilings in and around swimming pool halls and similar areas. With regard to ceiling specifications attention to detail is critical.

The following guidance should be considered:

- The boards to be used should be moisture resistant grade or Glasroc F specialist boards. They should be screw-fixed to a framed system at their recommended centres.
- The surface of the board should be finished using our recommended methods, and they must be set and dry before applying decoration. Thistle finish coat plasters are not recommended for this type of environment.
- The decoration should take the form of a suitable moisture impervious finish supplied by other manufacturers.
- Penetrations in the ceiling linings and perimeters should be avoided where possible. All service penetrations must be sealed using a moisture resistant sealant (even though the recommended plasterboards are moisture resistant it is unwise to allow moisture to gain access to the core of the board).
- The air in the pool area should be conditioned such that it will not form on the surface of the boards.
- In situations where there is a risk of condensation occurring within the ceiling cavity, it must be mechanically ventilated or the decorative finish must be impervious to water vapour. This will minimise the risk of condensation forming on ‘cold’ surfaces in the cavity, which could then come into contact with the unprotected back face of the plasterboard lining.
- It is good practice to protect the cut ends of Gypframe metal components using suitable material to prevent corrosion.
- Ensure that the Gypframe metal frame is totally encapsulated by suitable Gyproc plasterboard and waterproof finishing system (by others).

Wall lining

Glasroc H TileBacker is suitable for use as a wall lining in areas such as shower enclosures, swimming pool halls and adjacent areas.

Gyproc Moisture Resistant grade boards are not suitable to be used in those areas, but can be considered for use in adjacent areas of wall lining and in most domestic situations. Attention to detail is critical and, in addition to the guidance given above for ceiling linings, the following additional guidance should be considered:

- The lining boards must be lifted clear from any floor where free water is possible and a suitable skirting detail must be employed which will not allow water penetration.
- In extreme moisture environments, Glasroc H TileBacker must be used in conjunction with a tanking system.
- Thistle plasters are not recommended for this type of environment with the exception of Thistle OnDeck undercoat which could be considered in conjunction with a completely sealed, impervious, tanking system. Reference to Technical data sheet on the Thistle product website should be made in order to ensure all materials are compatible.
- Important guidance is given within BS 5385-1 and BS 5385-4, within which gyproc plasterboard and plasterboard plaster are deemed unsuitable backgrounds for tiling in frequently wetted areas. These areas include communal showers and pool halls.

Ceilings

EN 1814 includes class definition relating to exposure conditions and maximum deflection. The standard Gypsum MF ceiling layout is capable of complying with deflection Class 2 and exposure Class A, however the system can be modified to meet Classes 1 and B. See Technical Support on british-gypsum.com for further guidance.
**System design principles**

**Services within partitions and lining cavities**

The installation of electrical services must always be carried out strictly in accordance with BS 7671:2015 Requirements for electrical installations. IET Wiring Regulations. Services can be incorporated within all our partition and lining systems. As shown in figure 15 and figure 16 (page 2.33), Gyproc studwork have cut-outs or push-outs to accommodate routing of electrical services and other small services. Grommets or isolating strips should be installed in the cut-out to prevent abrasion of the cables.

Gypsum channels do not generally have cut-outs and so, if required, they need to be cut on-site, paying attention to Health & Safety guidance. Grommets or isolating strips should be installed in these cut-outs to prevent abrasion of the cables.

When installing electrical services within a partition, this might result in the concealed cable being less than 50mm from the surface of the partition, particularly if the partition is less than 100mm thick. Whilst it may be apparent that electrical services are contained within a partition cavity due to the appearance of electrical sockets / switches on the partition surface, this might not be obvious from the reverse side. Therefore, before carrying out work, e.g. drilling into the surface, the reverse side of the partition must always be checked to determine the location of any concealed cables. It is good practice to maintain a clear zone. Where the location of electrical outlets cannot be determined from the reverse side, then the cable must either be mechanically protected or run at least 50mm from the surface of the wall or partition on the reverse side. Refer to figure 17 and figure 18 (page 2.54).

Where heating pipes, particularly micro-bore systems, are to be located within the GyprocDryWall system, it is recommended that only one pipe is passed through each aperture in the metal framework. If this cannot be accommodated for wholesome reasons, it may be necessary to incorporate proprietary pipe restraining clips, or other means of keeping the pipes apart, to prevent vibration noise. If a lining system, such as Dri-Lyner, does not have sufficient depth to accommodate the service then the background should be ‘chased out’ to the appropriate depth considering maximum allowable tolerances. Pipes or conduits should be fixed in position before work commences.

The insulating backing of Gyproc ThermaLine should not be used. Please see National House Building Council (BHBC) advice regarding acceptable isolation methods such as conduit or capping of services. If this cannot be accommodated for whole or partial reasons, it may be necessary to incorporate proprietary pipe restraining clips, or other means of keeping the pipes apart, to prevent vibration noise. Fixing electrical socket boxes into the partition and walls can affect the technical performance e.g. fire, acoustic, air leakage, but careful detailing can minimise this. Building Regulations Approved Document E and Robust Details offer specific guidance on the installation of socket boxes in separating walls, particularly with regard to the avoidance of back-to-back services. Refer to figure 22 (page 2.35).

There are a number of putty pad products available on the market from a range of manufacturers and whilst we have no objection to the use of putty pads (by others) within drylining systems, all performance substantiation has to be provided by the fire-stopping manufacturer as is the case for any fire-stopping material. Refer to figure 23 (page 2.35), for example. The Robust Details pattern offer specific guidance on the installation of socket boxes in separating walls, particularly with regard to the avoidance of back-to-back services. Refer to figure 22 (page 2.35).

This method is increasingly migrating to projects where Pre-Completion Testing is being used, as best practice. However, it can lead to a downgrading of the D_x, C_y performance of the base wall due to the introduction of additional cavities within the overall cavity space. Robust Detail walls are designed to exceed the Approved Document E requirement so the slight potential downgrade in performance caused by the ‘sacrificial’ lining would not lead to system failure.

**Duct / damper penetration through drywall systems**

Fire and smoke resisting dampers can be installed in our systems. Dampers prevent fire and smoke from passing from one fire compartment to another through heating, ventilation and air conditioning systems. Dampers can be incorporated within all our partition and lining systems, which in turn removes the risk of a loss of fire resistance of the base wall due to fire spread. It is important to use only those services and their installations that have been shown by a fire test to be able to maintain the integrity of the construction. By designing service zones, through which all services pass, the number of individual service penetrations can be minimised. Service zones can be sealed after installation of the services using a tested and substantiated fire-stopping system.

In most situations, the services will be installed by contractors other than the drying contractor. It is important, therefore, that all relevant contractors are advised as to where and how their service penetrations should be made and maintained. The necessity to independently support services will depend on their size and weight and the drying specification.
## Service installations

### System design principles

#### Table 15 – Example fixing devices and typical Safe Working Loads (SWL) on partitions and wall linings (cont.)

<table>
<thead>
<tr>
<th>Reference and detail</th>
<th>Description</th>
<th>Typical SWL** (typical failure load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>No 10 woodscrew into Gyproc plasterboard</td>
<td>3kg (12kg)</td>
</tr>
<tr>
<td>B</td>
<td>Steel picture hook and masonry nail into Gyproc plasterboard</td>
<td>4kg (16kg)</td>
</tr>
<tr>
<td>C</td>
<td>Metal self-drive into single layer Gyproc plasterboard</td>
<td>6kg (24kg)</td>
</tr>
<tr>
<td>D</td>
<td>Steel expanding cavity fixing, e.g. M5 x 40, into Gyproc plasterboard (board thicknesses up to 12.5mm)</td>
<td>10kg (40kg)</td>
</tr>
<tr>
<td></td>
<td>Steel expanding cavity fixing, e.g. M5 x 65, into Gyproc plasterboard (board thicknesses from 15mm to 28mm)</td>
<td>18kg (72kg)</td>
</tr>
<tr>
<td>E</td>
<td>British Gypsum Drywall Screw fixed through Gyproc plasterboard into 0.5mm Gyproline metal stud / Gyproline 99 FC 50 Fixing Channel</td>
<td>19kg (76kg)</td>
</tr>
<tr>
<td>F</td>
<td>Heavy duty plastic plug fixed through Gyproc plasterboard into masonry with minimum 55mm penetration</td>
<td>20kg (140kg)</td>
</tr>
<tr>
<td>G</td>
<td>British Gypsum Jack-Point Screws fixed through Gyproc plasterboard into minimum 0.9mm Gypframe metal stud</td>
<td>30kg (120kg)</td>
</tr>
<tr>
<td>H</td>
<td>No12 self-tapping screws fixed through Gyproc plasterboard into minimum 0.9mm Gypframe metal stud</td>
<td>50kg (200kg)</td>
</tr>
<tr>
<td>I</td>
<td>Steel expanding metal cavity fixing, e.g. M4 x 40, through Gyproc plasterboard into 0.9mm Gypframe metal stud (board thicknesses up to 12.5mm)</td>
<td>40kg (160kg)</td>
</tr>
<tr>
<td></td>
<td>Steel expanding metal cavity fixing, e.g. M4 x 65, through Gyproc plasterboard into 0.9mm Gypframe metal stud (board thicknesses from 15mm to 28mm)</td>
<td>50kg (200kg)</td>
</tr>
<tr>
<td></td>
<td>Steel expanding metal cavity fixing, e.g. M5 x 65, fixing through Gyproc plasterboard into plywood supported by Gypframe Service Support Plate</td>
<td>50kg (200kg)</td>
</tr>
<tr>
<td>J</td>
<td>8mm steel frame fixing fixed through Gyproc plasterboard into masonry with minimum 55mm penetration</td>
<td>60kg (240kg)</td>
</tr>
<tr>
<td>K</td>
<td>No12 self-tapping screw fixed through Gyproc plasterboard into timber sub-frame</td>
<td>120kg (480kg)</td>
</tr>
<tr>
<td>L</td>
<td>M8 steel bolt / anchor fixed through Gyproc plasterboard into masonry with minimum 55mm penetration</td>
<td>130kg (520kg)</td>
</tr>
</tbody>
</table>

** Typical SWL**

*For GypWall Resilient, ensure that the fixings do not bridge the Gypframe RB1 Resilient Bars, otherwise the acoustic performance will be compromised.

**Safe Working Load (SWL) - a safety factor of 4 (steel fixings) and 7 (plastic fixings) has been used.*

For technical assistance on above fixings please contact the fixings manufacturer. The suitability of the fixing must be confirmed by the building designer / fixing manufacturer.

Reference can also be made to the Construction Fixing Association (CFA) guidance note Fixing For Plasterboard, which can be accessed at fixingscfa.co.uk.

When specifying a fixing for / through Gyproc ThermaLine, please give consideration to the thickness and compressibility of the insulation to ensure that the fixing used is fit for purpose.

Careful assessment must be done if anchors are spaced in close proximity to each other. To achieve the quoted maximum allowable loads, fixings must not incorporate several fixings per fixture to ensure the weight is distributed across the drylining system rather than a point load, particularly for medium to heavy fixtures.

*Safe Working Load (SWL) – a safety factor of 4 (steel fixings) and 7 (plastic fixings) has been used.*

For technical assistance on above fixings please contact the fixings manufacturer. The suitability of the fixing must be confirmed by the building designer / fixing manufacturer.

The information within tables 16a and 16b, does not take into consideration any additional forces that may be applied, whether it be accidental, abusive or otherwise. The example fixing devices, typical safe working loads and typical failure loads given in table 17 relate to the installation of single fixture. It is important to ensure that the drylining system is capable of supporting the loads, particularly if installing multiple fixtures. Furthermore, it may be necessary to incorporate several fixings per fixture to ensure the weight is distributed across the drylining system rather than a point load, particularly for medium to heavy fixtures. Careful assessment must be done if anchors are spaced in close proximity to each other. To achieve the quoted maximum allowable loads, fixings must not influence each other and shall be spaced far apart so that the zone of influence is not overlapping each other.

#### Table 16a – Example fixing devices and typical Safe Working Loads (SWL) on partitions incorporating Rigidur H

<table>
<thead>
<tr>
<th>Reference and detail</th>
<th>Description</th>
<th>Typical SWL** (typical failure load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Steel picture hook and masonry nail into 12.5mm Rigidur H</td>
<td>17kg (68kg)</td>
</tr>
<tr>
<td></td>
<td>Steel picture hook and masonry nail into 15mm Rigidur H</td>
<td>18kg (72kg)</td>
</tr>
<tr>
<td>F</td>
<td>Fischer PD nylon plug and screw into 12.5mm or 15mm Rigidur H</td>
<td>20kg (72kg)</td>
</tr>
<tr>
<td>A</td>
<td>No 10 woodscrew into 12.5mm or 15mm Rigidur H</td>
<td>15kg (60kg)</td>
</tr>
<tr>
<td>I</td>
<td>Fischer HM8 x 55 steel cavity fixing into 15mm Rigidur H</td>
<td>49kg (196kg)</td>
</tr>
<tr>
<td>M</td>
<td>Fischer KDI steel cavity fixing into 12.5mm Rigidur H</td>
<td>58kg (232kg)</td>
</tr>
<tr>
<td></td>
<td>Fischer KDI steel cavity fixing into 15mm Rigidur H</td>
<td>74kg (296kg)</td>
</tr>
</tbody>
</table>

** Typical SWL**

For technical assistance on above fixings please contact the fixings manufacturer. The suitability of the fixing must be confirmed by the building designer / fixing manufacturer.

Reference can also be made to the Construction Fixing Association (CFA) guidance note Fixing For Plasterboard, which can be accessed at fixingscfa.co.uk.

When specifying a fixing for / through Gyproc ThermaLine, please give consideration to the thickness and compressibility of the insulation to ensure that the fixing used is fit for purpose.

Careful assessment must be done if anchors are spaced in close proximity to each other. To achieve the quoted maximum allowable loads, fixings must not influence each other and shall be spaced far apart so that the zone of influence is not overlapping each other.

*Safe Working Load (SWL) – a safety factor of 4 (steel fixings) and 7 (plastic fixings) has been used.*

For technical assistance on above fixings please contact the fixings manufacturer. The suitability of the fixing must be confirmed by the building designer / fixing manufacturer.

The information within tables 16a and 16b, does not take into consideration any additional forces that may be applied, whether it be accidental, abusive or otherwise. The example fixing devices, typical safe working loads and typical failure loads given in table 17 relate to the installation of single fixture. It is important to ensure that the drylining system is capable of supporting the loads, particularly if installing multiple fixtures. Furthermore, it may be necessary to incorporate several fixings per fixture to ensure the weight is distributed across the drylining system rather than a point load, particularly for medium to heavy fixtures. Careful assessment must be done if anchors are spaced in close proximity to each other. To achieve the quoted maximum allowable loads, fixings must not influence each other and shall be spaced far apart so that the zone of influence is not overlapping each other.

#### Table 16b – Example fixing devices and typical Safe Working Loads (SWL) on partitions incorporating Gypframe Habito

<table>
<thead>
<tr>
<th>Reference and detail</th>
<th>Description</th>
<th>Typical SWL** (typical failure load)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Fischer HM4 x 45.5 steel cavity fixing into 12.5mm Gypframe Habito</td>
<td>13kg (52kg)</td>
</tr>
<tr>
<td></td>
<td>Fischer HM5 x 52.5 steel cavity fixing into 12.5mm Gypframe Habito</td>
<td>28kg (113kg)</td>
</tr>
<tr>
<td></td>
<td>Fischer HM6 x 57.5 steel cavity fixing into 12.5mm Gypframe Habito</td>
<td>35kg (149kg)</td>
</tr>
<tr>
<td></td>
<td>Fischer HM6 x 52.5 steel cavity fixing into 12.5mm Gypframe Habito</td>
<td>41kg (167kg)</td>
</tr>
<tr>
<td>M</td>
<td>Fischer KDI steel cavity fixing into 12.5mm Gypframe Habito</td>
<td>63kg (262kg)</td>
</tr>
</tbody>
</table>

** Typical SWL**

For technical assistance on above fixings please contact the fixings manufacturer. The suitability of the fixing must be confirmed by the building designer / fixing manufacturer.

Reference can also be made to the Construction Fixing Association (CFA) guidance note Fixing For Plasterboard, which can be accessed at fixingscfa.co.uk.

When specifying a fixing for / through Gyproc ThermaLine, please give consideration to the thickness and compressibility of the insulation to ensure that the fixing used is fit for purpose.

Careful assessment must be done if anchors are spaced in close proximity to each other. To achieve the quoted maximum allowable loads, fixings must not influence each other and shall be spaced far apart so that the zone of influence is not overlapping each other.

*Safe Working Load (SWL) – a safety factor of 4 (steel fixings) and 7 (plastic fixings) has been used.*

For technical assistance on above fixings please contact the fixings manufacturer. The suitability of the fixing must be confirmed by the building designer / fixing manufacturer.

The information within tables 16a and 16b, does not take into consideration any additional forces that may be applied, whether it be accidental, abusive or otherwise. The example fixing devices, typical safe working loads and typical failure loads given in table 17 relate to the installation of single fixture. It is important to ensure that the drylining system is capable of supporting the loads, particularly if installing multiple fixtures. Furthermore, it may be necessary to incorporate several fixings per fixture to ensure the weight is distributed across the drylining system rather than a point load, particularly for medium to heavy fixtures. Careful assessment must be done if anchors are spaced in close proximity to each other. To achieve the quoted maximum allowable loads, fixings must not influence each other and shall be spaced far apart so that the zone of influence is not overlapping each other.

*Safe Working Load (SWL) – a safety factor of 4 (steel fixings) and 7 (plastic fixings) has been used.*

For technical assistance on above fixings please contact the fixings manufacturer. The suitability of the fixing must be confirmed by the building designer / fixing manufacturer.

The information within tables 16a and 16b, does not take into consideration any additional forces that may be applied, whether it be accidental, abusive or otherwise. The example fixing devices, typical safe working loads and typical failure loads given in table 17 relate to the installation of single fixture. It is important to ensure that the drylining system is capable of supporting the loads, particularly if installing multiple fixtures. Furthermore, it may be necessary to incorporate several fixings per fixture to ensure the weight is distributed across the drylining system rather than a point load, particularly for medium to heavy fixtures. Careful assessment must be done if anchors are spaced in close proximity to each other. To achieve the quoted maximum allowable loads, fixings must not influence each other and shall be spaced far apart so that the zone of influence is not overlapping each other.
Service installations
System design principles

15. Gypframe studs service cut-out details – Gypframe ‘C’ and Gypframe ‘I’ Studs


17. Minimum distance of cabling

18. Standard zones of cabling

19. General arrangement of service support plates showing studs at 600mm centres

20. Socket box installation – up to 30 minutes fire resistance
Service installations

System design principles

21. Socket box installation – up to 120 minutes fire resistance (subject to board type)

Gypframe Folded Edge Standard Floor & Ceiling Channel receiving fixing of socket box - channel legs tabbed, bent and fixed to metal studs with British Gypsum Wafer Head Drywall Screws.

Stone mineral wool (minimum 80kg/m³) backing to socket box.

Gyproc plasterboard or Glasroc specialist board.

Gypframe ‘C’ Stud.

Electrical socket with metal back box fitted tight into plasterboard.

Gyproc Sealant at switch box perimeter for improved acoustics.

22. Electrical socket box with plasterboard baffle in GypWall Twin Frame Independent

Fire-resistant seal where required as per Robust Details by Building Regulations Approved Document B.

Electrical socket box.

150mm high Gyproc plasterboard baffle to match partition lining.

Gyproc plasterboard.

Gypframe ‘I’ Stud.

ISOVER insulation.

Gypframe GA4 Steel Angle.

Gyproc Sealant.

23. Electrical socket box with putty pad in GypWall Twin Frame Independent

Putty pad (by others) in accordance with manufacturer’s instructions.

Electrical socket box.

Gyproc plasterboard.

Gypframe ‘I’ Stud.

ISOVER insulation.

24. Robust Details sacrificial lining where a slight performance downgrade is not detrimental to the system

Gyproc plasterboard.

Gypframe ‘I’ Stud.

ISOVER insulation.

Electrical socket box.

Timber batten.

Gyproc plasterboard.

Gyproc Sealant.

25. Electrical socket box in sacrificial lining to GypWall Twin Frame Braced

50mm ISOVER Acoustic Partition Roll (APR 1200).

Gyproc plasterboard.

Gypframe ‘C’ Stud.

Gypframe 99 FC 50 Fixing Channel.

ISOVER insulation.

Electrical socket box.

GypLynar Single with minimum 70mm cavity.

15mm Gyproc SoundBloc.

Gyproc Sealant.
System design principles

Thermal insulation

Legislation and guidance documents

Building Regulations (England) - Thermal insulation

Minimum energy efficiency requirements in England are set out in Building Regulations Approved Document L (AD L), Conservation of fuel and power.

AD L comprises the following four documents:

- AD L1A Conservation of fuel and power in new dwellings
- AD L1B Conservation of fuel and power in existing dwellings
- AD L2A Conservation of fuel and power in new buildings other than dwellings
- AD L2B Conservation of fuel and power in existing buildings other than dwellings

Compliance with AD L1A for new dwellings is based on both the carbon dioxide performance and the fabric energy efficiency of the dwelling. Compliance targets are given through the use of the Standard Assessment Procedure (SAP) calculation and although compliance cannot be demonstrated by the elemental U-value method, U-values are important requirements within the SAP calculation. Limiting fabric parameter U-values are given in AD L1A but U-values better than these are likely to be required and AD L2A includes model U-values within a concurrent notional dwelling specification. Air permeability is also a requirement within the SBEM calculation. Refer to table 17a. Compliance with AD L2 A Conservation of fuel and power in new buildings other than dwellings is based upon the carbon dioxide performance. Compliance targets are given through the use of the Simplified Building Energy Model (SBEM) and although compliance cannot be demonstrated by the elemental U-value method, U-values are important requirements within the SBEM calculation. Limiting fabric parameter U-values are given in AD L2A but U-values better than these are likely to be required and AD L2A includes model U-values within a concurrent notional building specification. Air permeability is also a requirement within the SBEM calculation. Refer to table 17b. AD L2B Conservation of fuel and power in existing buildings and AD L2B Conservation of fuel and power in existing buildings other than dwellings are based on carbon dioxide performance with the need to meet U-values targets. Where an existing element forms part of the thermal envelope it must have a certain thermal value. This is known as the 'threshold' value. If the existing value of the element equals or is better than the threshold, no thermal renovation will be required. If it is worse than the threshold value then thermal renovation to achieve the required U-values has to be carried out. Refer to tables 18a and 18b.

Table 17a – AD L1A New dwellings

<table>
<thead>
<tr>
<th></th>
<th>England</th>
<th>Wales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall</td>
<td>0.30</td>
<td>0.18</td>
</tr>
<tr>
<td>Floor</td>
<td>0.25</td>
<td>0.13</td>
</tr>
<tr>
<td>Roof</td>
<td>0.20</td>
<td>0.13</td>
</tr>
<tr>
<td>Party Wall</td>
<td>0.20</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 17b – AD L2A New buildings other than dwellings

<table>
<thead>
<tr>
<th></th>
<th>England</th>
<th>Wales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall</td>
<td>0.35</td>
<td>0.26</td>
</tr>
<tr>
<td>Floor</td>
<td>0.25</td>
<td>0.22</td>
</tr>
<tr>
<td>Roof</td>
<td>0.25</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 18a – AD L1B Existing dwellings

<table>
<thead>
<tr>
<th></th>
<th>England</th>
<th>Wales</th>
</tr>
</thead>
<tbody>
<tr>
<td>New thermal elements (including replacements for existing elements) (U-value)</td>
<td>Upgrading retained thermal elements (U-value)</td>
<td>New thermal elements (including replacements for existing elements) (U-value)</td>
</tr>
<tr>
<td>Wall</td>
<td>0.28</td>
<td>0.30</td>
</tr>
<tr>
<td>Floor</td>
<td>0.22</td>
<td>0.25</td>
</tr>
<tr>
<td>Pitched roof insulation at rafter level</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Pitched roof insulation at ceiling level</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Flat roof or roof with integral insulation</td>
<td>0.18</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 18b – AD L2B Existing buildings other than dwellings

<table>
<thead>
<tr>
<th></th>
<th>England</th>
<th>Wales</th>
</tr>
</thead>
<tbody>
<tr>
<td>New thermal elements (including replacements for existing elements) (U-value)</td>
<td>Upgrading retained thermal elements (U-value)</td>
<td>Buildings essentially domestic in character*</td>
</tr>
<tr>
<td>Wall</td>
<td>0.28</td>
<td>0.30</td>
</tr>
<tr>
<td>Floor</td>
<td>0.22</td>
<td>0.25</td>
</tr>
<tr>
<td>Pitched roof insulation at rafter level</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Pitched roof insulation at ceiling level</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>Flat roof or roof with integral insulation</td>
<td>0.18</td>
<td>0.18</td>
</tr>
</tbody>
</table>

* e.g. student accommodation, care homes

Worst acceptable and concurrent notional values for existing materials are not required to be replaced by new thermal elements. New thermal elements (including replacements for existing elements) (U-value) include model U-values within a concurrent notional dwelling specification. Air permeability is also a requirement within the SAP calculation. Refer to table 17a. Compliance with AD L2B Conservation of fuel and power in existing buildings other than dwellings is based on both the carbon dioxide performance and the fabric energy efficiency of the building specification. Air permeability is also a requirement within the SBEM calculation. Refer to table 17b. New thermal elements (including replacements for existing elements) (U-value) includes model U-values within a concurrent notional building specification. Air permeability is also a requirement within the SBEM calculation. Refer to tables 18a and 18b.
Thermal insulation
System design principles

Table 19a – Technical Handbook Section 6 (Domestic) New buildings

<table>
<thead>
<tr>
<th></th>
<th>Scotland</th>
<th>Notional dwelling, package of measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td></td>
<td>(U-value W/m²K)</td>
</tr>
<tr>
<td>Wall</td>
<td>0.22</td>
<td>0.17</td>
</tr>
<tr>
<td>Floor</td>
<td>0.18</td>
<td>0.15</td>
</tr>
<tr>
<td>Roof</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>Cavity separating wall</td>
<td>0.20</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 19b – Technical Handbook Section 6 (Non-Domestic) New buildings

<table>
<thead>
<tr>
<th></th>
<th>Scotland</th>
<th>Notional dwelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td></td>
<td>(U-value W/m²K)</td>
</tr>
<tr>
<td>Fully fitted building</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shell only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heated and naturally ventilated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heated and mechanically ventilated / cooled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>0.27</td>
<td>0.23</td>
</tr>
<tr>
<td>Floor</td>
<td>0.22</td>
<td>0.20</td>
</tr>
<tr>
<td>Roof</td>
<td>0.20</td>
<td>0.15</td>
</tr>
<tr>
<td>Cavity separating wall</td>
<td>0.20</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Table 20a – Technical Handbook Section 6 (Domestic) Existing buildings

<table>
<thead>
<tr>
<th></th>
<th>Scotland</th>
<th>Extension</th>
<th>Conversion of heated buildings (and conservatories) (U-value W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td></td>
<td>U-values</td>
<td>U-values</td>
</tr>
<tr>
<td>Extensions</td>
<td></td>
<td>worse than 0.70 for walls and 0.25 for the roof</td>
<td>equal/better than 0.70 for walls and 0.25 for the roof</td>
</tr>
<tr>
<td>Wall</td>
<td>0.17</td>
<td>0.22</td>
<td>0.30</td>
</tr>
<tr>
<td>Floor</td>
<td>0.15</td>
<td>0.18</td>
<td>0.25</td>
</tr>
<tr>
<td>Pitched roof, insulation</td>
<td>0.11</td>
<td>0.15</td>
<td>0.25</td>
</tr>
<tr>
<td>Roof</td>
<td>0.13</td>
<td>0.18</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Table 20b – Technical Handbook Section 6 (Non-Domestic) Existing buildings

<table>
<thead>
<tr>
<th></th>
<th>Scotland</th>
<th>Extension</th>
<th>Conversion of heated buildings (U-value W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td></td>
<td>(U-value W/m²K)</td>
<td></td>
</tr>
<tr>
<td>Extensions</td>
<td></td>
<td>(U-value W/m²K)</td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>0.25</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Floor</td>
<td>0.20</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>Roof</td>
<td>0.15</td>
<td>0.25</td>
<td></td>
</tr>
</tbody>
</table>

Building Regulations - Condensation

In England the requirements are set out in Building Regulations Approved Document C – site preparation and resistance to contaminants and moisture.

The walls, floors and roof of the building shall adequately protect the building and people who use the building from harmful affects caused by interstitial and surface condensation. To provide resistance to surface condensation and mould growth, guidance is also given to ensure that the U-value does not exceed 0.70 W/m²K at any point within an external wall and within a floor (ground floor and other floors exposed from below) and 0.35 W/m²K at any point within a roof.

Guidance documents

Accredited Construction Details
Published by Local Government; it is intended to assist the construction industry to comply with the performance standards published in AD. It focuses on issues concerning insulation continuity and airtightness, providing theoretical information and large scale indicative drawings. It can be accessed via the website planningportal.gov.uk.

BR443 U-value conventions
Published by the Building Research Establishment (BRE), it provides calculation methods for the determination of U-values of building elements and includes common issues, together with data on typical constructions and the thermal conductivity of materials.

BR262 Thermal insulation avoiding risks
Published by the BRE, it highlights risks, causes and solutions of thermal design. The guidance supports the Building Regulations and represents the recommendations on good design and construction practice associated with thermal standards.

BS EN ISO 12524 Building material and products, Hygrothermal properties. Tabulated design values
This gives design data in tabular form for heat and moisture transfer calculations, for thermally homogenous materials and products commonly used in building construction. It also gives data to enable calculations and conversion of design thermal values for various environmental conditions.

BS EN ISO 15026 Hygrothermal performance of building components and building elements – Assessment of moisture transfer by numerical simulation
Commonly known as the ‘WUFI’ method, this standard defines the practical application of hygrothermal simulation software used to predict one-dimensional transient heat and moisture transfer to multi-layer building envelope components subjected to non steady climate conditions on either side. In contrast to the steady-state assessment of interstitial condensation by the Glaser method (as described in EN ISO 13788), transient hygrothermal simulation provides more detailed and accurate information on the risk of moisture problems within building components and on the design of remedial treatment. While the Glaser method considers only steady-state conduction of heat and vapour diffusion, the transient models covered in this standard take account of heat and moisture storage, latent heat effects, and liquid and convective transport under realistic boundary and initial conditions.

BS EN ISO 6946 Building components and building elements. Thermal resistance and thermal transmittance. Calculation method
The new calculation method gives the method of calculation of the thermal resistance and thermal transmittance of building components and building elements, excluding doors, windows and other glazed units; components that involve heat transfer to the ground; and components through which air is designed to permeate. The calculation method is based on the appropriate design thermal conductivities or design thermal resistances of the materials and products involved.

BS 250 Code of practice for control of condensation in buildings
This describes the causes and effects of surface and interstitial condensation in buildings, and gives recommendations for their control.
Thermal insulation
System design principles

The provision of thermal insulation

Reducing heat loss
Any building with an internal temperature higher than the external temperature will lose heat. Thermal insulation reduces this heat loss and therefore helps to conserve energy and reduce heating costs.

To comply with Building Regulations, levels of thermal performance are required for the external walls, roof and floors of almost all building types. Adequate insulation must also be provided for hot water heating systems, pipes, warm air ducts and hot water storage vessels. Savings are maximised where insulation is supported by other measures such as automatic controls, which govern the operation and output of heating systems and the temperature of stored water.

In addition to providing high levels of thermal performance in newly constructed buildings, insulation products and systems are also incorporated into existing buildings where the energy efficiency of the building may be inadequate. This will apply equally to both non-domestic buildings and to the existing housing stock. The scale of inefficiency for the latter has been highlighted by various Government surveys and subsequent corrective measures.

When specifying the insulation system for a particular building it is important to take into account both the heating regime and the pattern of usage of the building.

Infrequently heated buildings
If a building is only infrequently heated, thermal insulation materials should be located as near as possible to the internal surface of exposed building elements to provide a quick thermal response to heating input. This is essential in such conditions to reduce internal surface condensation during the warm-up period, when the maximum amount of water vapour is often produced. It will also ensure that comfortable room temperatures are quickly achieved.

Gyproc ThermaLine laminates are extensively used in both new and existing buildings to provide internal lining and insulation in one fixing operation. They can allow Building Regulation standards to be achieved using clear adhesive layers for the external walls, or in one fixing operation. However, the following is a list of some example air leakage paths:

- Cracks, gaps and joints in the structure
- Timber floors
- Joint penetrations of external walls
- Windows and doors
- Loft hatches
- Skirting boards
- Chimney and flues
- Service entries, ducts and electrical components
- Areas of unplastered walls

To improve airtightness when using a plasterboard internal lining system, e.g. Drylined, Dabi, continuous ribbons of adhesive should be applied around the perimeter of the wall and around openings / penetrations to seal airpaths.

Gyproc SoundCdt Plus can be used on most external masonry walls to seal air paths. This may also improve the airtightness before a drylining system is applied to the wall.

Terminology
Thermal conductivity (λ)
This is a measure of a material’s ability to transmit heat, and is expressed as heat flow in watts per metre thickness of material for a temperature gradient of one degree Kelvin (K). It is expressed as W/mK.

Generally, dense materials have high thermal conductivity and are inefficient thermal insulators. Lightweight materials have low conductivity and can be efficient thermal insulators. The lower the λ value of a material, the better its insulating efficiency.

Thermal resistance (R)
This is the measure of the resistance to the passage of heat offered by the thickness of a material and is expressed as m²K/W. The thermal resistance of a material is obtained by the following calculation:

$$ R = \frac{t}{\lambda} $$

Where t = thickness (in m) and λ = thermal conductivity (W/mK)

Thermal transmittance (U-value)
This is a property of the whole construction, including air spaces, and is a measure of its ability to transmit heat under steady state conditions. It is calculated by taking the reciprocal of the sum of all the individual thermal resistances, taking into consideration any thermal bridging, and is expressed as W/m²K. The lower the U-value of the material the better its thermal insulation.

For the purpose of calculating U-values, thermal resistances for the inside and outside surfaces of a building element, and for any cavities within it, have to be taken into account. This is in addition to thermal resistances directly relating to the thickness of materials.

The R-values of inside surfaces, outside surfaces and of any cavities will vary according to the surface emissivity. Emissivity should be taken as high for all normal building materials other than polished or metal surfaces, such as aluminium foil, which are regarded as low.

U-values are used as a common basis for comparing different constructions or for meeting a stated figure. When calculating the U-value for some constructions the effect of components that repeatedly bridge the insulation layer, such as mortar joints in lightweight blockwork, studs in timber frames, and even bricks, wall ties, and roof joists, should be taken into account. The U-value is calculated through the thermal bridge and combined with the U-value through the insulation in proportion to its face area, often resulting in a higher U-value for the element. More insulation may be needed to compensate for the presence of thermal bridges and return the U-value to a specified level. This can also be achieved by changing to a more efficient insulant. The additional heat loss for non-repeating thermal bridges, such as details at window and door openings, is determined separately.

Thermal mass / heat sink
Thermal mass describes a material’s capacity to absorb, store and release heat. For example, water and concrete have a high capacity to store heat and are referred to as ‘high thermal mass’ materials. Insulation foam, by contrast, has very little heat storage capacity and is referred to as ‘low thermal mass’. Gyproc plasterboards and Rigider H are effective in contributing towards the thermal mass effect. Thermal mass design, for example in school buildings, is a means of ensuring overheating is kept under control.

This principle is included with the SBEM and SAP procedure within which it is expressed as a Kappa (κ) value in calculating the thermal mass parameter to characterise the thermal mass of a building. As an example within SAP, the heat capacity κ of a single layer plasterboard partition is given as 9 kJ/m²K.

Condensation control in buildings

Harmful effects of condensation
Condensation can be one of the worst problems that designers, owners or occupants of buildings experience. Damaged and mould growth is often the result caused by surface condensation can not only be disturbing to the occupants of a building, but can eventually lead to damage in the building itself.

The thermal insulation and ventilation requirements of Building Regulations aim to reduce the risk of condensation and mould growth occurring in new buildings. However, designers should take care to eliminate all problems caused by condensation, particularly in refurbishment projects on existing buildings, where situations exist that are not directly covered by the regulations.

Reducing the risk
Due to changes in building design, occupancy patterns and increased thermal requirements, all buildings, particularly houses, are more sensitive to condensation now than in previous years. Homes that need to be heated intermittently and moisture-producing activities are concentrated into relatively short periods of time.

Thermal insulation correctly positioned within specific building elements, combined with adequate heating and the necessary water vapour control and ventilation, where appropriate, should ensure trouble-free design.

How condensation occurs
At any given temperature, air is capable of containing a specific maximum amount of water in vapour form. The warmer the air, the greater the amount of water vapour it can contain. Conversely, the lower the temperature, the smaller the amount.

Water vapour in air exerts a pressure, called the vapour pressure. Any differential in vapour pressure causes vapour to diffuse from high to low pressure areas.

Warm air inside a building usually contains more moisture than external air, due either to the occupants’ activities or resulting from the evaporation of residual moisture in new construction. This creates a pressure differential across structural elements. Water vapour in the internal air, being at a higher pressure, tends to diffuse through the structure towards the colder, lower pressure exterior.

If moisture-laden air comes into contact with a cold surface it will cool. As it cools, the amount of water it can hold in vapour form reduces until, at a specific temperature called the dew point, it becomes saturated. Water is then deposited in the form of condensation.

Building Regulations aim to reduce the risk of condensation and mould growth occurring in new buildings. However, designers should take care to eliminate all problems caused by condensation, particularly in refurbishment projects on existing buildings, where situations exist that are not directly covered by the regulations.

Reducing the risk
Due to changes in building design, occupancy patterns and increased thermal requirements, all buildings, particularly houses, are more sensitive to condensation now than in previous years. Homes that need to be heated intermittently and moisture-producing activities are concentrated into relatively short periods of time.

Thermal insulation correctly positioned within specific building elements, combined with adequate heating and the necessary water vapour control and ventilation, where appropriate, should ensure trouble-free design.

How condensation occurs
At any given temperature, air is capable of containing a specific maximum amount of water in vapour form. The warmer the air, the greater the amount of water vapour it can contain. Conversely, the lower the temperature, the smaller the amount.

Water vapour in air exerts a pressure, called the vapour pressure. Any differential in vapour pressure causes vapour to diffuse from high to low pressure areas.

Warm air inside a building usually contains more moisture than external air, due either to the occupants’ activities or resulting from the evaporation of residual moisture in new construction. This creates a pressure differential across structural elements. Water vapour in the internal air, being at a higher pressure, tends to diffuse through the structure towards the colder, lower pressure exterior.

If moisture-laden air comes into contact with a cold surface it will cool. As it cools, the amount of water it can hold in vapour form reduces until, at a specific temperature called the dew point, it becomes saturated. Water is then deposited in the form of condensation.

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Thermal insulation
System design principles

Surface condensation
Surface condensation occurs when air containing water vapour comes into contact with highly vapour resistant surfaces, which are at, or below, the dew point temperature. Refer to figure 29 - ‘Surface condensation’ (page 2.47). It usually shows itself as beads of water, damp patches, and, where the condition persists, mould growth. Surface condensation can be in localised zones in a particular building element caused by the presence of ‘cold bridges’, such as mortar joints in walls, which can be colder than the rest of the wall structure.

In addition, warm moist air will diffuse through a building into colder rooms, such as poorly heated bedrooms and stairwells. This is one reason why surface condensation does not always occur in the room where water vapour is produced.

Interstitial condensation
Warm moist air will also diffuse through building elements to reach colder, lower pressure conditions outside. If the building materials have low water vapour resistance, it is possible for condensation to occur within the building element. This will occur on the first cold surface, at or below dew point temperature, which is encountered by the moisture vapour on its passage through the structure. As an example, for double skin masonry walls, the position for condensation to form is on the inner face of the outer leaf whether or not insulation is included in the cavity. Refer to figure 30 - ‘Interstitial condensation’ (page 2.47).

There is no evidence to suggest that interstitial condensation will occur within the core of building materials under general building and climatic conditions. For other types of building structure vapour control layers can help to eliminate the risk of interstitial condensation. It is recommended that the risk of harmful condensation be assessed using an appropriate calculation procedure, for example as described in BS 5250. Refer to table 22 for typical hygrothermal properties.

Designing to reduce condensation risk
Thermal insulation
Thermal insulation helps to reduce the risk of surface condensation by maintaining surfaces above the dew point temperature. It is recommended that the risk of harmful condensation be assessed using an appropriate calculation procedure, for example as described in BS 5250.

Ventrilation
Ventilation removes the water vapour produced within a building to the outside air. Adequate ventilation, including the provision of small controllable slot ventilators in windows, electrical extractor fans controlled by humidists in bathrooms and kitchens, and cooker hoods extracted to the outside air, will help to reduce harmful condensation and mould growth. Ideally, ventilation should control the internal air to between 40% and 70% relative humidity (RH) for human occupation.

Other measures include the provision of adequate cross-ventilation of the roof spaces to the outside. The main requirements for ventilation in buildings are given in the Building Regulations Approved Document A (Ventilation).

Insulation
Thermal insulation should be located as near as possible to the internal surface of building elements to provide rapid thermal response. These surfaces will then be less prone to surface condensation during the warm-up period, which is often when the maximum amount of water vapour is produced. Being located on the warm side of the structure, Gyproc ThermaLine will help to provide this rapid thermal response and will also reduce the thermal bridge effects in a building, e.g. at lintels and reveals.

With some construction types the potential problem may be one of interstitial condensation. Gyproc ThermaLine is available with integral vapour control to minimise the risk. Alternatively, the choice of construction may demand a different position for insulation, away from the surface lining. Surface condensation will not generally be a problem in these circumstances, particularly where adequate heating is provided. Consideration should be given to establishing whether the particular construction brings with it any increased risk of interstitial condensation.

For most constructions the use of vapour permeable insulation, in combination with other building materials of low vapour resistance, will allow the structure to breathe naturally. In this instance, the likely occurrence of interstitial condensation will be shifted to less problematic areas, such as masonry walls (inner face of the outer leaf).

Thermal bridging, particularly at junctions, abutments and openings can occur and therefore good detailing is essential. Information on Psi (I) values (linear thermal transmission) relating to thermal bridging details is contained within SAP and within Accredited Construction Details (ACDs) which are available to view at planningportal.gov.uk/buildingregulations/approveddocuments/part/brassocialiseddocuments/acd Heating
Adequate heating helps to keep the temperature of the internal surfaces above the dew point. Ideally, an air temperature above 10°C should be maintained in all parts of the building.

New masonry walls
Full fill or partial fill cavity. Positioning insulating CWS 32 or 36 Blatt insulation within the cavity, either full fill or partial fill, can maintain the internal surface of the wall above dew point temperature and negate the cold bridging effects of mortar joints. Therefore a vapour resistant treatment to the surface of internal plaster finishes is not always necessary because any interstitial condensation will occur on the inner surface of the outer leaf. Thin plaster, or Gyproc WallBoard, fixed in the DriLyner or Gypliner systems, form suitable linings. Where a vapour control layer is required, the plasterboard lining surface can be treated with two coats of Gyproc Drywall Sealer. Alternatively, Gyproc WallBoard Duplex can be specified in conjunction with the DriLyner Fix or Gyplyliner systems. Refer to NABCE categories of exposure to wind driven rain for suitability of project location.

Timber / steel frame walls
To reduce the risk of interstitial condensation occurring on the inner surface of the sheathing, a vapour control layer is required as part of the internal lining, refer to NHBC (Technical Standards for domestic applications) at nhbc.co.uk. Insulin timber frame insulation is positioned within the stud cavity and Gyproc dup1ex grade plasterboards can be used as the internal face lining. The dew point will then fall within the outer cavity or external cladding.

Where the insulation does not meet the U-value requirement alone, a drying system using a Gyproc ThermaLine could be considered which will provide both thermal performance and a vapour control layer. Provision should also be made for water vapour to escape outward through very low vapour resistance sheathing boards, breather membranes, external claddings and by vented cavities. It is also good practice to ensure that any accumulation of moisture is directed outwards by incorporating flashings, drainage outlets and suitable timber detailing.

Existing masonry walls
Gyproc ThermaLine, internal drying system:
Gyproc ThermaLine containing vapour control layers can reduce the risk of interstitial condensation, provided the existing wall has low vapour resistance and does not incorporate any other material of high vapour resistance on the cold side of the construction.
Thermal insulation
System design principles

Table 21 – Recommendations for the use of vapour control layers to reduce the risk of interstitial condensation in some example external wall and roof constructions in dwellings

<table>
<thead>
<tr>
<th>Element</th>
<th>Type of external wall</th>
<th>Vapour control layer required?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>External wall</td>
<td>Timber or metal frame (brick outer leaf)</td>
<td>Yes</td>
<td>Low vapour resistance sheathing board and breather membrane.</td>
</tr>
<tr>
<td></td>
<td>Brick / insulated cavity / block</td>
<td>No</td>
<td>Consider vapour control layer in adverse conditions</td>
</tr>
<tr>
<td></td>
<td>Gyproc plasterboard lining or Thistle plaster</td>
<td>No</td>
<td>Consider vapour control layer in adverse conditions</td>
</tr>
<tr>
<td></td>
<td>Brick / clear cavity / block</td>
<td>Yes</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Gyproc ThermaLine lining</td>
<td>Yes</td>
<td>Ventilation of lining cavity to outside may be required depending on vapour resistance of masonry</td>
</tr>
<tr>
<td>Roofs</td>
<td>Cold pitched roof, tiles or slates on battens on membrane over loft space (ceiling and insulation horizontal)</td>
<td>No</td>
<td>Ventilated in accordance with BS 5250 and Approved Document F. Consider vapour control layer in adverse conditions</td>
</tr>
<tr>
<td></td>
<td>Warm pitched roof, tiles or slates on battens on membrane over batten – Ceiling and insulation inclined</td>
<td>Yes</td>
<td>Ventilated in accordance with BS 5250 and Approved Document F. Minimum 50mm ventilation zone above insulation (unless ventilated tiling battens/counter batten cavity over breathable membrane used)</td>
</tr>
<tr>
<td></td>
<td>Cold flat roof – Insulation at ceiling level (horizontal)</td>
<td>Yes</td>
<td>Ventilated in accordance with BS 5250 and Approved Document F. Minimum 50mm ventilation zone above insulation</td>
</tr>
</tbody>
</table>

Table 22 – Hydrothermal properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific heat capacity, Cp**</th>
<th>Water vapour resistance factor, dry***</th>
<th>Equivalent water vapour resistivity**** (MNs/m²)</th>
<th>Typical vapour resistance resistance MNs/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gyproc plasterboard</td>
<td>1000</td>
<td>10</td>
<td>50</td>
<td>0.63 (12.5mm thickness)</td>
</tr>
<tr>
<td>Gyproc plaster</td>
<td>1000</td>
<td>10</td>
<td>50</td>
<td>0.65 (13mm thickness)</td>
</tr>
<tr>
<td>Mineral wool</td>
<td>1030</td>
<td>1</td>
<td>5</td>
<td>0.25 (50mm thickness)</td>
</tr>
<tr>
<td>Expanded polystyrene</td>
<td>1450</td>
<td>60</td>
<td>300</td>
<td>15.0 (50mm thickness)</td>
</tr>
<tr>
<td>Extruded polystyrene</td>
<td>1450</td>
<td>150</td>
<td>750</td>
<td>37.5 (50mm thickness)</td>
</tr>
<tr>
<td>Polyisocyanurate foam</td>
<td>1400</td>
<td>60</td>
<td>300</td>
<td>15.0 (50mm thickness)</td>
</tr>
<tr>
<td>Vapour Control layer in duplex grade Gyproc plasterboard</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>60</td>
</tr>
<tr>
<td>Vapour Control layer in Gyproc ThermaLine FR</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4000</td>
</tr>
</tbody>
</table>

** Taken from BS EN 12524 Building materials and products - Hydrothermal properties - Tabulated design values.
*** Using conversion factor as per BS 5250 Code of practice for control of condensation in buildings.

Thermal insulation
System design principles

Pitchead roofs
Horiztonal insulated ceilings, e.g. cold loft space
Positioning a vapour control membrane at ceiling level should reduce the amount of water vapour migrating into the roof space. In practice, however, a continuous barrier is unlikely to be achieved because of the difficulty of sealing leaks through loft access hatches, electrical wiring drops, pipe penetrations and cracks. Gaps in the ceiling can be much more important in the mechanism of water vapour migration than diffusion through the ceiling liser. Appropriate cross-ventilation of the roof space is necessary. Insulation, e.g. ISOVER Spacesaver range, is located on top of and between the ceiling joints and Gyproc plasterboard fixed to the underside. Gyproc duplex grade plasterboards can be used as the ceiling lining if a vapour control layer is required.

Sloping insulated ceilings, e.g. warm room-in-the-roof
ISOTHERM ThermaLine insulation is located between the rafters and a minimum 50mm ventilation zone above the insulation is required. However, if the tiling batten / counter batten cavity is vented and a breathable membrane is used, the 50mm vented zone may not be required.

A vapour control layer is required at sloping ceiling level and given that it is likely additional thermal insulation is required to meet the stringent U-value requirements, Gyproc ThermaLine can be used as the sloping internal ceiling lining.

Flat roofs
Cold construction
In a cold roof construction, the thermal insulation, e.g. ISOVER Timber Frame Batt, is located directly above the ceiling. Most of the structure is on the unheated side of the insulation and is therefore vulnerable to the risk of interstitial condensation.

To reduce this risk, cross-ventilation must be provided above the insulation to disperse water vapour to the outside. Generally a minimum 50mm clear cavity well vented to the external air is required. An effective vapour control layer should be provided at ceiling level and perforations for pipes, electrical wiring drops, etc., should be sealed. Refer to figure 31 – ‘Timber flat roof, cold type’ (page 247). Gyproc duplex grade plasterboards or Gyproc ThermaLine can be used as the internal face ceiling lining.

Warm construction
In a warm roof construction, the thermal insulation (by others) is located on top of a high performance vapour control layer over the roof decking. The construction is referred to as a warm roof because in winter with adequate heating, the temperature of the vapour control layer, and of the materials below it, is maintained close to that of the internal air. It may not be necessary to include a vapour control layer at ceiling level or to ventilate the roof cavities. Consideration should be given, however, to the provision of vertical vapour control layers as necessary, e.g. the use of Gyproc duplex grade plasterboards in roof voids between rooms, to reduce the movement of vapour to adjacent rooms, which may be at different temperatures. Refer to figure 32 – ‘Timber flat roof, warm type’ (page 247).
Thermal insulation
System design principles

29. Surface condensation

Outside

Inside

High vapor resistance surface
Surface at or below the dewpoint

Warm moist air
Cold air

30. Interstitial condensation

Outside

Inside

Low vapor resistance surface
Low vapor resistance surface

lower vapor pressure
higher vapor pressure

31. Timber flat roof, cold type

Built-up felt (or similar) with solar reflective finish
Timber roof decking
Cross-ventilated roof cavities
ISOVER insulation
12.5mm Gyproc WallBoard Duplex

32. Timber flat roof, warm type

Built-up felt (or similar) with solar reflective finish
Insulation (by others)
Timber roof decking
12.5mm Gyproc WallBoard Duplex