Technical performance and principles of system design

Building acoustics

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 this 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. In the domestic situation, a noisy neighbour can be one of the main problems experienced in attached housing. 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 usage. Retrofitted remedial measures taken after occupation can be expensive and inconvenient.

Ideally, the sound insulation requirements of the building should take into account both internal and external sound transmission. The term 'building acoustics' embraces sound insulation and sound absorption. These two functions are distinct and should not be confused. See - 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). In designing for sound insulation, it is important to consider both methods of transmission. The walls or floors, which flank the dividing element, constitute the main paths for flanking transmission, but this can also occur at windows, cooling or ventilation ducts, doorways, etc.

The acoustic environment of the room and / or the building and the ability to reduce or eliminate air paths in the vicinity of the sound reducing element, e.g. doorsets, glazing, suspended ceiling cavities, ductwork, etc, will have a significant effect on its performance. For these reasons it is unlikely that figures quoted from laboratory test conditions will be achieved in practice. When the background noise is low, consideration may have to be given to a superior standard of sound insulation performance in conjunction with the adjoining flanking conditions. In any existing sound insulation problem, it is essential to identify the weakest parts of the composite construction.

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. See **Figure 2 - Common flanking paths.**

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 acoustic 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, other wise site sound insulation values may not meet the performance criteria required and expensive remedial treatment may be required.

Small openings such as gaps, cracks or holes will conduct airborne sound and can significantly reduce the sound insulation performance. For optimum sound insulation a construction must be airtight.

Small gaps or air paths around perimeter Gypframe framework should be sealed using Gyproc Sealant. At the base of the partition, gaps may occur, particularly when boards are lifted tight to the ceiling. Gaps greater than 5mm can be bulk filed at the finishing stage using Gyproc Jointing Compound.

Deflection head details – acoustic performance

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. The approach shown in **Figure 3a - Deflection head A** could, for example, result in a loss of around 4dB to 5dB due to air leakage, in addition to that loss due to flanking transmission, etc.

Where acoustic performance is a key consideration, steps can be taken to minimise this loss of performance. **Figure 3b - Deflection head B** shows the generally accepted method of achieving this and, provided that care is taken to ensure a tight fit between cloaking angle and lining board surface, the loss in performance can be significantly reduced. A loss in performance of around 1dB up to 2dB would be typical with this method. Other factors, such as flanking transmission through the structural soffit, can significantly affect the overall level of sound insulation. Therefore, to optimise sound insulation performance, other measures may need to be taken.

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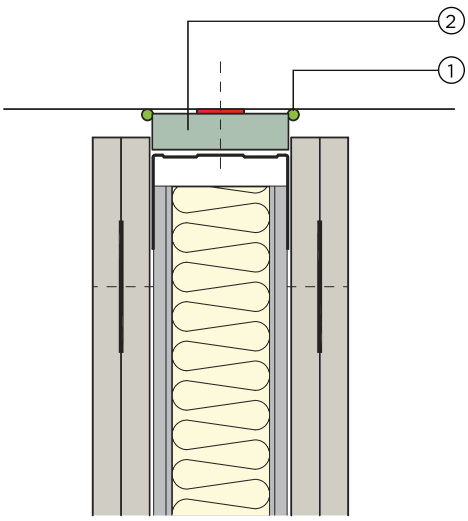
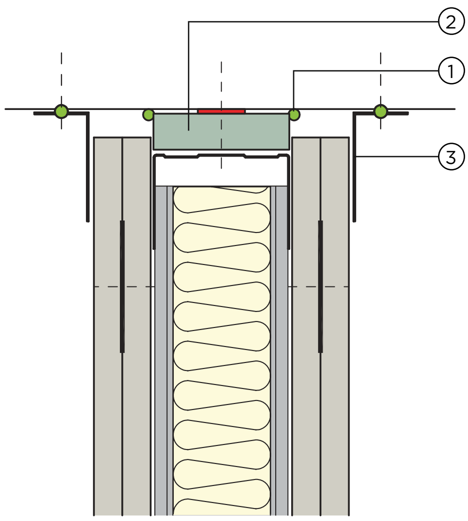
Common flanking paths

3a



Deflection head detail - A
(subject to fire performance)

3b



Deflection head detail - B
(subject to fire performance)

1. Gyproc Sealant for optimum sound insulation
2. Gyproc CoreBoard forming fire-stop
3. Gypframe GA4 Steel Angle to minimise loss of sound insulation performance due to air leakage

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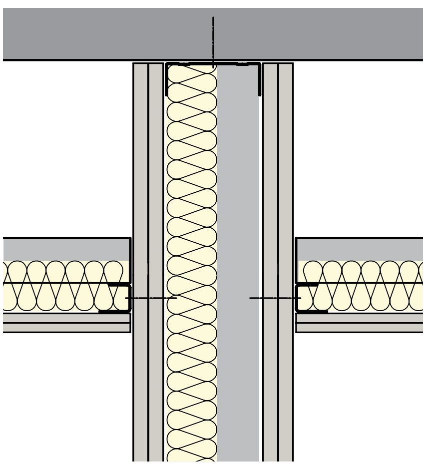
A suspended ceiling installed on both sides of the partition may provide a similar cloaking effect to that of steel angles. Gyproc MF incorporating imperforate plasterboard can deliver a similar reduction in air leakage at the partition head. A tight fit between the ceiling perimeter and the surface of the partition lining board is important, although mechanically fixed perimeters are not essential. Ceilings with recessed light fittings may be less effective and if these cannot be sealed in some way, the installation of cloaking angles at the partition head should be considered. A suspended ceiling may also reduce the level of sound flanking transmission via the soffit. Where perforated ceilings are used, e.g. Gyptone, the angles as shown in Figure 3b are recommended. However, if the distance between the ceiling and the deflection head is greater than 200mm and the ceiling plenum contained ISOVER Eco APR (minimum 25mm), then the angles may not be required.

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 porous to sound. Where sound insulation is important, partitions should, wherever possible, continue through the ceiling to the structural soffit and be sealed at the perimeter junctions. 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. Gyproc plasterboard suspended ceilings offer better insulation where partitions must stop at ceiling level to provide a continuous plenum, and in this instance an option is to include a cavity barrier above the ceiling line.

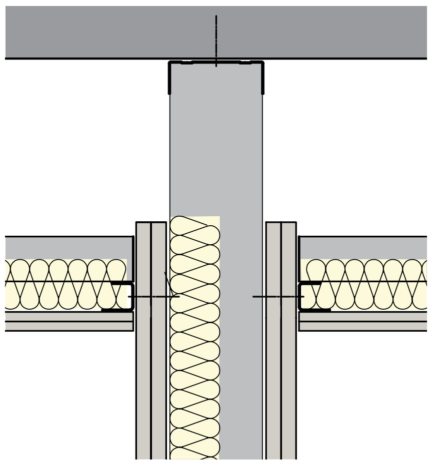
Figure 4a-4d - Performance of typical ceiling / partition junctions showing the different levels of flanking effect for typical ceiling / high performance partition junctions. The best result is achieved by running the partition through to the structural soffit.

4a



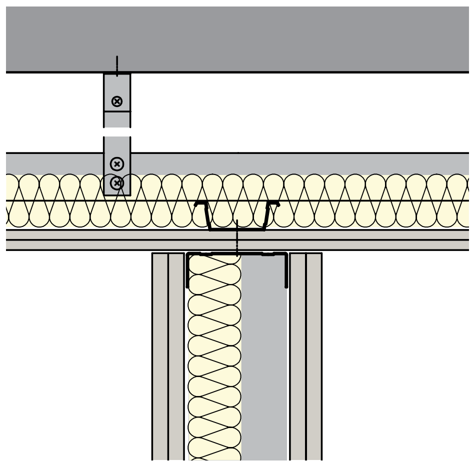
Partition lining continued to the soffit enabling the full potential of the partition to be achieved = 58dB

4b



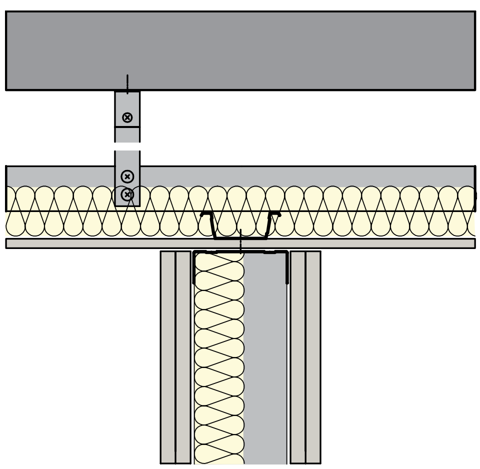
Concealed grid detail lined with a double layer of plasterboard within each room and overlaid with insulation = 56dB

4c



Concealed grid detail lined with a double layer of plasterboard and overlaid with insulation = 49dB

4d



Concealed grid detail lined with a single layer of plasterboard and overlaid with insulation = 48dB

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Building acoustics

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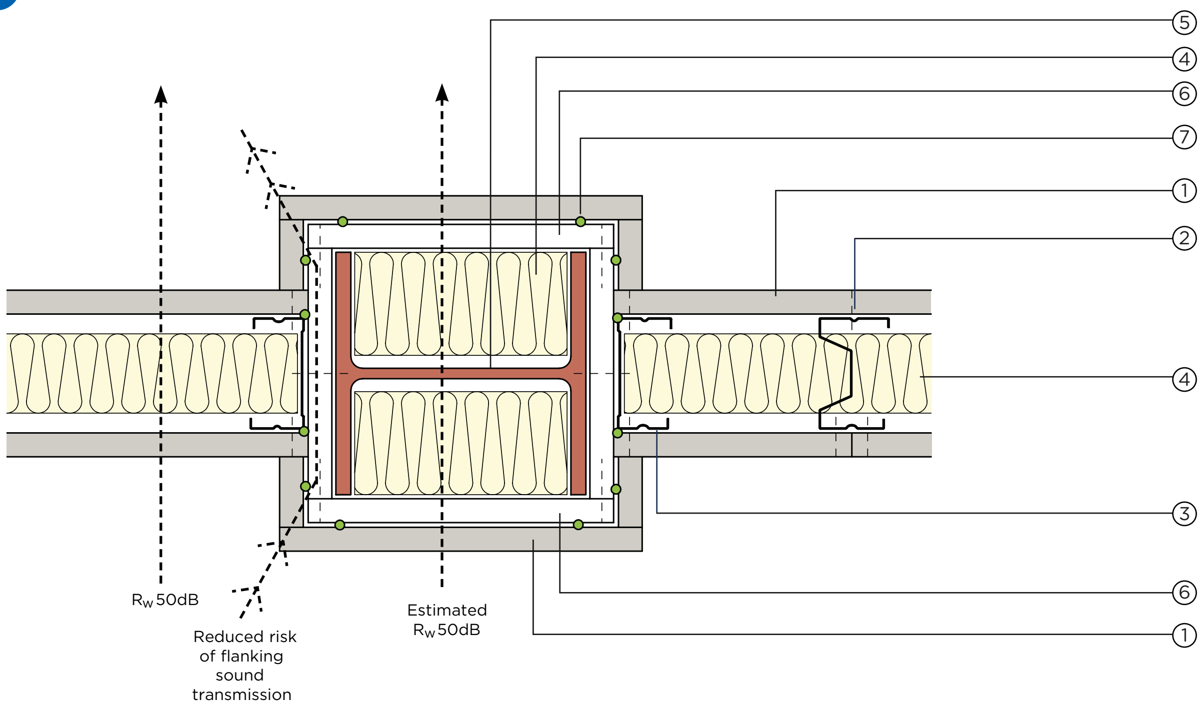
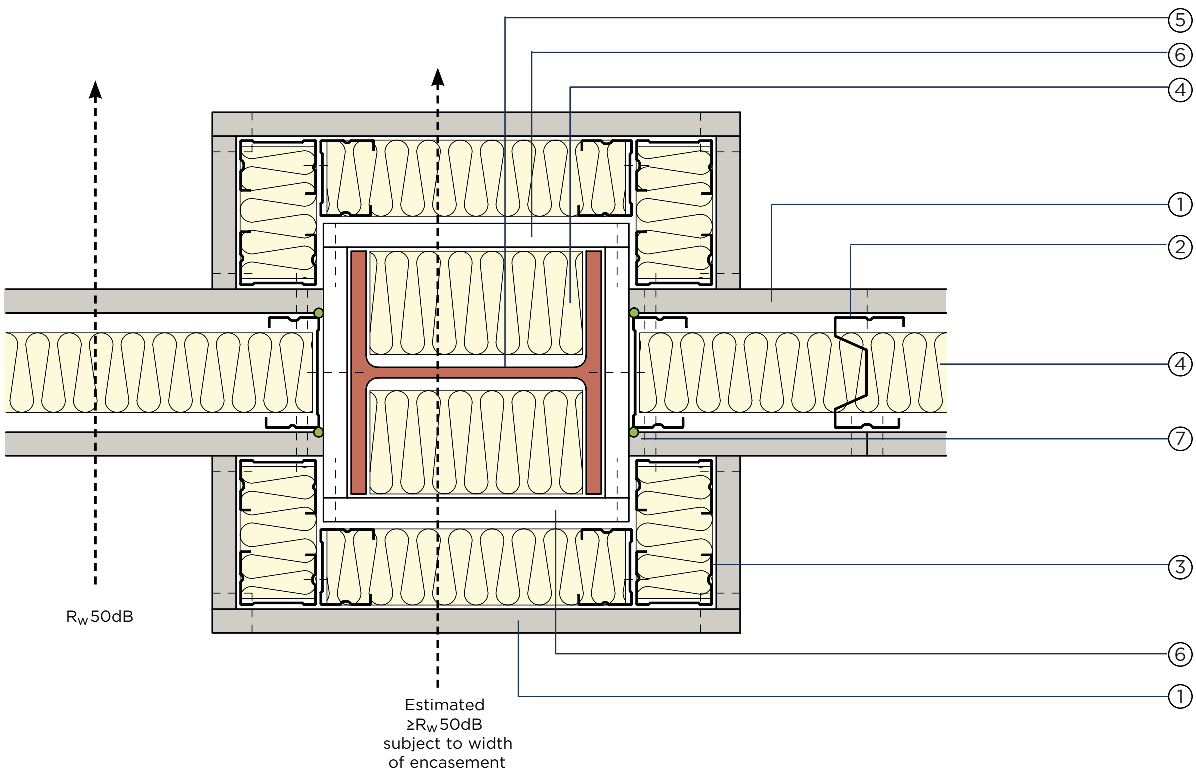


Encased steel column with additional plasterboard lining

6



Encased steel column with additional framing, insulation and plasterboard lining

1. Gyproc DuraLine
2. Gypframe AcouStud
3. Gypframe 'C' Stud
4. ISOVER Eco APR
5. Structural steel
6. Glasroc F FIRECASE - for fire protection of structural steel
7. Gyproc Sealant

Technical performance and principles of system design
Building acoustics

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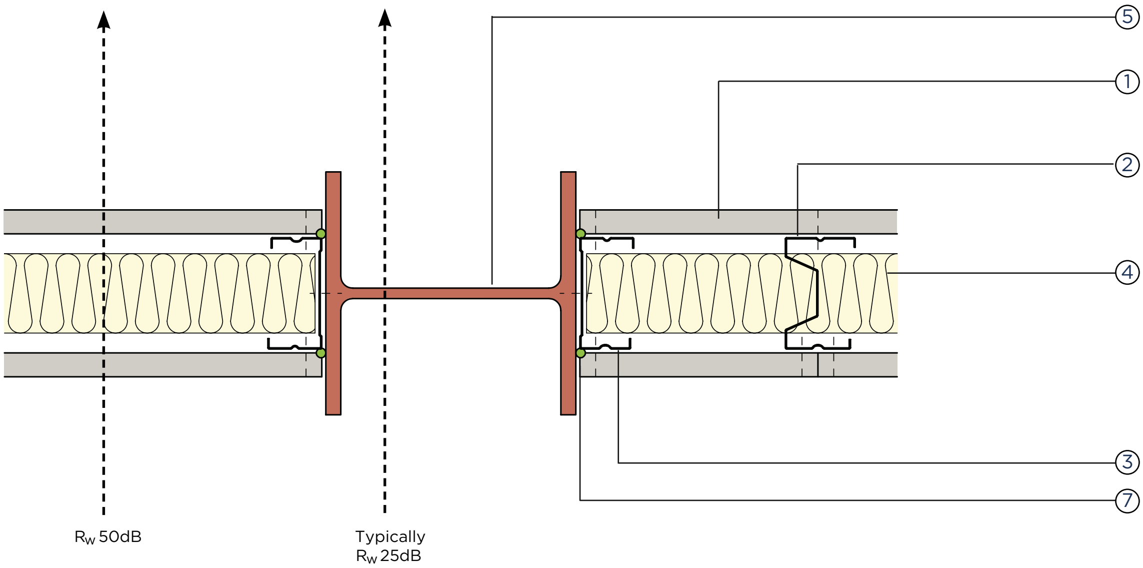
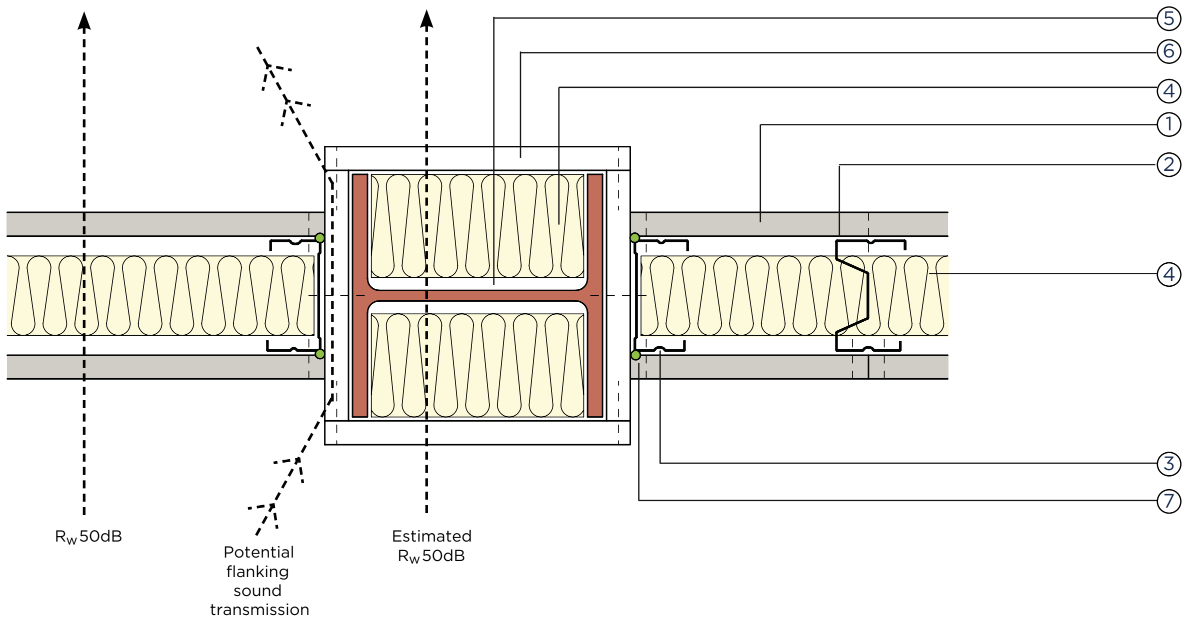


Exposed / painted steel column

8



Encased steel column

1. Gyproc DuraLine
2. Gypframe AcouStud
3. Gypframe 'C' Stud
4. ISOVER Eco APR
5. Structural steel
6. Glasroc F FIRECASE - for fire protection of structural steel
7. Gyproc Sealant

Technical performance and principles of system design

Building acoustics

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 it, e.g. a door within a partition. Where the difference between sound insulation is relatively small (7dB or less) there needs to be a comparatively large area of the lower performing element, eg. door, before the overall sound insulation is significantly affected. A greater difference in sound insulation between the two elements normally results in a greater reduction of overall sound insulation performance.

Figure 9 - Composite calculation chart can be used to calculate the net mean sound insulation of composite partitions, e.g. a window in a partition. The correct mean sound insulation value for each part of the partition must be known in order to calculate the difference. This difference, read off on the curved line against the appropriate ratios on the vertical scale, gives the loss of insulation in dB on the horizontal scale. This figure is subtracted from the value of the part with the higher resistance to obtain the net sound insulation of the partition. Figure 9 may also be used to assess the effect of gaps or holes in a partition by giving a sound insulation value of 0dB to the aperture.

Example
Difference between insulation values of 30dB with ratio of areas (vertical scale) equal to 1:4. Loss of insulation (horizontal scale) = 23dB. Therefore, if the two parts had mean sound insulation values of 15dB and 45dB respectively, the net sound insulation of the partition would be only 22dB, i.e. 45dB - 23dB = 22dB.

9

How to calculate the overall sound insulation of a partition that includes a door or window

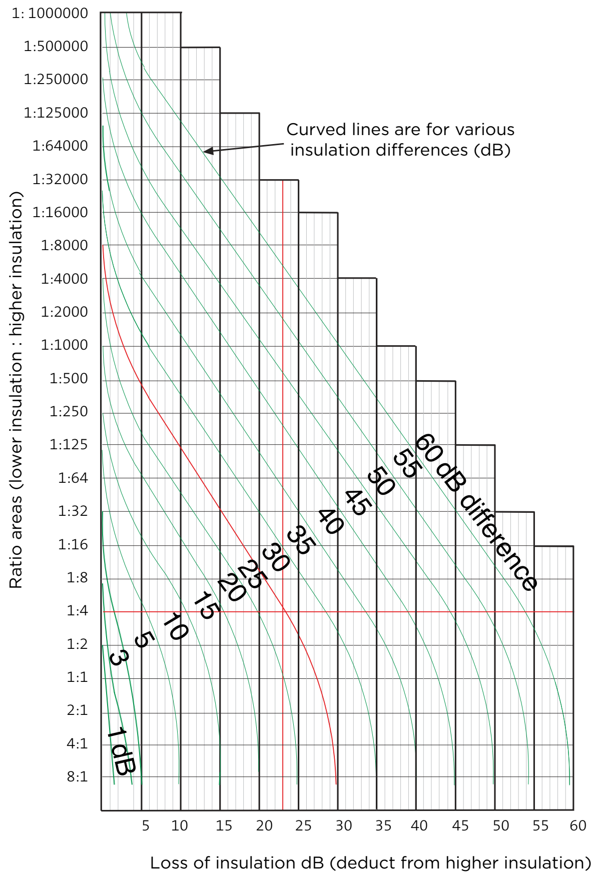


Table 1 shows the acoustic effect on a range of partitions when various types of door are installed. It can be seen that if a poor performance door is included in a partition, it does not matter if the wall achieves 25dB or 50dB sound insulation as the net performance will never be better than 27dB. The lowest performing element will always dominate the overall performance.

Table 1 - Effect of including various door types within a partition system

Door construction	Mean sound insulation of partition alone (dB)					
	25	**30**	**35**	**40**	**45**	**50**
	Mean sound insulation of partition with doorways accounting for 7% of area (dB)					
Any door with large gaps around the edge	23	25	27	27	27	27
Light door with edge sealing	24	28	30	32	32	32
Heavy door with edge sealing	25	29	33	35	37	37
Double doors with a sound lock	25	30	35	40	44	49

Technical performance and principles of system design

Building acoustics

Acoustic privacy

Two main factors affect the level of acoustic privacy achieved when designing a building:

- The sound insulation performance of the structure separating the two spaces.
- The ambient background noise present within the listening room.

The ambient background noise level can be a useful tool when designing buildings, as it is possible to mask speech from an adjacent space and hence provide enhanced speech confidentiality. There are a number of commercially available systems for achieving this and the technique is referred to as acoustic perfume or masking. It is, however, more common to treat the problem by specifying appropriate levels of sound insulation. A guide to sound insulation levels is given in **Table 2**.

Table 2 - Guide to sound insulation levels for speech privacy

Sound insulation between rooms R_w	Speech privacy
25dB	Normal speech can be overheard
30dB	Loud speech can be heard clearly
35dB	Loud speech can be distinguished under normal conditions
40dB	Loud speech can be heard but not distinguished
45dB	Loud speech can be heard faintly but not distinguished
> 50dB	Loud speech can only be heard with great difficulty

Specialist advice on acoustic privacy issues specifically for healthcare and educational environments can also be provided by contacting the Gyproc Technical Team. When designing for residential purposes, the standards of sound insulation given in **Table 2** are not adequate for separating walls as other sources of generated sound are often evident.

Ambient noise levels

Along with acoustic privacy, the level of sound energy acceptable within a room should be assessed with regards to intrusive noise levels and the level of potential noise likely to be generated within the room itself. For this purpose there are a number of methods, including the Noise Rating (NR) system. This rating quantifies the level of noise present within a space taking into account break-in of noise from the adjacent areas and also the background noise present within the space from ventilation or other building services. **Table 3** gives the recommended maximum noise within different activity spaces using NR criteria.

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

Situation	NR criteria (dB)
Sound studios	15
Concert halls, large theatres, opera houses	20
Large auditoria, large conference rooms, TV studios, hospital wards, private bedrooms, music practice rooms	25
Libraries, hotel rooms, courtrooms, cinemas, medium-sized conference rooms	30
Classrooms, small conference rooms, open-plan offices, restaurants, public rooms, operating theatres, nightclubs	35
Sports halls, swimming pools, cafeteria, large shops, circulation areas	40
Workshops, commercial kitchens, factory interiors	45

The 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.

Where control of ambient noise is critical, advice should be sought from an acoustic consultant.

Sound Insulation – rating methods

The sound insulation rating methods that follow are defined in European literature:

R_w

This single figure rating method is the rating used for laboratory airborne sound insulation tests. The figure indicates the amount of sound energy being stopped by a separating building element when tested in isolation in the absence of any flanking paths. The acoustic range as per BS EN ISO 717-1 is 100 Hz – 3150 Hz.

R'_w

R'_w is the apparent sound reduction index and gives the airborne sound insulation performance between two adjacent rooms within a building as measured on site taking into consideration the reverberation time of the receiving room.

D_{nTw}
The single figure rating method that 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
The C adaptation term is a correction that can be added to the R_w rating. The C term is used because it targets the middle frequency performance of a building element. The rating R_w+C may also be defined as RA.

C_{tr}
The C_{tr} adaptation term is a correction that can be added to either the R_W (laboratory) or D_{nTw} (site) airborne rating. The C_{tr} term is used because it targets the low frequency performance of a building element and in particular the performance achieved in the 100 - 315 Hz frequency range. This term was originally developed to describe how a building element would perform if subject to excessive low frequency sound sources, such as traffic and railway noise. Some of the performance tables in this book present relevant sound insulation values both in R_W terms but also in the C_{tr} adapted form. This rating is expressed as $R_W + C_{tr}$ and allows the acoustic designer to critically compare performances. The rating method has not been universally welcomed. Some acousticians believe that the method is too crude as it only considers the low frequency performance, and because site measurements at low frequencies are prone to difficulties, which can lead to a lack of confidence in the results achieved. Consequently, within separating constructions, Gyproc can offer enhanced specifications that meet the low frequency performance of the C_{tr} rating whilst also offering good mid and high frequency sound insulation.

L_{nw}
This single figure rating method is the rating used for laboratory impact sound insulation tests on separating floors. The figure indicates the amount of sound energy being transmitted through the floor tested in isolation, in the absence of any flanking paths. With impact sound insulation, the lower the figure the better the performance.

L_{nTw}
The single figure rating method that is used for impact sound insulation tests for floors. The figure indicates the sound insulation performance between two adjacent rooms within a building as measured on site. The result achieved is affected not only by the separating floor but also by the surrounding structure, e.g. flanking walls and associated junction details.

D_{nfw} / D_{ncw}
The single figure laboratory rating method BS EN ISO 717 - 1 that is used for evaluating the airborne sound insulation performance of suspended ceilings. Laboratory tests simulate the room-to-room performance of the suspended ceiling when a partition is built up to the underside of the ceiling with sound transmitted via the plenum.

The sound insulation rating methods that follow are defined in American literature:

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

The frequency range differs from the European figure as it starts from 125 Hz – 4000 Hz which provide different average values less focused on low frequencies.

ASTC / FSTC
This single figure rating method that 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.

IIC
This single figure rating method is the rating for laboratory impacts sound insulation tests on separating floors. The higher the impact insulation class is, the better the acoustic insulation will be.

CAC
A single figure laboratory rating for the performance of a ceiling system as a barrier to airborne sound transmission through a common plenum between adjacent closed spaces in accordance with ASTM E1414.

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 about 4dB, the mass must be doubled. This is known as the empirical mass law.

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

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Figure 10 - 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 when satisfying acoustic design requirements and that lightweight systems, if correctly designed, can provide very effective acoustic solutions.

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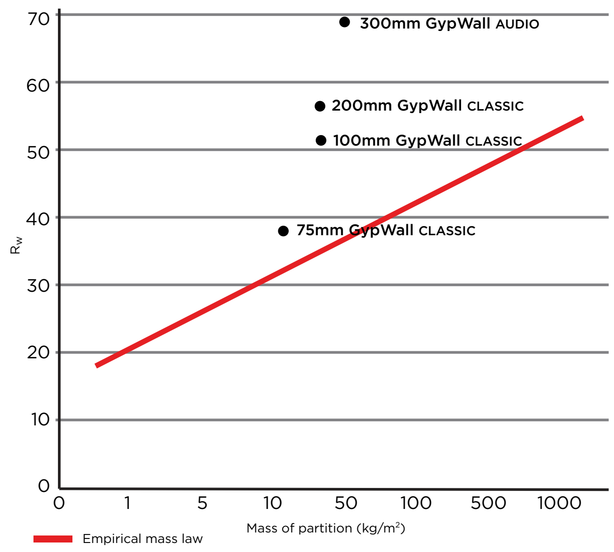

Acoustic performance is commonly expressed as a decibel (dB) value. The logarithmic scale of decibels provides a simple way to cover a large range of values and show them as a convenient number. Unfortunately the decibel scale can create confusion especially when comparing alternative systems as the 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 R_w 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 using a flexible mounting system, such as Gypframe RB1 Resilient Bar, sound transmission through the framing 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.

Two important effects; resonance and coincidence, occur in partitions and walls. These are governed by physical properties such as density, thickness and bending stiffness, and can result in a reduction in sound insulation at certain frequencies.

In lightweight cavity constructions, resonance and coincidence effects can be decreased by the use of two or more board layers. A simple way of increasing the sound insulation performance of a single layer metal stud partition is to add an additional layer of plasterboard to one, or both sides. This will increase the sound insulation performance by approximately 6dB or 10dB respectively.

Designing for on-site performance

Achieving a D_{nTw} + C_{tr} performance on site

The C_{tr} rating method puts increased emphasis 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 less than 60mm should be avoided. Two matched 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 needs to be used, then 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. See **Figure 11 - Optimum design of panel linings for C_{tr}.**

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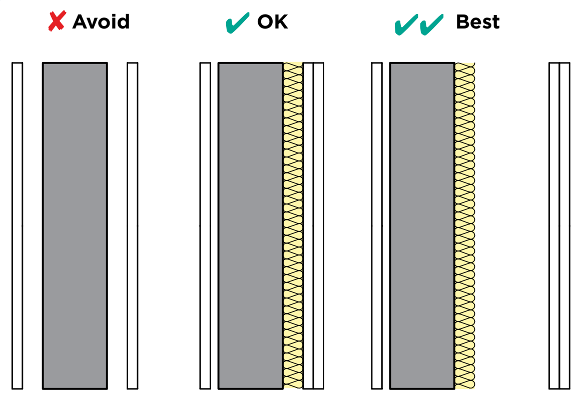

Matched cavities less than 60mm to be avoided

If space restrictions limit the cavity size then install one side only, ensure glass mineral wool is used in the cavity and use a double layer of plasterboard

Single cavity as large as possible (preferably greater than 85mm), lined with a double layer of plasterboard and glass mineral wool included in the cavity

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To increase the sound insulation of new or existing masonry walls, GypLyner systems can be used in conjunction with ISOVER Eco APR insulation and the metal framing should be lined with plasterboard. The cavity depth for the GypLyner lining should be as large as possible, and small matched cavities either side of the wall should always be avoided.

For lightweight separating floors it may be necessary to have an imperforate plasterboard ceiling that is partially de-coupled from the floor structure, e.g. Gyproc MF Ceiling system.

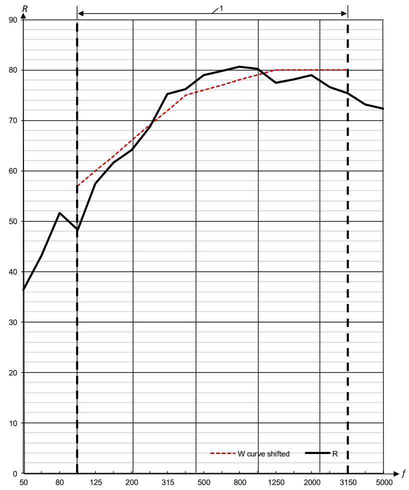
Inappropriate detailing of flanking conditions can greatly reduce the level of performance of the system from that achieved in the laboratory. For separating wall and floor constructions to be fully effective, care must be taken to correctly detail the junctions between the separating wall or floor and 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 the required performance criteria may not be achieved in practice. For good practice detailing, please refer to the construction details sections from the relevant system sections within this book, available to download from **www.gyproc.ae**

Typical test report for a sound airborne insulation test

Source Room

Receiving Room

Frequency f Hz	R one-third octave dB
50	36.4
63	43.2
80	51.6
100	48.3
125	57.5
160	61.6
200	64.1
250	68.7
315	75.2
400	76.2
500	79.0
630	79.8
800	80.6
1000	80.2
1250	77.5
1600	78.1
2000	78.9
2500	76.6
3150	75.4
4000	73.1
5000	72.3



R sound reduction index, in dB f frequency, in Hz

1 frequency range for rating in accordance with the curve of reference values (ISO 7171-)

Rating in accordance with ISO 7171:2013-:
R_w (C;C_{tr}) = 76 (-3;-9) dB

$C_{503150-}$ = **-4 dB** $C_{505000-}$ = **-5 dB** $C_{1005000-}$ = **-3 dB**

Evaluation based on laboratory measurements results obtained by an engineering method:
$C_{tr,503150-}$ = **-17 dB** $C_{tr,505000-}$ = **-17 dB** $C_{tr,1005000-}$ = **-9 dB**

Rating in accordance with ASTM E413 - 16:
STC = 76 dB

On site testing may expose poor flanking details and inadequate separating wall and floor specifications. Therefore good flanking detailing and specifications that provide a reasonable margin of safety on site are essential.

A method of predicting the site D_{nTw} + C_{tr} performance achievable from a system is to refer to a laboratory R_W + C_{tr} rating. When looking at the difference between R_W + C_{tr} and D_{nTw} + C_{tr}, a minimum drop of 5dB is typical depending on the wall specification, however Gyproc recommend that a safety margin of + 9dB should be built in to reduce the risk of failure through on site workmanship and/or poor detailing.

D_{nTw}
Similar to D_{nTw} + C_{tr}, a realistic safety margin should be incorporated to reduce the risk of failure. Gyproc recommend a safety margin of + 7dB when comparing site performance (D_{nTw}) to laboratory performance (R_W). For example, to comply with a requirement of D_{nTw} 56dB, a system capable of achieving R_W 63dB under laboratory conditions should be specified.

$L_{nT,w}$
A minimum drop of 5dB is typical when comparing site performance ($L_{nT,w}$) to laboratory performance (L_{nw}). When designing separating floors, an improved performance is achieved when de-coupling of the walking surface from the structural floor slab is implemented, when normally a resilient layer of Ethafoam / neoprene or similar gasket is laid below an upper sand and cement screed. In addition to a de-coupling of the ceiling, e.g. Gyproc MF ceiling, a much reduced risk of impact sound flanking transmission into and down the flanking walls and surrounding structure is now achieved.

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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 and 92mm wall systems.

Figure 12 shows the performance improvement possible using acoustic stud technology compared with a standard 'C' stud of the same cavity dimension.

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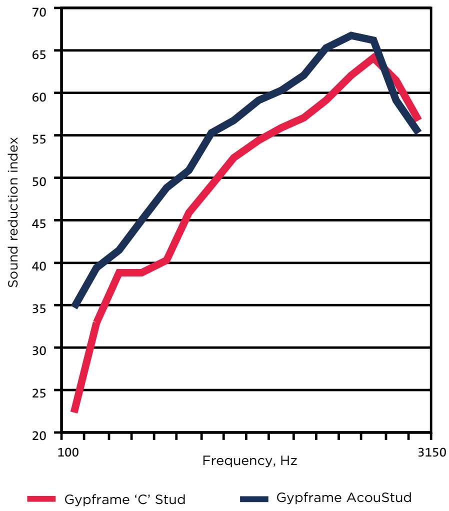
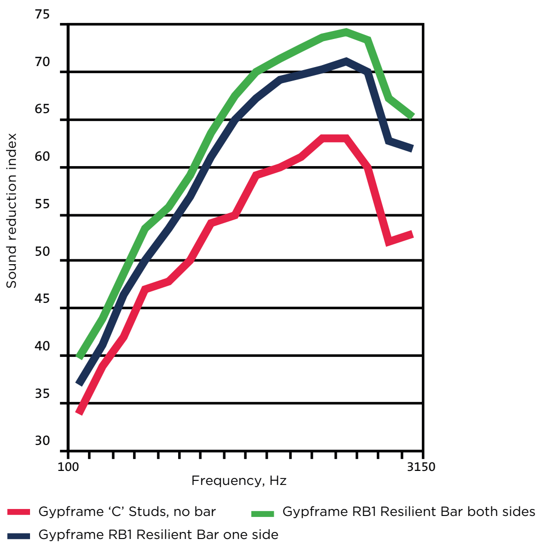


GypWall QUIET SF
GypWall QUIET SF utilises Gypframe RB1 Resilient Bars to partially de-couple the plasterboard linings from the partition stud frame, leading to enhanced levels of sound insulation.

Figure 13 shows the improvements possible when including Gypframe RB1 Resilient Bar on one or both sides of a standard Gypframe 70mm 'C' Stud partition.

13



GypWall AUDIO
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 14 shows the difference achievable by using a twin framed wall approach as opposed to a standard GypWall CLASSIC 'C' stud partition. The plasterboard linings and insulation are the same for both partitions and the key difference is the overall partition thickness – typically 212mm 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

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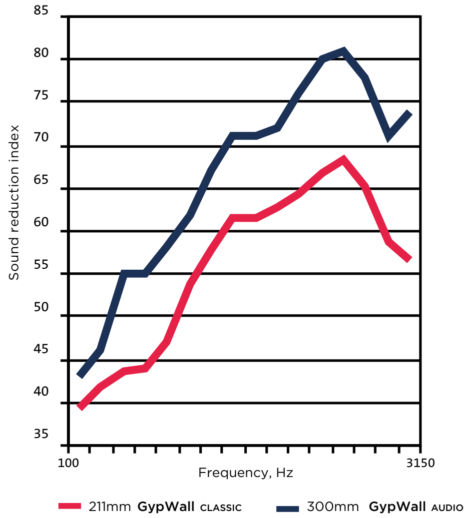

Floating floor treatment
Floating floor treatments are used with both lightweight and concrete separating floors to de-couple the walking surface from the floor structure and thereby improve both the airborne and impact sound insulation performance of a separating floor.

The value of this technique is recognised in Robust Details, and is currently featured in a number of separating floor solution.

Sound insulating drylinings
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 Gyproc partition is constructed in a masonry building. Care should be taken to ensure that the abutting structure is able to achieve the level of sound insulation required when flanking another wall or partition.

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

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

Sound absorption

Sound absorption is the term given to the loss of sound energy on interaction with a surface. Sound absorbent surfaces are used to provide the correct acoustic environment within a room or space. The choice of material will be influenced by its acoustic efficiency, appearance and durability. By converting some of the sound energy into heat, sound absorbing materials will also help sound insulation because less noise will be transmitted to other rooms. However, this reduction in noise is very small when compared with the potential reduction due to sound insulation. Sound absorption is therefore never a substitute for adequate sound insulation.

Reverberant energy
Reverberation is the persistence of sound in a particular space after the original sound is removed. A reverberation, or reverb, 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. Some typical reverberation times are given in **Table 4.**

Table 4 - Typical reverbertion times

Type of room / activity	Reverberation time (mid frequency)
Swimming pool	<2.0 seconds
Dance studio	<1.2 seconds
Large lecture theatre	<1.0 seconds
Small lecture room	<0.8 seconds
Primary school playroom	<0.6 seconds
Classroom for hearing impaired	<0.4 seconds

Reverberation time (T, T60 or RT)
The time it takes for the sound pressure level to fall by 60dB after the sound has been turned off. Measuring the reverberation time allows us to calculate the total sound absorption. The reverberation time varies according to the frequency.

Speech clarity
Speech clarity (intelligibility) is now recognised as essential in helping pupils in an educational environment to achieve their full potential. For further information please contact the Gyproc Technical Team.

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 15** - Sound transmission in a typical classroom. 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.

Clarity measurement
The Clarity measurement (C50) compares the sound energy in early sound reflexes with those that arrive later. It is expressed in dB. A high value is positive for speech clarity.

Sound absorption rating methods
The following ratings are calculated in accordance with BS EN ISO 11654: 1997.

Sound absorption coefficient, α_s
Individual sound absorption figures quoted in 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, α_p
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.

The absorption diagrams here show the practical sound absorption coefficient, α_p in accordance with the international standard BS EN ISO 11654: 1997.

The same standard defines the weighted sound absorption single value, α_w and the sound absorption classes, which are provided for the products in this publication.

The absorption classes are designated A-E, where absorption class A has the highest sound absorption. Overall depth of the system (o.d.s) must always be stated for a given absorption class.

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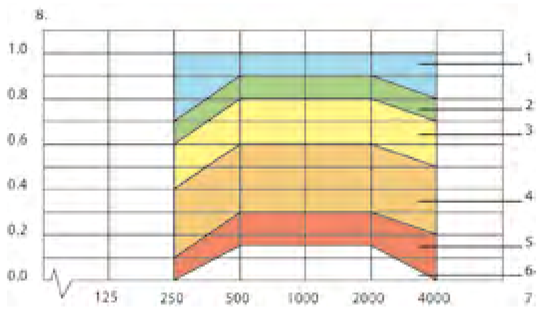
The ASTM standard C423 specifies two different single values, the NRC (Noise Reduction Coefficient) and the SAA (Sound Absorption Average).

Both values are calculated as an average over the frequency ranges (250-2000 Hz and 200-2500 Hz respectively).

TABLE 5 - Absorption classes



Acoustic graph illustrated by Saint-Gobain Ecophon

1. Absorption class A
2. Absorption class B
3. Absorption class C
4. Absorption class D
5. Absorption class E
6. Unclassified
7. Frequency Hz
8. α_p Practical absorption coefficient

Sound absorption class	α_w
A	0.90, 0.95, 1.00
B	0.80, 0.85
C	0.60, 0.65, 0.70, 0.75
D	0.30, 0.35, 0.40, 0.45, 0.50, 0.55
E	0.15, 0.20, 0.25
Unclassified	0.00, 0.05, 0.10

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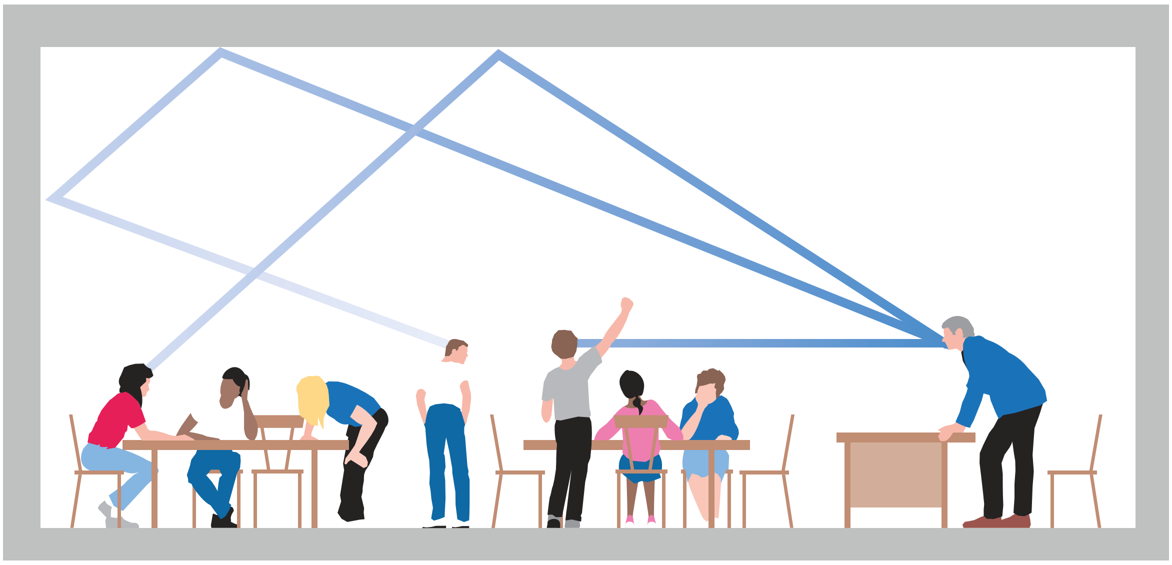

Sound transmission in a typical classroom

Weighted Sound Absorption Rating, α_w

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. See **Figure 16 - Typical test data sheet for a sound absorption test**.

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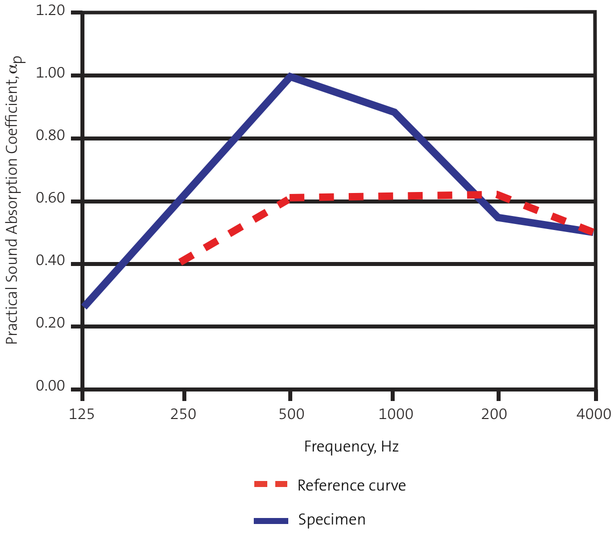
Test code: R13402AA

Freq. H	Ref. curv	Specimen
125		0.25
250	0.40	0.60
500	0.60	1.00
100	0.60	0.90
200	0.60	0.55
400	0.50	0.50

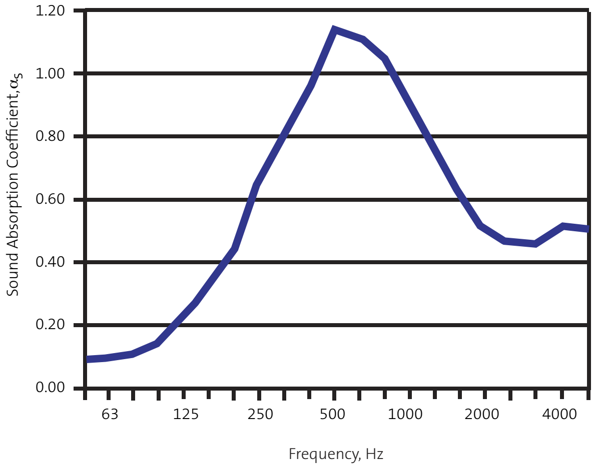


Rating and Sound absorption class according to

EN ISO 11654: 1997 α_W = 0.60 (M) Class = C

It is strongly recommended to use this single figure rating in combination with the complete sound absorption coefficient curve.

Freq. Hz	α_s
50	0.10
63	0.10
80	0.12
100	0.16
125	0.24
160	0.35
200	0.44
250	0.63
315	0.80
400	0.96
500	1.15
630	1.12
800	1.04
1,000	0.89
1,250	0.76
1,600	0.62
2,000	0.52
2,500	0.46
3,150	0.45
4,000	0.51
5,000	0.50
6,300	
8,000	
10,000	



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Sound absorption treatments are referenced within some international regulatory documents, such as Approved Document E (AD E), Health and Technical Memorandum HTM 08-01 Acoustics - Healthcare Buildings and Building Bulletin 93 (BB93) to control the noise levels generated within common areas of residential and educational buildings, e.g. entrance halls, lobbies, corridors, stairs and landings. AD E specifies sound absorption in terms of a class of absorber. The values ascribed to the different classes are given in **Table 5**, according to BS EN ISO 11654: 1997, including frequencies 200-5000 Hz.

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 according to ASTM C423, derived as the mean value of 4 frequencies in the range 250-2000 Hz; 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 α_w rating should be used.

Useful reference documents covering international legislation and guidance

Building Regulations Approved Document E (AD E) – Residential Buildings
Many of the regional authorities make reference to the national building regulations of the UK covering the resistance to the passage of sound – AD E gives guidance on providing a reasonable level of sound insulation between dwellings and offers suggested forms of separating construction. These forms of construction do not, however, guarantee that the required performance level will be achieved in practice. Ultimately the developer needs to demonstrate that the dwelling, when built, meets the performance levels set by means of Pre-Completion Testing.

AD E sets performance levels for the following areas of a residential building:

- The common areas – ie lobbies or reception areas of buildings that contain apartments or rooms for residential purposes should have an area equal to or greater than the floor area covered with a Class C absorber or better. An alternative calculation method is given with AD E.
- For stairwells or a stair enclosure in buildings containing apartments or rooms for residential purposes, an area equal to the surface area of the stair and landings, plus the ceiling area of the top floor, must be covered with an equal area of Class D absorber or alternatively 50% of the area must be covered with a Class C absorber or better.

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

Where applicable	Minimum airborne sound insulation $D_{nT,w} + C_{tr}$ (site test result)	Maximum impact sound transmission $L_{nT,w}$ (site test result)	Minimum airborne sound transmission R_w (laboratory test result)
Separating walls between new homes	45dB	-	-
Separating walls between purpose-built rooms for residential purposes	43dB	-	-
Separating walls between rooms created by a change of use or conversion	43dB	-	-
Separating floors between new homes and purpose-built rooms for residential purposes	45dB	62dB	-
Separating floors between rooms created by a change of use or conversion	43dB	64dB	-
Internal wall without a door between a bathroom, or WC, and a habitable room	-	-	40dB
Internal wall without a door between a bedroom and another room within the dwelling	-	-	40dB
Internal floor	-	-	40dB

Robust details
There are two methods of demonstrating that separating elements as defined within AD E will meet the requirements as set by the standard. The first option would be to employ pre-completion testing prior to hand over, typically one in ten units, that demonstrate compliance to the standard.

The second option would be to design to Robust Details. Where designers are looking for guidance in specifying suitable constructions to meet the requirements of AD E, then they can make reference to this catalogue of details that are approved by the UK government for construction without the need for pre-completion testing. Robust details are designed to give an improved safety margin over constructions that are typically used to allow for flanking and site installation issues.

Further information can be found at www.robustdetails.com

BS 8233 - Guidance on Sound insulation and noise reduction for buildings
Code of practice setting out acoustic ratings appropriate to a variety of different building types.

BB93 - Building Bulletin 93: Acoustic design of schools
Building Bulletin 93 contains acoustic design requirements for sound insulation between spaces, ambient noise levels and optimum reverberation times for various spaces within educational buildings. For more information contact the Gyproc Technical Team.

Health and Technical Memorandum HTM 08-01 Acoustics - Healthcare buildings
HTM 08-01 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. For more information contact the Gyproc Technical Team.