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Guidance and Recommendations
Acoustic Doorsets

ASDMA
Architectural & Specialist Door Manufacturers Association

Guidance and Recommendations
Acoustic Doorsets
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Doortech 2000

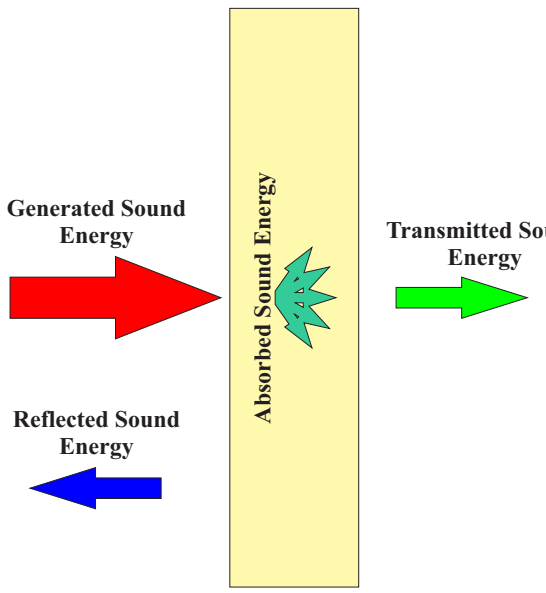
Acoustics Explained:

This document attempts to simplify what is an extremely complex subject. Where acoustic considerations are critical, reference should be made to qualified Acoustic Engineers.

'Acoustic' is a term that is used loosely in connection with doorsets. When considering the 'acoustics' of a room or space, acoustics relates to a number of considerations.

When sound is generated, the 'loudness' refers to sound pressure which is expressed in decibels 'dB'. When striking a surface, some sound will be reflected, some will be absorbed *(converted to heat)* and some will pass through the structure. Sound will also lose energy with distance in accordance with the inversed square law. ***(See Fig. 1).***

Sound Events *Fig. 1*

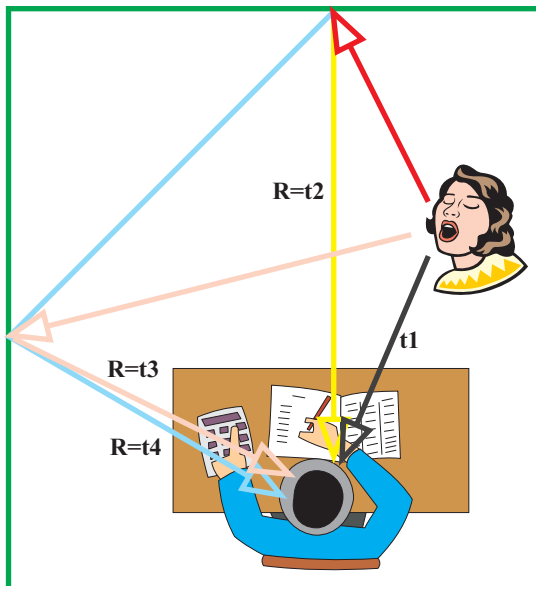


When the sound source is cut off *(or stopped)*, the residual *(reflected)* sound will continue to be heard until it decays to a level that cannot be heard. This is referred to as 'reverberation'.

The time taken for the sound pressure to drop by 60dB is measured. This loss of sound pressure, related to time is measured as a 'reverberation time'. If the time it takes for the sound pressure to be reduced by 60dB is less than 0.3 seconds the room will sound 'dead' with hearing made difficult due to an apparent loss of bass.

If the reverberation time is in excess of 5 seconds the reverberation *(or echos)* can give rise to confusion which again makes hearing difficult. The optimum reverberation times may vary according to the intended use of the space. A reverberation time of 1 second might be ideal for a lecture hall providing for clear speech but this might not be ideal for a concert hall where a reverberation time of up to 3.5 seconds would provide for fuller and richer musical sound. For 'general purpose' use Acoustic Engineers will generally try to 'tune' the space to provide for reverberation times between 1.5 ~ 2.5 seconds. *(See Figs. 2 & 3).*

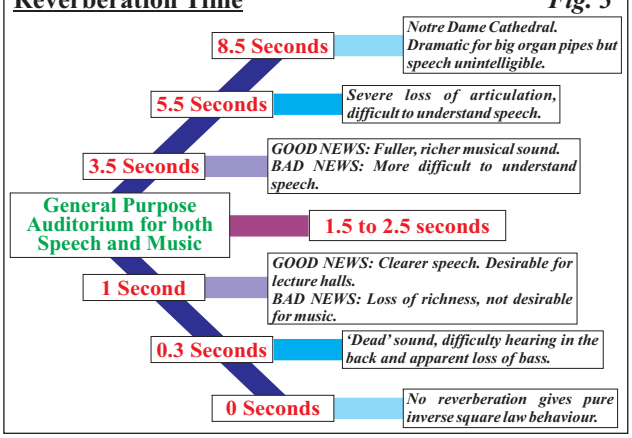
Reverberation *Fig. 2*



There will be a time delay between hearing the direct sound t1 and the reflected sounds t2, t3 and t4.

The reverberation times can be adjusted by the use of sound absorbers. i.e. by the use of materials that are less likely to reflect sound. Soft furnishings, carpet and curtains will provide for some sound absorbing properties. Mineral wool provides for a good example of a material that will readily convert sound energy into heat energy thus absorbing sound and consequently reducing the reflected sound. The performance of a sound absorber is measured by a 'coefficient of adsorption'.

Reverberation Time *Fig. 3*

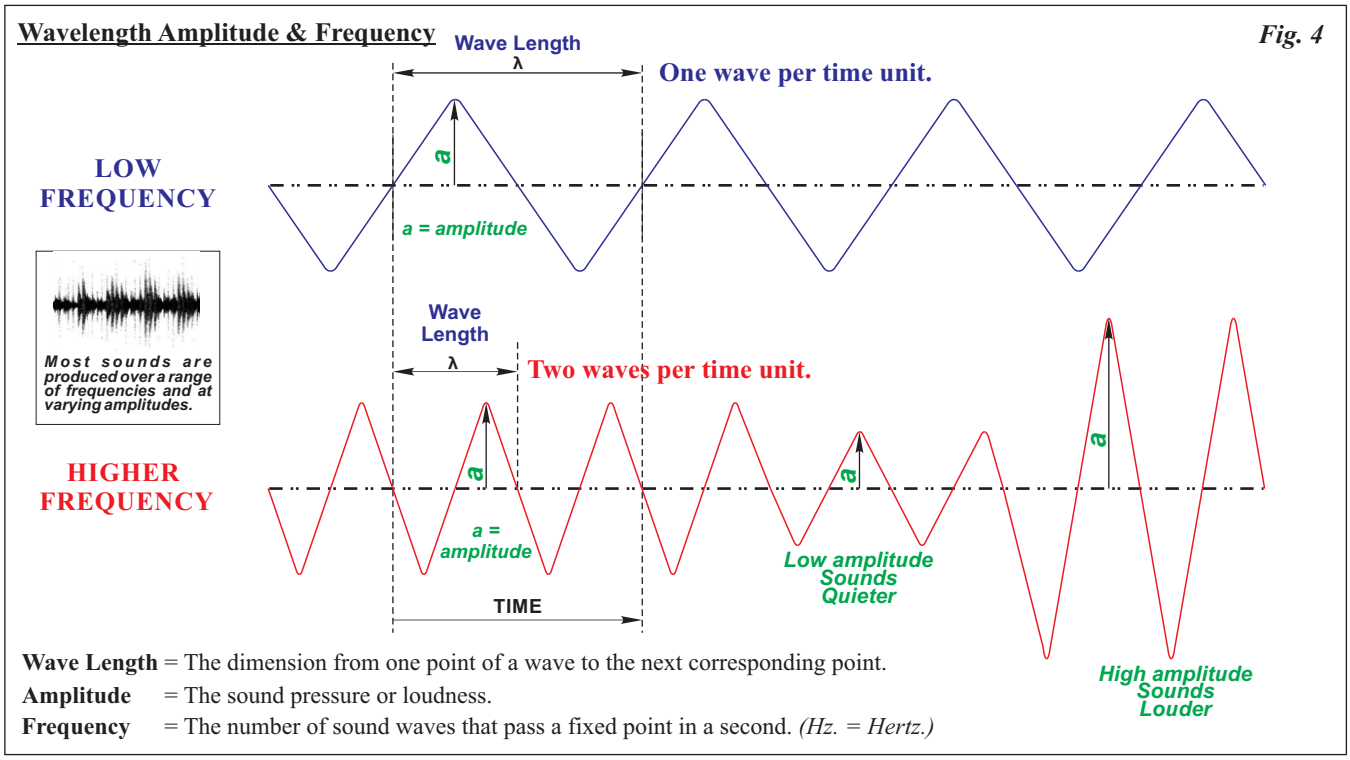


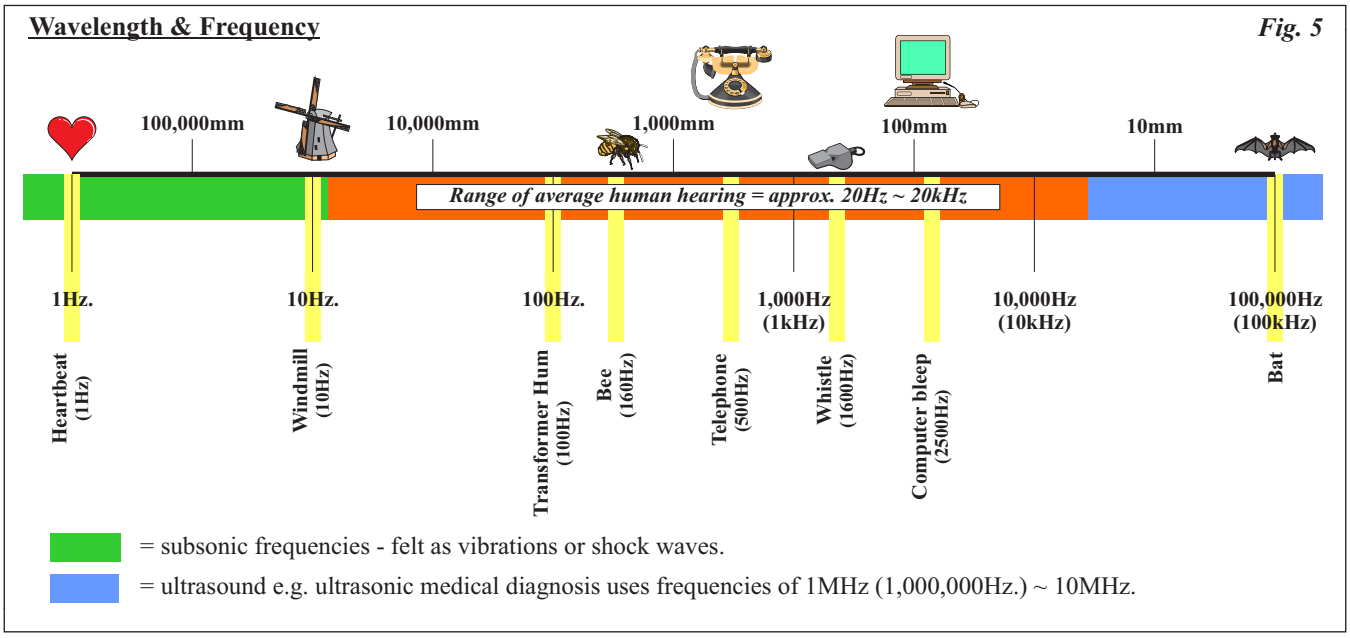
Acoustics Explained contd.:

The other issue of concern to Acoustic Engineers is the influence of sound created outside of the measured space and the ability of a structure to minimise the influence on a 'protected space' by preventing or reducing the transfer of external sound through a structure. This is referred to as 'sound attenuation' and it is the measure that generally applies to structures between spaces. e.g. walls, windows and doorsets. Thus, when referring to 'acoustic' doors we generally mean 'sound attenuating' doorsets.

Sound is generated at different frequencies. The 'frequency' is the number of sound waves that pass through a given point in a second and described in 'Hertz' *(Hz.)* where 1 hertz = one wave per second. Differences in frequency can be identified by a change of pitch. An example of a high frequency sound might be a computer bleep *(approx. 2,500Hz.)* while a low frequency sound might be the hum of an electrical generator *(approx. 100Hz.)*. Few sounds are made up of a pure single frequency. Sound is generally produced simultaneously over a range of frequencies. We might refer to the random structure of sound over a range of frequencies as noise, while sound produced over a range of frequencies in a structured manner might be referred to as speech or music.

Another consideration is the 'loudness' or 'amplitude' of the sound. These considerations can be expressed in a wave form. *(See Fig. 4 & 5).*



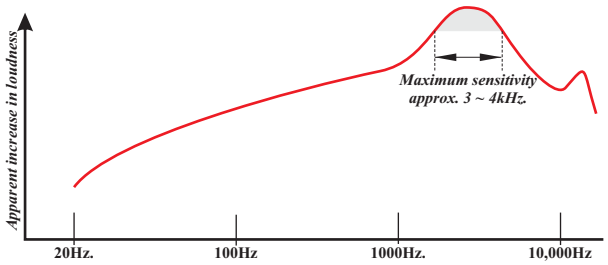


Acoustics Explained contd.:

The average human ear is not a perfect sound receiver. We cannot hear some very low frequency sounds e.g. at frequencies below *(about)* 20Hz. referred to as 'sub sonic'. However, we might feel low frequency sound as vibration. At the other end of the spectrum human hearing may not notice sound at frequencies in excess of *(about)* 20,000Hz. *(20kHz.)*. This is referred to as the 'ultra sound region'. Bats navigate using sound in the ultra sound range and ultra sound can be used for medical purposes to create images. *(See Fig. 5).*

Even within the audible range *(approx. 20Hz. ~ 20kHZ.)* the human ear is less than perfect, being more sensitive to sound produced at frequencies of about 3,000 ~ 4,000Hz. *(3 ~ 4kHz.)* than sound produced at other frequencies. Thus, if sound is produced at the same amplitude *(or loudness)* at all frequencies, sound in the 3~4kHz. range will be perceived to be predominant. *(SeeFig.6).*

Average Human Ear Sensitivity *Fig. 6*



Human sensitivity to sound is an individual thing and may vary from person to person for a number of reasons, including age.

If sound is generated at the same amplitude (loudness) over the full range of audible frequencies then sound in the region of 3 ~ 4kHz. would be perceived to be predominant.

Standards for acoustic measurements relate to a frequency range between 100Hz. ~ 4,000Hz. being the most sensitive range for average human hearing.

ISO 140 and ISO 10140 set out the range of frequencies used for the purpose of testing for acoustic performances. The test procedure for the measurement of the sound attenuating performance of doorsets in the United Kingdom and Europe is described by reference to BS EN ISO 10140 Pt.2 2010. This measures performances over a frequency range of 100Hz. *(Hertz)* to 3,150Hz.

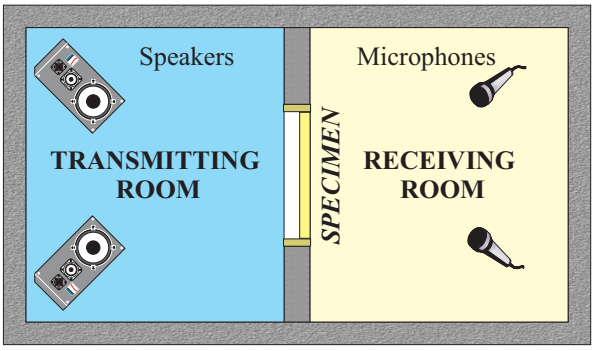
NOTE 1: A frequency range of 125Hz. ~ 4000Hz. is used for testing in the United States and Australia.

NOTE 2: BS EN ISO 10140 Pt.2 : 2010 replaces BS EN ISO 140-3 : 1995 the test methods are identical and the BS EN ISO 140-3 data is still valid.

Acoustic Testing - Sound Attenuation:

The basic principles associated with testing for sound attenuating performances are quite simple. The 'specimen' is located between a transmitting room and a receiving room. Sound is generated across the full frequency range determined by reference to the test standard in the transmitting room. The sound pressure levels on the receiving room side of the specimen are then measured. The sound pressure levels recorded in the receiving room can then be deducted from the sound pressure levels in the transmitting room with the resultant loss in sound pressure levels *(amplitude)* measured in decibels recorded at each of the measured frequencies.

BS EN ISO 10142 - 2 Test Laboratory Arrangement *Fig. 7*



For some purposes it is necessary to know the performances at particular frequencies but for most applications an average performance over the measured range is required. To determine this, the decibel reduction over the measured range could simply be averaged out. However, this would be misleading as this would not reflect human perception resulting from the imperfections of human hearing.

To relate to human perception, the average sound reduction is modified to provide for a 'weighted index' i.e. the measured results are 'weighted' to relate to average human perception. This 'weighted' performance over the measured frequency range is identified by the use of the prefix 'Rw'. The weighted index is calculated by reference to BS EN ISO 717-1 : 1997.

Application of Test Data:

The base test data will provide for a measurement of a sound attenuating product as laboratory tested to the requirements of BS EN ISO 10140 - 2 : 2010 *(or BS EN ISO 140 - 3 : 1995)* with the performance expressed by use of a weighted index (Rw.) to relate to human perception.

When applying the test data, consideration must be given to the anticipated 'background' noise within the protected area *(i.e. noise normally expected to be generated within the protected space)* and the external noises where the amplitude reduction is required.

In the absence of a vacuum, most spaces will be subject to a background noise:

Typical Background Noise Levels:

	dBA
Library or Museum	40
Private Office	45
Quiet Restaurant	50
General Office	55
General Store	60
Average Restaurant	65
Mechanised Office	70
Noisy Canteen	75
Factory Machine Shop	80
Main Street *(at kerbside)*	85
Plant Room	90

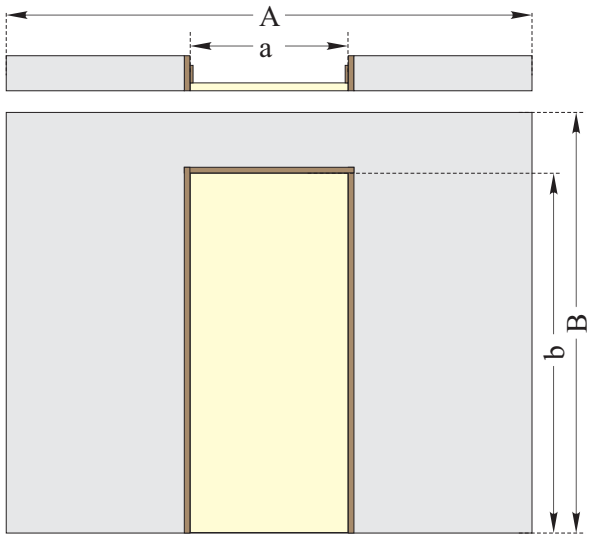
NOTE: The 'A' suffix indicates a 'weighted' measurement. i.e. measurements determined by use of instruments that are corrected to relate to human perception.

The objective when considering sound attenuation *(or sound insulation)* is to reduce the external sound levels to the background levels in the protected area. Thus, if *(say)* a Private Office is located next to *(say)* a Factory Machine shop then, by reference to these typical background noise levels, the barrier between the Machine Shop *(generating 80dBA)* is required to reduce the sound pressure levels by 35dBA to match the background noise levels in the Office *(45dBA)*. i.e. the total barrier between the Machine Shop and the Office is required to reduce the noise levels by 80 - 45dBA = 35dBA.

It should be appreciated that the average performance of the complete sound attenuating barrier is the important thing. A doorset, as an operable product, is likely to be a weak point in a sound attenuating barrier. However, for the example given above, it may not be necessary to use an Rw.35dB rated doorset.

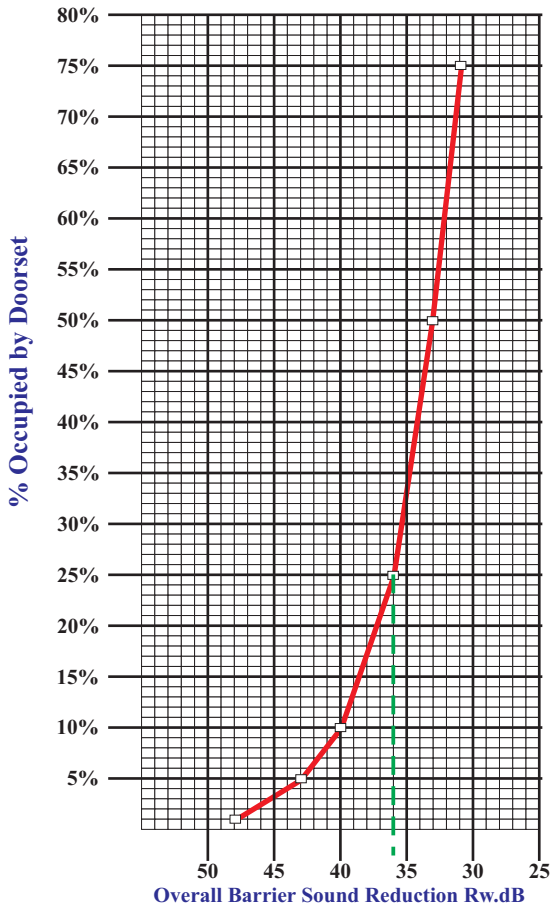
The required performance of the doorset may vary according to the performance of the surrounding structure and the percentage area of the sound attenuating barrier that is occupied by the doorset.

Sound Attenuating Barrier *Fig. 8*



Total area of barrier = AxB = X
Total area of door = axb = y
(100/X) x y = % doorset area.

Sound Attenuating Barrier *Fig. 8*



This graph illustrates the total sound attenuating performance when using an Rw.30dB doorset in an Rw.53dB wall.

Example: The overall sound attenuating performance of a barrier where an Rw.30dB doorset occupies 25% of an Rw.53dB wall would be about Rw.36dB.

Sound Attenuating Doorsets:

Generally any material will provide a sound attenuating performance if used as a barrier between a sound source and a 'protected' area. Some materials provide for better performances than others.

Doorsets are essentially functional products with a primary purpose to provide a means for 'traffic' to pass from one side of a wall to the other. For this purpose the door must be operable. As the thing that we are trying to stop is the transfer of airborne sound then an open door will not provide for any performance. When the door is closed, the sound attenuating performance will be influenced by the residual airflow across the doorset. To minimise the airflow it is necessary to use sealing systems.

Some door constructions have been specifically developed to provide for excellent sound attenuating performances when used with suitable sealing systems.

Some of these 'specialist' constructions rely on the mass law technology. i.e. generally increased mass provides for improved sound attenuating performances. However, there is not a direct relationship between mass and sound attenuating performances.

Adding a dense material such as lead will generally improve performances but this will also change the characteristics of the doorset resulting in significant improvements at some frequencies with no improvement or even a loss of performance at other frequencies.

Other 'specialist' door constructions rely on air gap technology in a similar manner to that used for glazed units. Essentially air gaps between layers of material within the door construction can have a 'decoupling' effect which limits the ability for materials to be set in motion.

NOTE 1: Each layer will resonate (or vibrate) when subjected to sound pressure thus converting sound energy into mechanical / heat energy. Maximum resonation for a particular material / thickness will be achieved at a particular (natural) frequency. Structures made up of different materials and / or with each layer of a different thickness, with air gaps between the layers may be effective over a wide range of frequencies and can provide for excellent sound attenuating properties.

NOTE 2: Use of facing materials that change the stiffness of the door, glazing systems or hardware fittings that bridge the door thickness can have an adverse influence on the sound attenuating performances on doors using this technology.

The only method for determining the precise performance to be expected of a particular doorset design is to test a product that is identical in all respects to the product that is intended for use in the building with the specimen installed into a structure in a manner that replicates precisely the methods intended for use.

Door size.
Doorset configuration.
Facing materials.
Glazing.
Choice of hardware.
Door construction internal framing.
Sealing systems.
Nature of the surround structure.
Method and quality of installation.

ASDMA members will generally manufacture sound attenuating doorsets using door cores that have been tested by core suppliers or using designs developed by the particular manufacturer. Confidential base test evidence can generally be provided for reference by Acoustic Engineers where required.

For bespoke doorsets the base test data will relate to a particular design. Often a 'standard' Nom. 2040 x 926mm flush door is tested with this being the largest internal single door leaf dimension anticipated by reference to BS4787 Pt. 1 : 1980. There is less base test data related to pairs of doors. However, some core suppliers and doorset manufacturers have tested unequal pairs *(using the same frame as used for the single leaf doorset)* and may additionally have base test evidence related to larger pairs.

A series of tests will usually include for measurement of a 'fully caulked' performance. This is a test carried out using high density sealing *(caulking material)* to fill all gaps and will usually provide for guidance with regard to the maximum possible performance of a particular door construction. The door is not operable. This base test data provides for a useful reference with regard to the efficiency of sealing systems that are essentially used for subsequent operable door testing.
NOTE: Reference to an extensive range of 'fully caulked' base test data indicates very similar or identical performances for single leaf and double leaf doorsets.

Generally a nom. 44mm thickness 'general purpose' solid laminated timber core door will provide for a doorset with a potential to provide for an Rw.30dB performance when competently installed with suitable sealing systems. A 54mm thickness door otherwise of the same construction has the potential to provide for an Rw.34~35dB performance but additional sealing may be required.

Sound Attenuating Doorsets:

Typical Doorset Test Data:

The loss in amplitude at each of the $^{1}/_{3}$rd. Octave frequencies is recorded and plotted in accordance with BS EN ISO 10142 - 2 : 2010 *(BS EN ISO 140 -3 : 1995).*

Calculations are then applied in accordance with BS EN ISO 717 - 1 : 1997. These calculations can be illustrated by use of a *'Reference Curve'* that depicts average human hearing and provides for the weighted index rating 'Rw.dB'.

In the United Kingdom and Europe the calculations are applied to $^{1}/_{3}$rd. Octave performances over a frequency range of 100Hz. ~ 3150Hz. The same calculations apply to determine an 'STC' rating used in the United States and Australia *(among others)* but using data related to $^{1}/_{3}$rd. Octave data over a frequency range of 125Hz. ~ 4,000Hz.

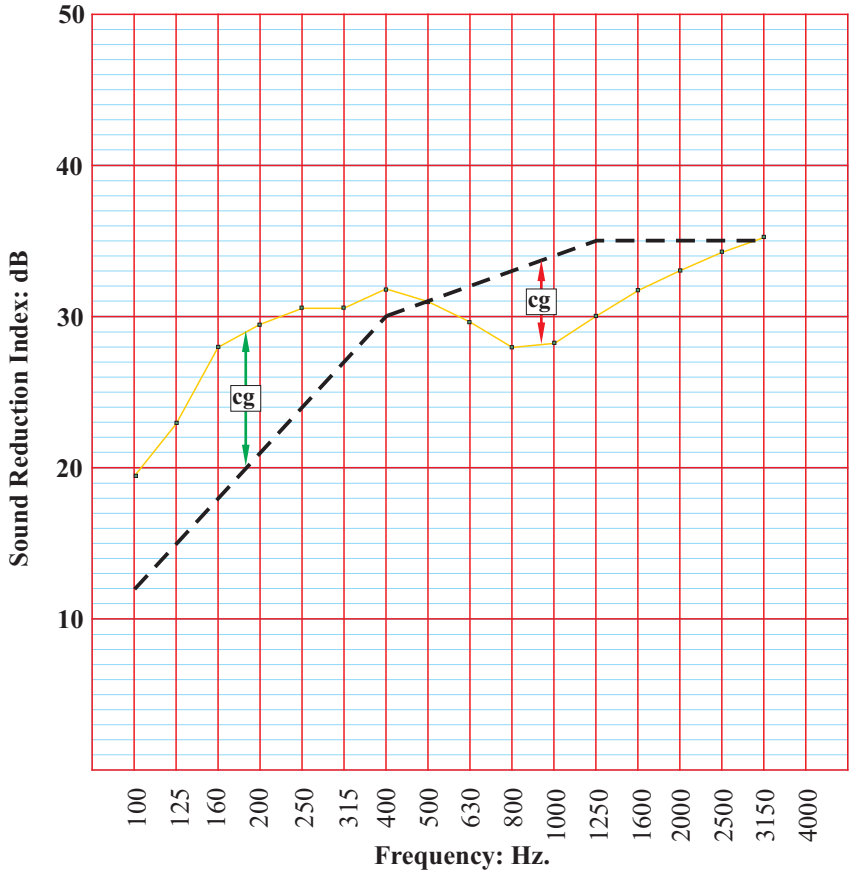
Most solid core general purpose door constructions will suffer from a 'Coincidence Gap' i.e. where the plotted graph determined by testing deviates from the calculated Reference Curve. *(See page 11)*

The plotted performance of some 'dedicated' acoustic products may follow the pattern of the Reference Curve more closely.

Octave:
Expressed simply, one octave is a difference in frequency *(or pitch)* that can be discerned by the average human ear. e.g. The average human may notice the difference between sound produced at *(say)* 200hz. and 400Hz. *(1 octave)* but may not notice a difference between sounds produced at *(say)* 200Hz. and 250Hz. *($^{1}/_{3}$ octave)*.

Rule of Thumb:
Sound attenuation is measured using a logarithmic scale. Within the range applicable to most doorsets, an Rw.3dB variation in performance may be taken to be a doubling or halving of performance. e.g. an Rw.36dB doorset provides for double the performance of an Rw.33dB doorset.

Reference Curve & Coincidence Gap: ***Fig. 9***



44mm GDC Door Construction - Operational - Basic Acoustic Seals. ***(Rw.31dB)***.

Reference Curve (BS EN ISO 717-1 : 1997)

cg Coincidence gap.

Sound Attenuating Doorsets:

Acoustic Seals:

To achieve desired performances for operational products such as doorsets it is necessary to use sealing systems to prevent the movement of air, *(and consequently airborne sound)* through and around the doorset, when the door is in the closed position.

For lower performances, typically up to Rw.30dB, simple sealing systems can generally be used. For higher performances of *(say)* Rw.35dB + additional sealing may be necessary.

Perhaps the easiest way to appreciate this is to consider a bath full of water into which a bowl with a small hole in the bottom is floated. Where a low pressure is applied to the bowl the water will flow though the hole as a gentle trickle. When greater pressure is applied the water will eventually spout up rather like a fountain. To reduce the flow through the hole at the higher pressure a smaller hole *(i.e. additional sealing)* is required.

Airborne sound will always seek the easiest route to pass through an acoustic barrier and will exploit any gaps.

Comparison base test data using a 2040 x 926mm Nom. 44mm GDC *(Graduated Density Chipboard)* 'general purpose' door construction is illustrated in the graph below. The same door leaf was tested:

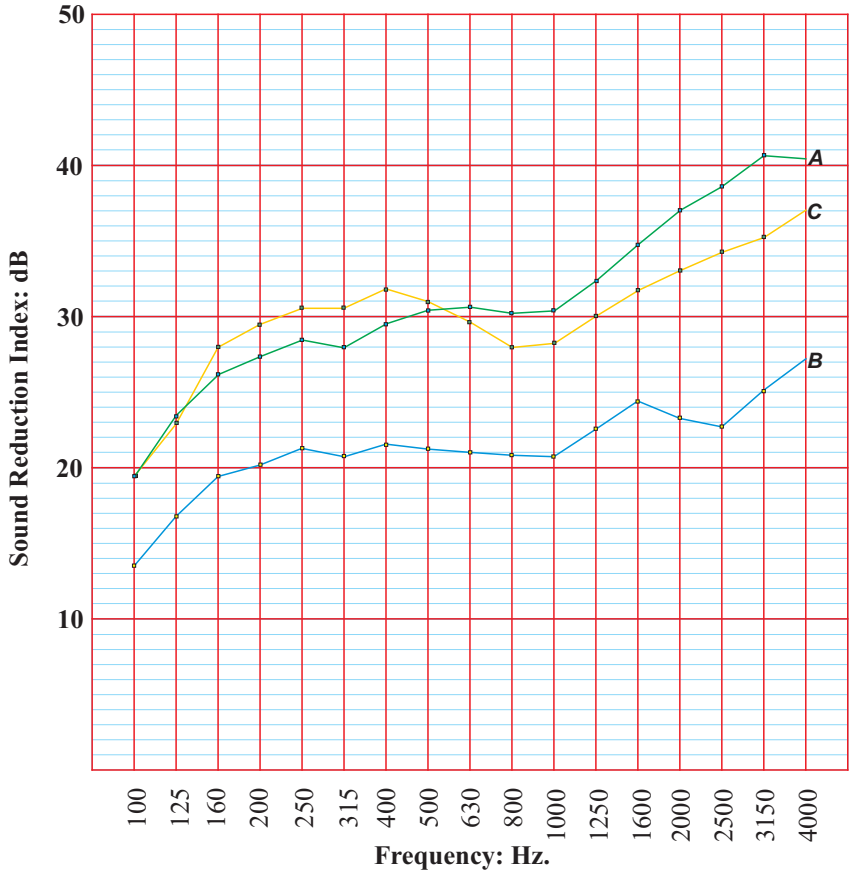
- Test 2 = Fully Caulked.
- Test 3 = No acoustic seals.
- Test 4 = Basic Acoustic sealing system.

NOTE 1: These graphs are indicative only - brand variations may apply.

NOTE 2: The performance for the unsealed doorset applied where the operating gaps conformed with the nominal dimensions approved by reference to BS4787- Pt.1.

NOTE 3: The acoustic seals were adjusted to provide for an initial opening force of 30N by reference to Building Regulations - Approved Document 'M' and BS8300.

Comparisons Test Data: SRL Ref: C/04/5L/0938/1 Tests 2, 3 & 4 ***Fig. 10***



A Fully Caulked 44mm GDC Door Construction ***(Rw.33dB)***.

B 44mm GDC Door Construction - No Seals* ***(Rw.23dB)***.

C 44mm GDC Door Construction - Operational - Basic Acoustic Seals. ***(Rw.31dB)***.

*** = Operating gaps complied with BS47897 Pt.1 standard requirements***

Sound Attenuating Doorsets:

Acoustic Seals:

There are a wide range of sealing systems available that are suitable for use as 'acoustic seals'.

Most seal manufacturers / suppliers will be able to provide base test data with recommendations to suit particular performance requirements. There are however some general issues to be considered as follows:

Conflicts with Hardware: To minimise the risk of air *(and therefore airborne sound)* leakage, care must be taken to avoid the interruption of sealing systems to accommodate hardware, *(OR, to provide for the making good of seal interruption).*

Conflicts with other sealing: e.g. fire / smoke seals.
NOTE: Generally proven acoustic seals will also meet specification requirements for smoke sealing performances. i.e. seals that are effective at preventing the flow of airborne sound are also likely to be effective in the prevention of the flow of airborne particles.

Operating forces: Efficient seals providing for excellent acoustic performance can often give rise to a *'bath plug'* effect. i.e. additional force may be required during the initial opening of the door.
NOTE: This effect may be more apparent for higher performance acoustic doorsets using multi bank sealing systems. Automatic opening / closing devices may be required for locations where Building Regulations - Approved Document 'M' - (BS 8300) considerations apply.

Minimal Interference: It is generally recommended that fixed seals are located to ensure that they are in contact with the adjacent door or frame for the minimal amount of the swing of the door. Generally this will result in frame fixed seals being located towards the doorstop face *(lining / frame rebate)* with door leaf fitted seals located towards the opening face of the door.
NOTE: This will generally result in reduce influence on opening forces and will extend the working life of sealing systems.

Over Compression: Care must be taken to avoid over compression of seals. This can lead to seal distortion, undermining of the sealing function, a need for increased operating forces and increased seal wear. Seal manufacturers / suppliers can generally provide for guidance relative to the particular seal type. In the absence of any other guidance, 50% compression of a sealing gasket may be taken as a guide for achieving optimum performance.

Generally Acoustic Seals will fall into two categories:

Perimeter Seals: Seals designed to seal at the perimeter of the door leaf generally at the head and jambs *(unless a 4 sided frame is used)* and meeting stiles for pairs.

There are numerous designs for perimeter seals, some with simple self adhesive fixing others with aluminium or plastic carriers. Reference should be made to the seal manufacturers / suppliers literature to determine the most appropriate seal for the particular application.
NOTE: When locating perimeter seals consideration must also be given to the operation of the door and in particular the 'door growth' during operation that may require the use of a 'leading edge'. See the ASDMA publication* 'Guidance and Recommendations for the Coordination of Bespoke Doorsets' *for further information on this subject.

The use of pencil rounds or small splays to the edges of door leaves that contact the seals is recommended to provide for a 'lead' for the activation of the seals and for improved seal life.

Threshold Seals: Seals designed to seal the gap between the bottom edge of the door and the floor.

There are two fundamental types of threshold seal. The most common is perhaps the 'Automatic Door Bottom' *(or 'drop seal)*. These are mechanical devices where a gasket is extended from the bottom of the door by the action of a plunger that contacts the frame jambs during the final stages of closing.

The other type is the fixed bottom edge seal.

Fixed bottom edge seals should normally be used with a threshold strip to ensure that the door leaf fitted seals clear the floor for the whole of the swing of the door.

Whereas automatic door bottoms can seal directly onto the floor it is recommended that these are used with threshold strips *(particularly where floors are carpeted)* unless the floor is smooth and level.

Stepped thresholds incorporating seals will generally provide for optimum threshold sealing with these being recommended for use in locations where 'trip hazard' considerations may not apply. e.g. Plant Rooms.

Optimum Performance: Optimum sealing performance is likely to be achieved where the perimeter and threshold sealing gaskets are in a single plane within the thickness of the door.

Sound Attenuating Doorsets:

The influence of Hardware:

Provided that care is taken to select and position hardware to avoid the need to interrupt sealing systems, the choice of hardware will generally have little effect on sound attenuating performances.

Hardware items that require the removal of any of the door core should be kept as small as possible, with gaps around the hardware kept to a minimum.

The main risk to the performance of a sound attenuating doorset results from the creation of flanking routes through the door that may be created by providing for hardware items that essentially pass through the thickness of the door. e.g. lever handles, cylinders / keyholes. The use of lever sets with back plates will generally allow for the use of mastic *(or other sealants)* to prevent the passage of airborne sound. Similar action can be taken with cylinders. For key ways, the use of escutcheons with escutcheon plates will generally provide for a sufficient barrier.
NOTE: Letter plates passing through the door have been successfully tested for performances up to Rw.40dB.

Flanking:

'Flanking' is the term given to the leakage of airborne sound through or around the door leaf and / or the doorset.

The main causes of flanking are:

- Insufficient care and adjustment when fitting seals.
- Worn seals.
- Interruption of seals to receive hardware.
- Inadequate sealing around hardware items that pass through the door.
- Inadequate sealing around glazed apertures.
- Inadequate sealing between the frame and the surrounding structure.

When fitting seals, the main areas of weakness are at the junctions between horizontal and vertical seals i.e. at the four corners of a single leaf doorset. Seals should extend to the full shoulder height and width of the frame with the head seal carefully jointed to the jambs seals.

The operating gap at the seal position should suit the dimensions of the seal. Generally, for seals that act on the edges of the door leaf, the seal should overlap the door *(or frame)* by 0.5 ~ 1mm to provide for optimum acoustic sealing with minimal effect on operating forces.
NOTE: This recommendation may vary according to the particular seal type. The particular seal manufacturer / supplier installation recommendations take precedence in the event of any conflict with this advice.

For perimeter seals acting on the face of a door leaf it is recommended these 'compression' seal gaskets are set to compress not more than 50% unless the seal manufacturers / suppliers fixing instructions advise otherwise.

The gaskets for automatic door bottoms should be cut to suit the full width of the door to provide for a close fit with the end plates. The automatic door bottoms should be carefully adjusted to ensure that they seal across the full width of the door onto a smooth level floor or onto a threshold strip.

Carefully locating seals, particularly perimeter seals to suit the action of the door can ensure that the seals are in contact with the door / frame for the minimum amount of the swing of the door thus reducing the influence on operating forces and reducing wear resulting from friction.

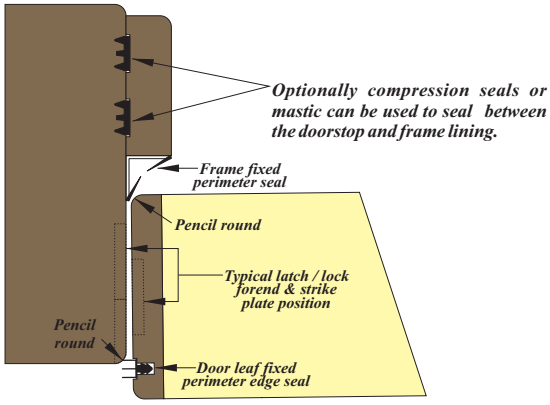
Threshold strips or stepped thresholds with seals should be carefully scribed to the frame with mastic *(or other suitable sealant)* used to fill any gaps that might provide a route for flanking.

The use of door leaf and frame designs that provide for a pencil round at junctions where the seals meet the door leaf or the frame are recommended. These will act as a lead to the compression of the seal providing for optimum performance and improve seal durability.

Typical Frame Design & Positioning of Perimeter seals ***Fig. 11***

Moulded or planted door stops may be used.

The use of planted stops allows for a means of adjustment to assist setting for optimum sealing.



Frame designs that include a pencil round at junctions where seals meet the frame or the door leaf will provide for a lead for the compression of the seal blades in a manner that will generally optimise performance and improve seal durability.

Seal positions should be carefully considered to ensure that the seals are in contact for the minimum amount of the travel of the door as it swings. This will minimise the influence on operating forces and reduce seal wear resulting from friction.

Sound Attenuating Doorsets:

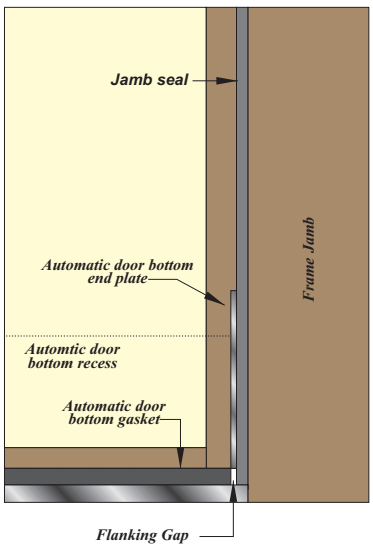
Flanking contd:
The doorset must be installed plumb and square. Any distortion may give rise to difficulties when fitting seals.

The gap between the frame and the surrounding structure should be carefully packed with mineral wool *(or suitable acoustic packing)* between installation fixings to prevent flanking around the frame. A mastic sealant should be applied to both sides of the frame before fixing architrave *(if used)*.

Because doorsets are essentially operational products they must provide for ease of operation. This requires a careful balance when fitting *(and adjusting)* seals. The effect of the seals can usually be felt in the last part of closing but more particularly when opening. For well fitted seals there should be a 'bath plug' effect resistance to opening. *(Air is trapped between seals as the door opens resulting in a lowering of air pressure).* The pressure is equalised by the slow feed of air into the space. This effect will result in difficulty if an attempt is made to snatch open the doors. i.e. for normal operation the doors should be opened more gradually.

One part of the doorset that may be difficult to seal is at the bottom of the doors *(threshold)* at the hanging, closing and meeting stiles. This results from an essential gap between the end plates of automatic door bottoms and the adjacent frame or door leaf.

Flanking Gaps - Single leaf doorsets. *Fig. 12*



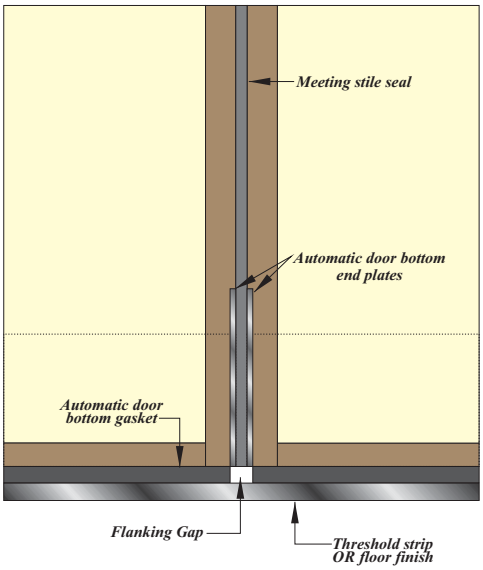
For single leaf doorsets there will generally be a flanking route at the threshold position caused by the essential need to provide for operating gaps.

Flanking can be minimised by ensuring that operating gaps, particularly at the threshold are kept as small as possible (recommended 4 +/- 1mm) and that threshold sealing gaskets extend as far as possible to the full width of the door. This is usually limited by the automatic door bottom end plates.

For single leaf doorsets these flanking routes fall outside fo the normal pedestrian used space. It is therefore sometimes possible to add small additional sealing devices to address this problem.

For pairs of doors a flanking gap also occurs at the bottom of the meeting stiles. A stepped threshold with seal *(currently)* provides for the only effective way for sealing this gap.

Flanking Gaps - Pairs. *Fig. 13*



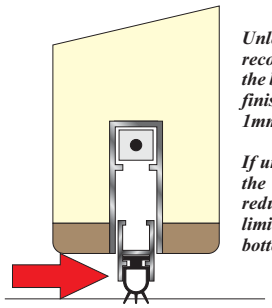
When using automatic door bottoms or fixed bottom edge seals at the threshold there will be a gap at the bottom of the meeting stiles which will be exploited by airborne sound.

This leakage is unavoidable for an operational door but can be minimised by ensuring that under door gaps are kept as small as possible (recommended 4 +/- 1mm) and that threshold sealing gaskets extend as far as possible to the full width of the door. This is usually up to the automatic door bottom end plates.

Flanking at the bottom of meeting stiles can be significantly reduced by use of a stepped threshold with seal where the threshold gasket bridges this gap.

NOTE: Acoustic seals are used to seal the operating gaps around the door. Some of these, particularly automatic door bottoms, can fill some quite large gaps. However, for acoustic applications operating gaps should be kept as small as possible (unless supported by test data) and should generally comply with BS4787 Pt.1. with a recommended 4mm +/- 1mm under door gap from the bottom of the door to the top of the floor or threshold strip.

Increased under door gap *Fig. 14*



Unless otherwise supported by test data the recommended under door operating gap (from the bottom edge of the door leaf to the top of the finished floor or threshold strip) is 4mm +/- 1mm.

If under door gaps are too large, the barrier to the sound attenuating performances may be reduced as the barrier provided at this point is limited by the thickness of the automatic door bottom carrier and gasket.

ADVICE: Installation Times:
It is recommended that Installation Contractors allow for approximately five times the normal installation time for fitting a doorset when installing acoustic doorsets. Considerable care is required to ensure that the doorsets are fitted plumb and square and that seals are carefully fitted and adjusted to provide for optimum sound attenuating performances with minimal influence on operating performances. The installation gap between the door frame and the surrounding structure will also need to be carefully sealed.

Sound Attenuating Doorsets:

The influence of glazing:

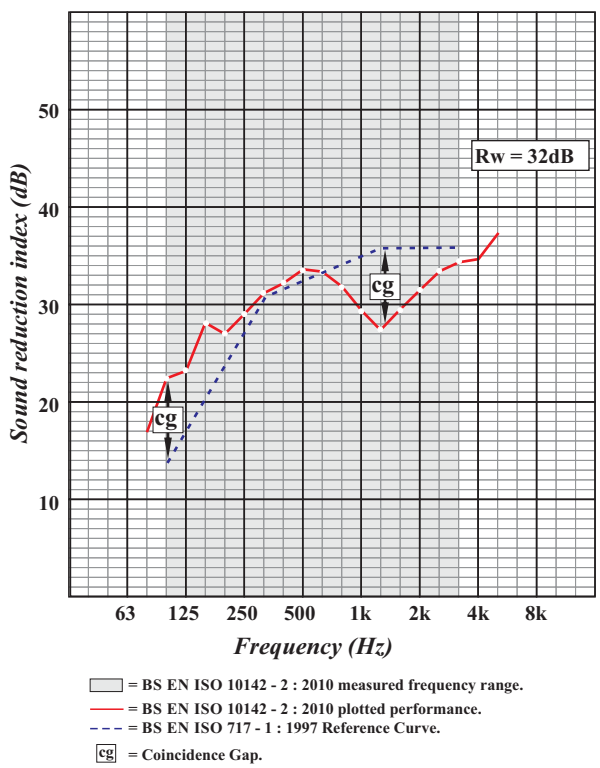
Most solid core 'general purpose' door constructions suffer from a 'coincidence gap'. The 'coincidence gap' is the difference between the plotted curve, measured by reference to BS EN ISO 10140 Pt.2 : 2010 and the reference curve that is calculated by reference to BS EN ISO 717-1 : 1997.

Where the plotted measurement falls above the reference curve, this indicates a surplus of performance at the particular frequencies relative to the weighted index (Rw.).

Where the plotted measurement falls below the reference curve, this indicates a deficiency in performance at the particular frequencies relative to the weighted index (Rw.).

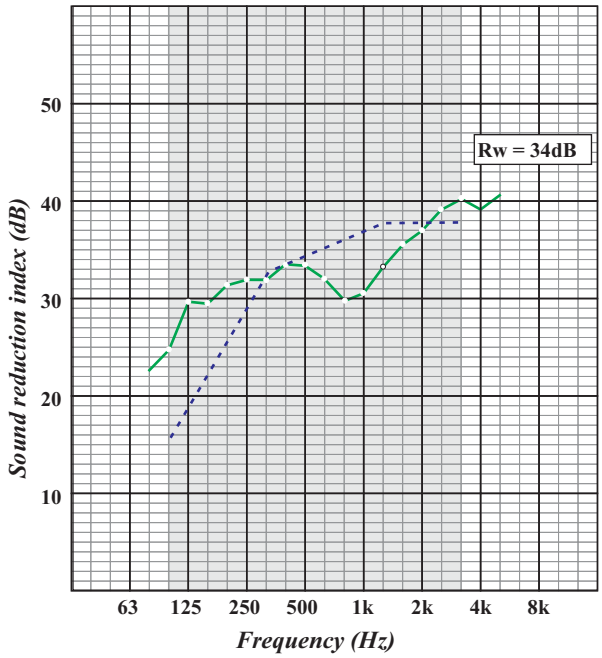
The test data for a Nom. 44mm GDC *(Graduated Density Chipboard)* core flush door fitted with simple perimeter seals and an automatic door bottom threshold seal is illustrated as follows:

44mm GDC flush door - operational *Fig. 14*
SRL Test Ref C/08/5L/20184/R01 Test 4



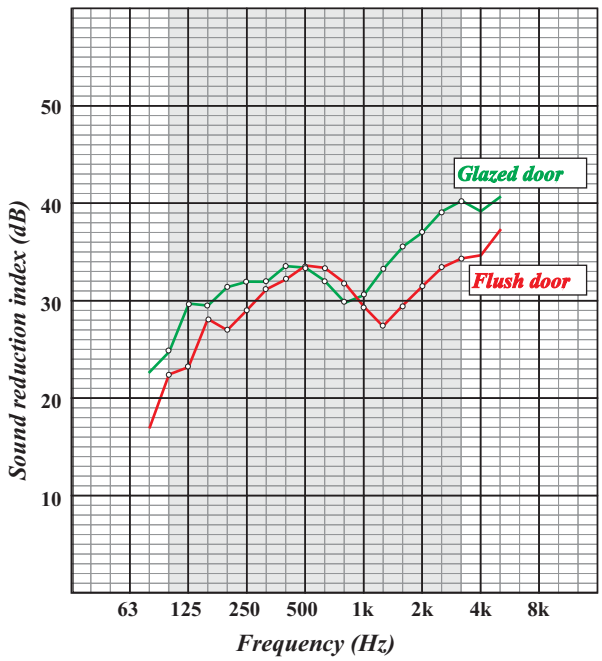
The maximum coincidence gap deviation for this particular specimen occurred at about 1,250Hz. Tests were then carried out using the same arrangement but with the door glazed using various glass types.

44mm GDC door glazed
25% area 12mm thickness glass *Fig. 15*
SRL Test Ref C/08/5L/20184/R01 Test 45



These and other tests demonstrated that the glazing of 'general purpose' solid core door constructions has a beneficial influence on sound attenuating performances. This base test data also demonstrated that the performance was related to glass thickness rather than glass type and that a 'plateau' performance is achieved for any glass thickness / door type construction after which further increases in glass thickness had little if any effect.

44mm GDC Glazed door and
flush door plotted graphs overlaid. *Fig. 16*



Sound Attenuating Doorsets:

The influence of glazing contd.

Glass type:

To measure the influence of glazing the specimen doors were glazed to provided for a clear glass area equal to 25% of the total door area. This dimension was chosen on the basis that the area would be sufficient to indicate the influence of glazing on the door leaf without the glass performance overwhelming the door leaf characteristics.

This test series and other base test data indicated that the glass thickness rather than the glass type influenced the sound attenuating performance of a doorset design using 'general purpose' solid core door leaf constructions.

Generally thicker glass types provided for improved performances. However, for any given door construction and sealing arrangement it was found that a plateau performance was achieved after which further increases in glass thicknesses had little if any effect.

For a doorset providing for a fully caulked flush door performance of Rw.32dB, the following results have been achieved with operational doors with a 25% clear glass area using basic acoustic sealing systems:

6mm GWPP type = Rw.32dB
10mm Laminated fire rated type = Rw.34dB.

For a doorset providing for a fully caulked flush door performance of Rw.35dB, the following results have been achieved using operational doors with a 25% clear glass area using basic acoustic sealing systems:

6mm GWPP type = Rw.35dB
10mm Laminated fire rated type = Rw.36dB.
16.8 Acoustic laminated type = Rw.37dB

For a doorset providing for a fully caulked flush door performance of Rw.36dB, the following results have been achieved with operational doors with a 25% clear glass area using basic acoustic sealing systems:

7.2mm GWPP type = Rw.36dB
10mm Laminated fire rated type = Rw.36dB.
15mm Laminated fire rated type = Rw.36dB
23mm Laminated fire rated type = Rw.37dB

Glass area:

Base test data relating to the influence of the clear glass area is more limited but the following can be advised for guidance:

For a doorset providing for a fully caulked flush door performance of Rw.31dB, the following results have been achieved with operational doors using a basic acoustic sealing system:

7.2mm GWPP type @ 8.9% = Rw.32dB
7.2mm GWPP type @ 22.35% = Rw.32dB

For a doorset providing for a fully caulked flush door performance of Rw.30dB, the following results have been achieved with operational doors using basic acoustic sealing systems:

7.2mm GWPP type @ 27% = Rw.32dB
7.2mm GWPP type @ 35% = Rw.33dB

Glazing acoustic doors - general advice:

The beading system in itself will change the characteristics of the door leaf with further influences resulting from the glass thickness and the clear glass area.

For general purpose solid door constructions providing for a fully caulked performance up to Rw.32dB as a flush door construction: Test evidence indicates that this performance can be matched or bettered for an operational doorset *(otherwise to the same details)* using 6.5 ~ 10mm thickness glass types in conjunction with a basic acoustic sealing arrangement.

For doors providing for a fully caulked performance up to Rw.35dB as a flush door construction: Test evidence indicates that this performance can be matched or bettered for an operational doorset *(otherwise to the same details)* using 10mm *(or thicker)* glass types in conjunction with a more robust acoustic sealing arrangement.

More limited base test data indicates that the area of glazing can have an influence and that, for use with general purpose door constructions, the clear glass area should not be less than 10% of the door leaf area.

NOTE: GWPP = Georgian wired polished plate.

Rule of Thumb:
Sound attenuation is measured using a logarithmic scale. Within the range applicable to most doorsets, an Rw.3dB variation in performance may be taken to be a doubling or halving of performance. e.g. an Rw.36dB doorset provides for double the performance of an Rw.33dB doorset.

Sound Attenuating Doorsets:

High Performance Sound Attenuation:

This document primarily relates to the use of 'general purpose' solid core door constructions that are sometimes required to provide for a sound attenuating performance in addition to other performance requirements. e.g. fire performance, heavy duty mechanical performances, security performance etc.

Doorsets using 'general purpose' solid core door constructions have the potential to satisfy the performances required by reference to currently published national regulations:

- **Building Regulations - (England & Wales) - Approved Document 'E': Rw.29dB. for entrance door to residential units.**
- **Building Bulletin 93 - Educational Establishments - Classroom & Lecture areas: Rw.30dB.**
- **Building Bulletin 93 - Educational Establishments - Music Rooms: Rw.35dB.**

Where a sound attenuating performance in excess Rw.35dB is required consideration should be given to the use of either 'acoustic lobbies' or the use of 'dedicated' acoustic doorsets.

Acoustic Lobbies:

2No. 44mm GDC *(Graduated Density Chipboard)* door leaves positioned back to back in the same frame *(typical hotel communicating door arrangement)* using with basic sealing systems have been tested and provided for a sound attenuating performance in excess of Rw.40dB.

This 'technology' can be extended to provide for higher levels of performance by using two doorsets with basic sealing systems positioned at each end of a structure to form a lobby. The space within the lobby can be lined within sound absorbing materials to further enhance the overall performance of the lobby.

The use of acoustic lobbies will generally provide for the following advantages:

- ***They will often provide for a cost effective solution to meet demanding sound attenuating performance requirements while using 'general purpose' solid core doors that are also capable of satisfying a wide range of other performance requirements.***

- ***Excellent sound attenuating performances can be achieved using basic sealing systems that will minimise the influence on operating forces.***

- ***The lobby solution provides for the added bonus that some sound attenuating performance is maintained when one door is opened with the other closed. (As opposed to the 'all or nothing' performance provided by a single doorset).***

'Dedicated' Acoustic Door Constructions:

Where a sound attenuating performance in excess of Rw.35dB is required without the use of a lobby then it is likely that the use of a 'dedicated' acoustic door construction will be required.

One method for improving the sound attenuation is by the application of the 'mass law'. i.e. increased mass results in improved sound attenuating performance. A simple method for increasing mass might be to incorporate lead sheet *(or similar)* into the construction of the door. This does have an influence on the performance of the door but the improvement might be less than might otherwise be anticipated on the basis of mass alone.

The use of thicker doors will also result in increased mass with improved sound attenuation. However, the use of thick doors *(in excess of 54mm)* can give rise to some operating geometry and hardware problems.

When considering high performance sound attenuating doorsets based upon 'mass law' technology, consideration must also be given to the design and load bearing capabilities of the hardware.

Some *(considerable)* improvements in sound attenuating performances can be achieved by using multi layer cores, perhaps incorporating air gaps and / or acoustically efficient materials such as acoustic mats and / or rubberised cork. Whereas when tested as a fully caulked basic core material these constructions provide for exceptional performances; for door leaf applications the acoustic cores may often need to be supported by a perimeter framing that can give rise to a 'flanking' route that may result in a reduced finished door construction performances.

The introduction of glazed apertures into multi layer door constructions may also have an adverse effect on sound attenuating performances where the beading system bridges the acoustic core construction.

Doors with high sound attenuating performances will generally require more robust sealing systems that can have an adverse influence on operating forces. This may also give rise to an increased risk of conflicts with items of hardware.

Some 'dedicated' acoustic door constructions may not be as proficient at providing for other performances that may be required for the same location.

It is recommended that designs for sound attenuating doorsets providing for a performance in excess of Rw.35dB should conform precisely to 'as tested' details in all respects.

For further information and details of other ASDMA publications contact:

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