## SUMMARY

- Good acoustics help music, encourage singing and enhance the sound of an organ.
- A shallow freestanding organ in an open position is the most efficient for sound projection, allowing a smaller instrument to sound bigger than it really is.
- Sound travels best in straight lines, so an organ should ideally be placed on the main longitudinal axis of a building.
- Alterations to the interior of the church, based only on visual grounds, may have unexpected acoustics consequences.
- Hard and reflective materials will augment a source of sound if placed near it but can lead to echoes if placed far away.
- Porous and absorbent materials will weaken sounds if placed nearby, but can promote clarity if positioned at a distance.
- An over-dry acoustic will have a negative effect on the experience of worship.

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THE INSTITUTE OF IBO BRITISH ORGAN BUILDING

# Acoustics and Church Music

*A Guide for Churches and Organ Builders*

### WHY DO ACOUSTICS MATTER?

Because acoustics are unseen, many people regard the subject as rather mysterious and uncertain. As a result, its implications are often ignored. However, acoustics vitally affect the way in which a congregation experiences both worship and musical performance.

Too often, decisions made on aesthetic grounds have unexpected acoustic consequences. In particular, alterations to a church or its furnishings can have a significant effect on both speech and music, including the sound of the organ.

### WHAT ARE THE OBJECTIVES?

In an ideal building:

- Speech from the front of the church should be as clear as possible and of adequate loudness in all parts of the building.
- The singing of both congregation and choir (if there is one) should be encouraged by the acoustic environment.
- In an age when congregations will be familiar with recordings of music performed to the highest standards, it should be possible to perform choral and instrumental music in the context of worship without distorting the intentions of the composer.
- The sound of the organ should be heard with warmth and clarity throughout the whole building.
- The organ should be positioned to allow good egress of sound. The player should be suitably placed to hear both instrument and other musicians in reasonable balance.

## SOME BASIC PRINCIPLES

The principles of architectural acoustics were established in the USA about a century ago, but until recent times decisions were often taken with only a vague understanding of their acoustic implications. Acoustic principles have been applied with more precision in the last twenty years and are now well proven in the design of opera houses and concert halls.

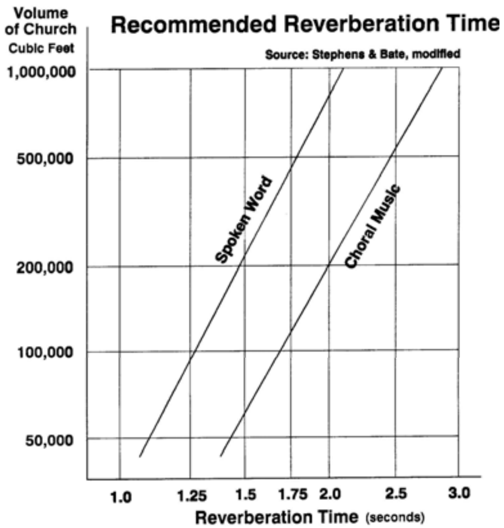
Most sound travels in straight lines; the so-called 'line of sight' rule. There are two exceptions. First, sound will travel round corners that are small in comparison to the wavelength of that sound. The effect of this is that extreme bass is virtually unaffected by corners. However, the higher notes which give clarity to the music (typically from 2ft organ pipes and smaller) do obey the 'line of sight' rule.

The other exception is that sound is reflected by hard surfaces, particularly smooth surfaces such as marble floors. This does enable reflected sound 'to go round corners' to some extent, depending on the nature and position of the reflecting surfaces.

A sound made in the open air will appear to diminish rapidly as the listener's distance increases and to stop as soon as the source of sound ceases.

However, in an enclosed space, the sound will be reflected many times between the walls, ceiling and floor of the space, giving it increased carrying power. The reflected sound will however arrive later than the direct sound.

The effect of sound dying away gradually is known as 'reverberation' and is measured by the time (in seconds) for a loud impact to die away to one millionth of its original value in decibels, i.e. virtual inaudibility.






Because sound travels relatively slowly, a console more than 12 m (40 ft) from the organ pipes within a poor acoustical environment will prove difficult to play in fast music.

### *4. It is difficult to hear speech from the back of the church.*

If the problem is caused by echo, clarity can sometimes be enhanced by providing some acoustic absorption on the back wall of the church - banners perhaps. Do not introduce absorbent surfaces at the front of the church; this will only make matters worse.

The intelligent use of speech reinforcement will also help, but only up to a point. Because the placement of loudspeakers is always a compromise between cost, appearance and acoustic effect, over-amplification of speech often sounds unnatural.

### *5. The congregation doesn't sing like they do on 'Songs of Praise'.*

Singers are easily discouraged by difficult (non reverberant) acoustics. People don't like singing if they cannot hear those around them. This problem often arises where pews have been fitted with seat cushions or replaced by upholstered chairs and the nave floor covered in carpet. An aisle carpet can also be bad. A cork floor can be a compromise that muffles the sound of the congregation's footfall.

If this issue is ignored, congregational participation will be reduced, the singing may suffer and the sound of the organ may be spoiled.

### *6. One member of the congregation thinks that in our particular church an attractive carpet will make no practical difference to the acoustics.*

Every church is different, but no-one can opt out of the rules of physics.

## SOME FURTHER READING


Sounds of Music, Charles Taylor, BBC Publications
*Chapter five gives an excellent introduction to architectural acoustics.*

The Organbuilder, Volume 10, Positif Press
*The article "No Carpet Baggers please" shows how to calculate the effect of additional absorption on church acoustics.*

The Organ Today, Herbert & H. John Norman (2nd edition) David & Charles
*Chapter fourteen "The placing of the organ".*

A larger and louder organ is needed to provide adequate support for congregational singing when the instrument organ is 'round the corner'. Organs speaking across the building should be elevated, so that the sound has more chance to disperse widely and not be too local.

A simple, but useful, rule of thumb is to place the organ in a location where as many seats as possible have a direct line of sight to the front pipes of the instrument.

## SOME TYPICAL ISSUES

### *1. The organ sounds well in the chancel but is disappointing in the nave.*

Are there obstructions in front of the organ (such as an arch)? Has someone put curtains or other hangings near the sound outlet? Are the spaces in front of the instrument hard and reflective? Has the original reflective floor surface in front of the instrument been covered with carpet? Any of these factors may restrict the sound of the organ from travelling effectively (see also point 5).

### *2. The sound of the organ is very soft and dull.*

This commonly occurs if alterations, such as the introduction of carpets or soft materials, have reduced the reverberation time of the building. The graph on page two illustrates some established reverberation guidelines. Too little reverberation not only reduces the volume of an instrument but also makes the music sound lifeless.

### *3. We want to move the organ to the back of the church but leave the choir and organ console at the front. What are the pros and cons?*

This arrangement can often help the projection of sound from a previously boxed-in organ. However, an instrument intended for an 'east-end' position may sound too loud when placed in the west gallery, leading to complaints from the congregation.

If the organ is placed at a distance from the choir, the player may find it difficult to achieve a good musical balance with the singers.

A console detached from the organ will necessitate the provision of electric action to control the instrument; this may be undesirable in the case of an old organ, and will increase the costs.



As the reverberation graph shows, the acoustic requirements for speech and music are different, and often a compromise has to be reached. In a very large and resonant church, the number of reflections may be too great and the reverberation time too long. Reflections from distant surfaces may also cause echoes that increase the adverse effect on clarity. Music may sound glorious but speech may be unclear.

However, too little reinforcement from reflections is a more common problem. This causes a reduction in the volume of sound heard by the congregation, and a perceived 'dryness' of sound which is discouraging for the player, singers, other musicians and the congregation alike.

## REFLECTORS AND ABSORBENTS

Every surface absorbs sound. Some surfaces absorb very little. For example, a polished tile floor reflects 99% of the sound striking it. On the other hand, porous materials absorb sound; curtains absorb a considerable percentage of the higher-pitched sounds striking them – at some frequencies exceeding carpet which absorbs up to 75%. It is frequently overlooked that a carpet installed to "make the church more welcoming" or hide the sound of footsteps may have a serious effect on the acoustics. Reverberation may be greatly reduced, affecting the audibility of speech as well as spoiling congregational singing and emasculating the sound of the organ.

Tables of absorbencies are published for many different materials. The following extract from one table gives an insight into the extent of what the impact of a material might be.

| | *Sound Frequency* | | | | |
|---|---|---|---|---|---|
| ***Surface Type*** | **250Hz** | **500Hz** | **1000Hz** | **2000Hz** | **4000Hz** |
| Acoustic tile, suspended | 0.7 | 0.6 | 0.7 | 0.7 | 0.5 |
| Ordinary plaster, on lathe | 0.15 | 0.1 | 0.05 | 0.04 | 0.05 |
| Concrete Block, painted | 0.05 | 0.06 | 0.07 | 0.1 | 0.1 |
| Brick | 0.03 | 0.03 | 0.04 | 0.05 | 0.07 |
| Vinyl tile on concrete | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 |
| Heavy carpet on felt | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 |
| Ordinary Window glass | 0.2 | 0.2 | 0.1 | 0.07 | 0.04 |
| Curtains, medium weight | 0.3 | 0.5 | 0.7 | 0.7 | 0.6 |
| Upholstered seating, empty | 0.4 | 0.6 | 0.7 | 0.6 | 0.6 |
| Upholstered seating, occupied | 0.6 | 0.8 | 0.9 | 0.9 | 0.9 |
| Wooden Pew, empty | 0.03 | 0.03 | 0.06 | 0.06 | 0.05 |
| Wooden Pew, occupied | 0.4 | 0.7 | 0.7 | 0.8 | 0.7 |

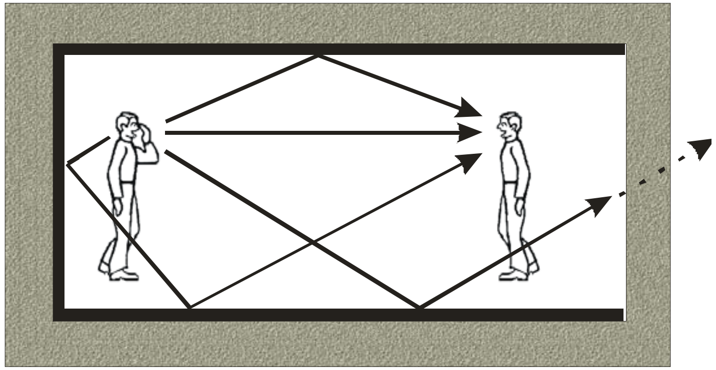
*Source - Musical Acoustics, Donald E Hall, 2nd Ed, Brooks/Cole Publishing, 1991*

**Note:** The units shown here are 'Sabine units of coefficient' which is a representative measurement, expressed between 0 and 1, for the absorbing efficiency of any particular material. It is only necessary therefore to appreciate the simple relationship between each figure. For example, at 2000Hz heavy carpet will typically have a detrimental acoustical impact over vinyl tiles on concrete by a factor of 20.

Because people themselves absorb sound, acoustic conditions in the building will vary with the numbers present, becoming 'dryer' as the building fills up. Compare, for example, the difference in a single empty wooden pew to an occupied one in the previous table.

## REFLECTIVE AND ABSORBENT SURFACES

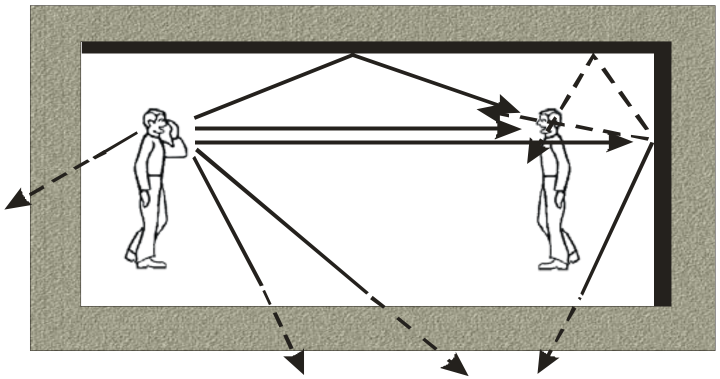
Reflective surfaces placed close to the source of sound can help to boost the power of that sound. The presence of absorbent surfaces at the rear of a church can help to prevent confusing echoes in some circumstances.



**Example A:**

A reflective ceiling and walls with an absorbent surface confined to the rear wall, resulting in clear sound for the listener.

The converse arrangement with absorbent surfaces close to the source of sound and reflective surfaces further away, leads to an under-powered and confused-sounding result.



**Example B:**

Absorbent surfaces on the floor and wall near the sound source, resulting in under-powered and confused sound for the listener.



Although these principles have long been known - they lie behind the provision of testers over pulpits - there are many churches whose acoustics are spoiled by poor positioning of reflectors and absorbents.

Good acoustical conditions are often described as "the best stop on the organ", but it is surprisingly easy to spoil them.

## ORGAN POSITION AND DESIGN

Sound emerges from the front of an organ and may, depending on the case design, also emerge from the top and sides. The sound from a swell box emerges only through the louvres – adjustable openings controlled by the player and normally on the front of the box. Their physical arrangement can help to direct sound in the required direction. As with the swell box itself, louvres should be well fitted and constructed of dense, reflective materials.

Organs sound best (and take the least space) if they can be free-standing, clear of the structure of the building and built in a case to project the sound. A shallow layout from front to back is more acoustically efficient than a deep one.

Because the higher-pitched sounds necessary for clarity do not travel round corners well, an organ should ideally be placed on the main longitudinal axis of the building. This was, in fact, the position of most eighteenth and early nineteenth-century instruments, either on a west gallery or, in cathedrals, on a screen at the entrance to the choir. However, following the Victorian trend to chancel-based choirs, many organs were moved or replaced by instruments placed to one side, facing across the 'east' end of the church.

The consequence of an organ speaking in this direction is that it will be less effective at a distance, since transmission of sound along the length of building is by reflection only. In these circumstances, the layout of the organ needs to be designed for the best possible projection. Organ position is less critical if there is ample reverberation, but more critical if the acoustics are 'dry'.

The problem of transmission of sound along the length of a building is particularly acute where the chancel arch is low. This affects choirs and the spoken word just as much as organs and, where the arch is particularly restrictive, it may be better to use a pre-1850 arrangement with a west-end choir and organ. The problem is compounded if the sound of the organ is 'trapped' within the organ chamber by a restrictive arch.

Equally, sound generated in a transept (other than extreme bass) also travels poorly round the corner into the nave.