

Criteria for Good Acoustics

1. *Adequate loudness.* Everyone must be able to hear the speaker or performer. The room should not be too large or have excessive absorption.
2. *Uniformity.* Listeners in all parts of the room should hear as nearly the same sound as possible. There must be a sufficient number of sound diffusing surfaces to avoid “dead” spots. All sections of an orchestra should blend together in a balanced way.
3. *Clarity.* There must be sufficient absorbing surfaces that the reverberant sound does not mask following sounds.
4. *Reverberance, or liveness.* The listener should feel bathed in sound from all sides, but at the same time be able to localize the sound source. Clarity and liveness may be partly contradictory.
5. *Freedom from echoes.* Reflected sound should arrive early enough to reinforce the direct sound but not be perceived as a separate echo.
6. *Low level of background noise.* The noise from heating and ventilating systems and from external sources should be kept very low.

Concert Halls

1. *Intimacy, or presence.* A hall is said to have *acoustical intimacy* if music played in it gives the impression of being played in a small hall.
2. *Reverberation, or liveness.* *Reverberation* refers to sound that persists in a room after a tone is suddenly stopped. *Liveness* is related primarily to the reverberation times at frequencies above 350 Hz. (A hall can sound live and still be deficient in bass.)
3. *Spaciousness: apparent width (ASW).* A concert hall has one of the attributes of spaciousness if music appears to emanate from a source wider than the visual width of the source.
4. *Spaciousness: listener envelopment (LEV).* Listener envelopment is highest when the reverberant sound appears to come from all directions.
5. *Clarity.* Clarity is the degree to which the discrete sounds in a musical performance stand apart from one another.
6. *Warmth.* Warmth is defined as liveness of the bass or fullness of bass tones (75 to 350 Hz) relative to that of the midfrequency tones (350 to 1400 Hz). The term *dark* is also applied to a hall with a strong bass.
7. *Loudness.* Loudness is largely related to the size and shape of the hall and to its reverberation.
8. *Balance.* Some of the ingredients that combine to give good balance are acoustical; some are musical. Good balance is promoted by good stage design.
9. *Blend.* Mixing of the sounds from the various instruments of the orchestra depends partly on sound-reflecting surfaces close to the stage.
10. *Ensemble.* The ability of the performers to play well together also depends partly on the sound-reflecting surfaces close to the stage.

Spatial impression A sufficient portion of the early sound should arrive from the side (from the side wall reflections). In recent work, two different aspects of spatial impression have been identified. One is called the Auditory Source Width (ASW) which refers to the impression that the music appears to emanate from a source wider than the visual width of the source. A second aspect, called Listener Envelopment (LEV), refers to the impression that the reverberant sound appears to come from all directions.

Early decay time The initial rate of decay of reverberant sound is more important than the total

reverberation time. A rapid initial decay is interpreted by the ear as meaning that the reverberation time is short.

Things to be avoided in auditorium design include the following:

1. *Echoes*. An echo is a strong reflected sound that is sufficiently delayed (over 50 ms, usually) from the direct sound that it can be heard as a separate entity rather than as a continuation of the original sound. When echoes are heard in an auditorium, a likely culprit is the rear wall.
2. *Flutter echoes*. Flutter echoes are a series of echoes that occur in rapid succession; they usually result from reflections between two parallel surfaces that are highly reflective.
3. *Sound focusing*. Focusing of sound can be caused by reflection from large concave surfaces. Certain sounds will be heard too loudly near the focus of a curved surface.
4. *Sound shadows*. Under balconies at the rear of the auditorium, there may be insufficient early sound, because most of the reflections from the side walls and ceiling do not reach this area even though they are in a direct line of sight to the performer and therefore receive the direct sound.
5. *Background noise*.

Things preferred in concert halls.

1. The greater the early decay time, the greater the preference for the hall, up to a reverberation time (determined from the early decay time) of 2 s. Above 2 s, the preference for the hall decreased with increasing reverberation time.
2. Narrow halls were generally preferred to wide ones.
3. Considerable preference was shown for halls having a high *binaural dissimilarity*; that is, listeners preferred dissimilarity of sound at their two ears, such as might result from a high degree of asymmetric sound diffusion.
4. Halls with less *definition* were preferred. Definition represents the ratio of energy in the first 50 ms to the total energy.