Sound Reflection in Performance Spaces

Everyone agrees that “good acoustics” is essential to performance spaces, but not everyone knows how to achieve it. “Good acoustics” involves factors related to room design, sound transmission path from the source to the listener, and the listener’s perception of the sound.

One of the most important factors to good acoustics is how sound is reflected in a room. Research in architectural acoustics has shown a strong correlation between perceived acoustical quality and the sequence of sound reflections arriving at the listener’s ear. The research has gone on to show that the acoustical character of the room is controlled by the early sound reflections which arrive at the listener within about 200 milliseconds after the arrival of the direct sound.

Pioneering work by Dr. Leo Beranek in the late 1950’s showed the perception of acoustical intimacy in a space is controlled by the difference between the time of arrival of the direct sound and the first major reflection. He called this the “initial time delay gap” (ITDG) and noted that rooms with excellent acoustical properties had ITDG values no greater than 25 milliseconds.

Work by other acoustical researchers has shown the perceived sense of clarity and strength of sound can be enhanced by sound reflections provided they arrive at the listener no more than 50 milliseconds after the direct sound.

Use of Ceiling Sound Reflecting Panels

Properly designed sound-reflecting ceiling surfaces in lecture, music halls, auditoriums, and religious sanctuaries are necessary to create good acoustical conditions. They provide for acoustical intimacy, clarity, and strength of room sound. Suspended ceiling reflector panels can provide the correct “ceiling shaping” for useful early reflections that improve these acoustical characteristics. This is due to the ear’s relative insensitivity to localizing sound in the vertical plane.

Ceiling sound reflecting panels can be applied to both new construction and renovation of existing spaces. Common applications include: (1) improving sound distribution; (2) correcting sound focusing from concave ceiling surfaces; (3) increasing early reflections in fan-shaped rooms which lack such reflections; and (4) increasing sound levels in rooms where a sound amplification system may not be appropriate.

Since the ceiling plane is the major architectural element in the room that can provide reflections, it is critical to factor the design of this surface in the room.

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Placement of Ceiling Sound Reflecting Panels

Ceiling sound reflecting panels should be placed above the sound source and over the audience seating. The height of the panels depends in part on the type of programs to occur in the space. Generally, the following guidelines are applicable: speech (15'-0" to 20'-0"); soloist and small instrumental/choral ensembles (20'-0" to 30'-0"); and large instrumental/choral ensembles (30'-0" to 40'-0"). In some cases where multiple programs are to occur it may be necessary to strike a compromise in the ceiling panel height unless the budget permits the panels to be installed on movable winches.

A ray diagram analysis should be performed to confirm that the path length difference between the direct sound and the reflection from the ceiling panels throughout the audience seating area does not exceed:

- Speech (20'-0")
- Soloist and small instrumental/choral ensembles (25'-0")
- Large instrumental/choral ensembles (35'-0")

In practice the ray diagram analysis can be limited to the front row, middle row, and rear row. Both room centerline and side locations should be examined, especially if the room has a fan-shaped plan form.

Ceiling Sound Reflecting Panel Layout Patterns

The ceiling panel layout will be room specific. The designer should consider how the panels will be distributed around the ceiling along with HVAC diffusers, down lights, sprinkler heads, and other building services.

Experience indicates that full coverage over the ceiling plane is not needed to provide useful early sound reflections. Typically, 40 to 60 percent coverage is adequate with the remaining space between the panels open to the room volume above which is used to develop room reverberance. Denser ceiling panel layouts will not provide adequate acoustical coupling between the upper and lower volumes separated by the ceiling panels and reverberation will suffer.

The ceiling panels are normally angled to direct sound from the source to the audience. Shallow vertical angles will tend to direct sound to seating areas behind the reflector. Steeper vertical angles will tend to direct sound down to seating just below the reflector. Overall, the right panel layout will direct sound evenly throughout the audience.

Research in the early 1990s has shown that ceiling panel arrays tend to be more effective with a larger number of medium sized rather than a lesser number of larger panels.

Size and Shape of the Ceiling Sound Reflecting Panels

The size of the ceiling panels will be a function of whether the room is used primarily for speech or music. Music programs require larger panels than speech programs. Increasing the panel size improves low-frequency sound reflection. If both music and speech are to occur in the space, the panels should be designed for the more critical musical applications. For speech programs, the ceiling panels should be a minimum size of 8'-0" by 8'-0" when the panels are widely spaced. For music, a minimum panel size of 10' to 12' in both dimensions should be anticipated for widely spaced panels. Denser panel arrangements can use smaller panels.

Ceiling panels for speech applications may be either flat or convex to direct sound in a particular direction. For music, convex-shaped panels offer the benefit of added sound scattering which improves the sense of audible "spaciousness".

The panels should be constructed of a material which has minimal sound absorption (i.e. high reflectivity). Finished panels having a surface weight of 2 lb/square foot, which is framed and braced at the back, will satisfy this criterion. In some cases it is desirable to add an additional mass layer or sound absorptive blanket to the top (unexposed) side of the reflector.

Advantages of Kinetics Ovation Reflector Panels

Kinetics Ovation reflector panels can provide acoustical intimacy, clarity, and increased sound strength that will benefit both speech and music programs. The panels are available in a variety of standard and custom sizes and finishes to suit the architectural and acoustical requirements of the project. Both flat and convex shaped panels are available. The factory-fabricated panels reduce contractor labor normally associated with erection and finishing of field-fabricated panels. They arrive at the project ready to install, complete with mounting hardware. Acoustical testing of the panels shows practically no sound absorption with absorption per square foot of panel at approximately 0.10 Sabins or less.

Let the audience hear what they have been missing by specifying Kinetics Ovation reflector panels on your next project.