Flush Mounting to Wall

- flush-mounting minimizes diffractions
- eliminates back wall reflection
- boosts speaker output
- removes the front baffle effect
- low frequency room resonances need to be attenuated

Implementing half space

An enclosed dynamic loudspeaker drive unit has theoretically ideal working conditions only if its radiation space is either a full space (spherical radiation) or a half space (hemi-spherical radiation). To achieve ideal full space conditions the drive unit and the enclosure must be small compared to the radiated wavelength.

In practice the radiation angle will decrease at higher frequencies because of the finite front baffle size of the speaker cabinet and finally because of finite size of the drive unit itself. For example, a medium sized speaker cabinet having front baffle dimensions of 300 x 500 mm will change the loading of the drive unit from full space characteristics to half space characteristics between the frequencies 200...600 Hz.

The half space loading generated by the front baffle is far from ideal. The baffle edges produce reflections because of diffraction of the sound energy at these edges. These degrade the transient response and directional characteristics of the loudspeaker system.

Frequency response dip caused by a reflection

Considering the practical control rooms, a free standing speaker is always surrounded by walls that will generate reflections. These walls act as acoustical mirrors to the speaker's radiation, enhancing or canceling the direct sound, depending on the phase difference between the reflection and the direct sound at the listening position.

The most common problem at low frequencies is the interference between the speaker's direct radiation and the reflection from the wall behind a speaker. At very low frequencies this reflection is in phase with the direct sound. When the frequency increases the reflection begins to lag more and more because of the distance it has to travel compared to the direct sound.

Finally, at some frequency reflection will be delayed so much as to be in opposite phase relative to the direct sound. Depending on the relative amplitudes of the direct and reflected sounds, a cancellation dip (typically 6...20 dB deep) will occur in the frequency response.

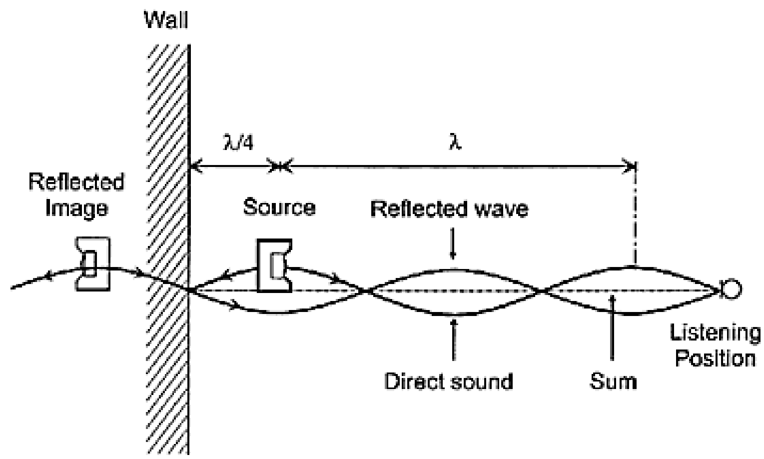

Figure 1. Sound reflection from a wall.

The frequency of this dip can be calculated from the distance of the speaker from the wall (figure 1). The sound in air travels 344 meters/second. The dip frequency can be calculated from the distance of the speaker relative to the wall. Dividing this distance with the speed of sound in the air, we obtain a traveling time. The dip frequency is the inverse of this time multiplied by four (figure 2).

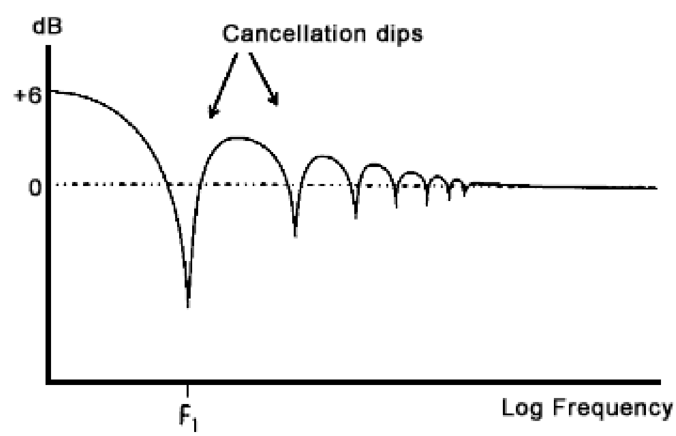

Figure 2. The frequency response dips caused by a wall reflection.

Moving the dip frequency

There are basically two ways to overcome this problem.

The first is to position the speakers far enough from the wall to move the first order interference dip below the lower cut-off frequency of the speaker. To move the dip down to 30 Hz, the distance needed is 2.8 meters. This would not be possible in most control rooms simply because of lack of space.

The second method is to push the speaker as close to the wall as possible to decrease the time delay of this reflection relative to the direct sound. This moves the interference problem to a higher frequency, where the speaker's own directivity decreases the rearward radiation and in this way the amplitude of the reflected sound attenuates effectively relative to the direct sound. By taking the wall to zero distance from the drive unit we reach a situation where the speaker is mounted flush to the wall. Then the mirror image of our speaker created by the wall merges now completely with the actual speaker radiation. Because of this "double" speaker effect the total sound power radiated into the room has gained up to 6 dB compared to a free standing loudspeaker at frequencies where the loudspeaker alone radiates omni-directionally and has substantial rearward radiation.

Flush mounting removes diffractions

Flush mounting the loudspeaker into a wall offers also other important advantages by eliminating unwanted secondary sound radiation from the loudspeaker cabinet's edges and nearly idealizing the radiation space to a half space. The result is minimization of diffraction effects, improved transient response and imaging.

Response to be optimized for flush mounting

There are a few things to observe when installing speakers flush to the wall. Most commercially available systems are designed to deliver a flat free field response. When flush mounted, their frequency response will no longer be flat, but will usually have a bass boost of 4...6 dB in the region below 200 Hz.

If the speaker does not have a built-in bass shelving control, one has to use a separate equalizer to correct this problem. This is usually the case with passive speaker systems.

How to flush mount a loudspeaker

Another important aspect is to install the cabinets exactly flush with the front wall without leaving any gaps or edges between the loudspeaker cabinet and the room wall.

Some people like to build a solid concrete base for the speakers to anchor them to the building structure. Although this is good, except for the high cost of the mounting, we have found floating mounting to provide some superior properties.

A floating mount places the speaker cabinet on rubber springs, which effectively decouple its mechanical vibrations from room structures. Then, all acoustical radiation really originates from the loudspeaker, not from the nearby walls, the floor or the ceiling.

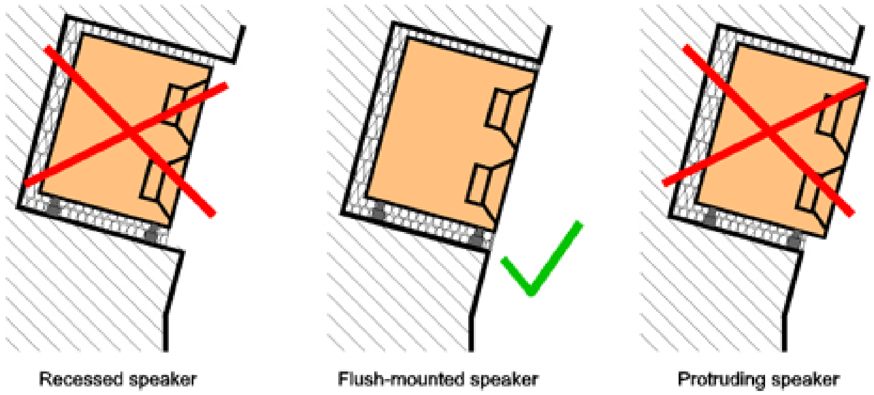

Figure 3. Flush-mounting a speaker correctly into a wall.

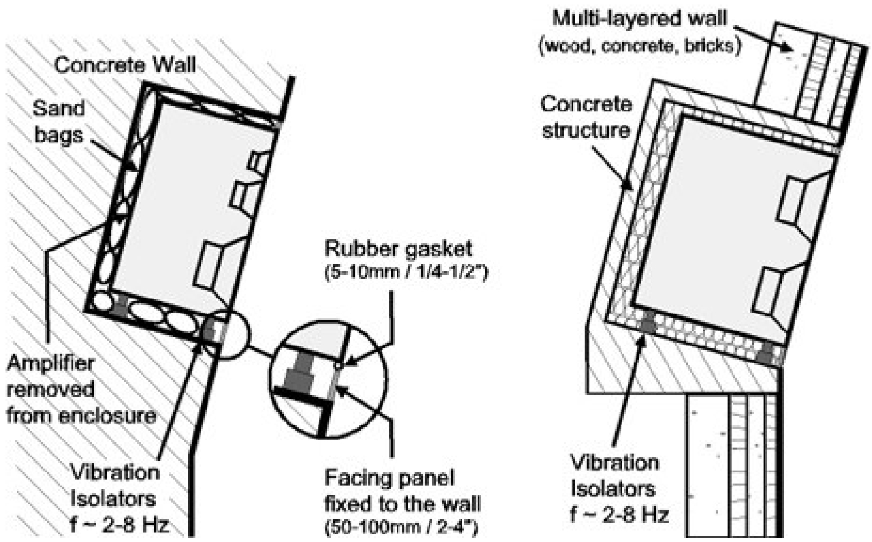

Figure 4. Flush-mounting construction details.

Battling room modes

In a flush mounted system where the drive units are in the plane of the wall, the standing waves in the room may be excited more than with other speaker placements. To effectively excite a standing wave one needs to have a pressure source at a standing wave pressure maximum. A standing wave has a pressure maximum for all resonance frequencies at the wall surface. An enclosed dynamic speaker behaves like a pressure source, and placed flush to the wall will excite all longitudinal standing wave modes.

The only effective way to overcome this problem is to heavily damp the rear wall of the control room at low frequencies with absorption material. Practice has shown that no other method is as efficient for this purpose.

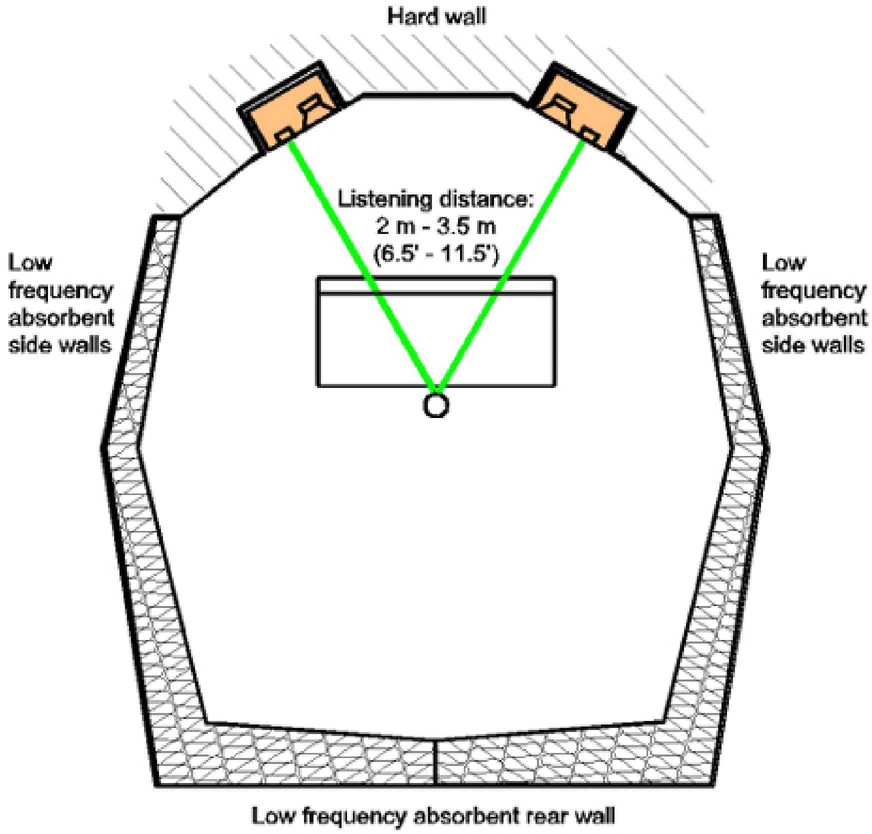

Figure 4. Low frequency room modes damping.

Summary

A well designed flush mounted speaker system will remove several problem sources in the reproduction chain, helping to attain the goal of absolutely accurate and true sound reproduction. Flush mounting minimizes diffractions, eliminates back wall reflection, boosts the speaker output, and removes the front baffle effect. Proper flush mounting of the loudspeakers as well as adequate damping of the rear wall of the control room have to be implemented.