HORIZON AUDIO SERVICES LTD.

What is Speech Intelligibility?

Simply put, speech intelligibility is the ease with which you can understand the words being spoken. In your church, it's the words of the talker at the pulpit delivered to the listener in the pew.

Factors Affecting Intelligibility

There are many factors which affect intelligibility. Some are personal; does the listener have a hearing disability? Other factors are external to the listener. Some of these factors are:

- Outside environmental noise (traffic, weather)
- Inside environmental noise (heating, air conditioning systems, ceiling fans)
- People noise (coughing, baby crying, kids talking, shuffling feet)
- The sound system design and installation
- Architectural (excessive reverberation and/or discrete echoes in the room)

Requirement For Good Intelligibility

There are several requirements for good intelligibility as implied above. Here I will focus on one important requirement: A good direct to reverberant sound ratio.

To understand what the direct to reverberant ratio (D/R ratio) is, we need to understand what the direct sound and reverberant sound is. Direct sound is that which travels directly from the sound source (speaker system) to your ear without reflecting off any surface on its way. Reverberant sound is that which travels from the sound source to various reflecting surfaces before reaching your ears. Reverberation is simply sound bouncing around a room until materials in the room, including the air, absorb it. If the ratio of direct sound to reverberant sound is positive, intelligibility will be good, (provided the signal to noise ratio is good). As this ratio goes further negative, intelligibility will become poorer.

When you are in personal conversation with a friend, intelligibility is good because the talker is facing, and close to, the listener. If the talker were to turn around with their back to the listener, intelligibility would immediately drop, because most of the sound the listener is now receiving is indirect or reverberant sound.

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Achieving A Good D/R Ratio

We can achieve a good D/R ratio using a number of methods. One way would to provide everyone with headphones. This may seem silly at first, but keep in mind this is exactly what we do when we use hard wired or wireless hearing enhancement systems. Headphones also improve the signal to noise ratio by tending to block out ambient sound. Another method is to keep the distance from the loudspeaker to the listener as short as reasonably possible. Yet another method is to keep the natural reverberation of the room as short as possible. This is not very practical in most churches, as a reverberation time compromise between what is ideal for speech and what is ideal for music is usually desired.

Often the most practical method is to use speaker system components that will provide a short **acoustical** distance between the speaker and the listener.

Critical Distance

You may know that as one moves further away from a speaker placed outdoors the volume decreases according to the inverse square law. The sound pressure level decreases 6 dB every time you double the distance from the speaker to the listener. Indoors sound pressure level from the same speaker will decrease accordingly until the point known as the *Critical Distance* is reached. This is the point where the direct sound pressure level equals the reverberant sound pressure level. Beyond this point the volume heard in the room will remain constant due to the reverberant sound field. The direct sound level beyond critical distance will continue to decrease.

A rule of thumb is that in the average room no listener should be beyond about three time's critical distance in order to have reasonable intelligibility.

The 'Q' of the Loudspeaker

The critical distance is partially dependant upon the speaker used in the sound system. Different speakers have varying ability to control or direct where their sound disperses. A speaker that does not control its dispersion, that disperses in a very wide pattern horizontally and vertically, will add a great deal to the apparent reverberation time of the room. A speaker that tightly controls its dispersion pattern will add very little to the apparent reverberation time.

The ability of a speaker to control its dispersion is a designed-in characteristic and it costs money. This ability is referred to as the directivity of the speaker. It is quantified as the 'Q' of the speaker. Thus a 'high Q' speaker has high directivity and will definitely produce a higher D/R ratio at a given seat in a given sanctuary than will a 'low Q' speaker. Therefore, the intelligibility will be better in that seat.

Measuring Intelligibility

The principle 'unit' used in North America for intelligibility is referred to as '%ALCONS'; the percent articulation loss of consonants of speech. In the past this was measured by using a representative group of listeners randomly located in the room listening to a word list and marking what they thought was the correct word from multiple choice lists. Of course this is a rather time consuming and awkward to arrange process. Today, we use the Techron TEF 20 computer audio analyzer to measure %ALCONS. This is fast, accurate, and does not require a group of people.

The professionally accepted standard for a good system is a maximum %ALCONS of 15%. However, we have had occasions where the measured result was about 10%, yet some seniors and others with a degree of personal hearing impairment were beginning to complain. We aim for a measured result of between 4% and 8%.

What Speaker System Should Be Used?

The million-dollar question many people ask first is what is the best speaker system to use? This question cannot be answered without first knowing what the church wants the system to do; is it a speech only system, music only, or both? What are the reverberation characteristics of the church? What is the shape and size of the sanctuary? What is the maximum sound pressure level required? How much money does the church wish to invest? And so on.

I note some general rules (these are not opinions but rather are based on the laws of physics).

- Intelligibility is dependent upon a high direct to reverberant ratio.
- One can have high sound volume in a room, but still have poor speech intelligibility.
- The longer the reverberation time in the room, the more difficult it is to understand speech.
- Smaller sanctuaries with short reverberation time can use a good speaker with only a moderate amount of dispersion control.
- Larger sanctuaries with longer reverberation times require well-controlled dispersion speaker systems to provide the high D/R ratio and thus good intelligibility.

Conclusion

This is by no means an exhaustive discussion on intelligibility. It is important that churches, especially those with very reverberant sanctuaries, seek out a knowledgeable experienced contractor or consultant to design the sound system. Otherwise, chances are high the church will be going through the sound system purchase process again three or four years later.

I close with the following general notes.

- Achieving high intelligibility in reverberant rooms will likely mean the use of highly directional horns in the speaker system, rather than full range cabinets with lower Q components.
- The speaker system that is excellent for speech reproduction will not be excellent for music reproduction, and visa versa.
- Humans process speech and music with different sections of our brain, which is possibly one reason why we prefer different speaker systems for speech and music.
- A good compromise for speech and music in a church requiring music reproduction is to employ a computer programmable equalizer to tailor the system equalization for each function.
- There are many speaker manufacturers partly because the sensation of 'good sound' is partially subjective. The typical congregation will 'learn to live' with any of a number of loudspeaker models provided they all have similar basic performance characteristics.

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Date: unknown