

Reverberation

(Is reverberation echo? echo? echo? no!)

Friend or Foe?

by Bob Applegate

Reverberation – What is it??

Reverberation is the “tail” of decaying sound that remains when a steady sound in the room is stopped. When a calibrated noise source is played through a loudspeaker in the room and the sound is stopped abruptly, the decay of the sound may take a very short time (1/2 second) or an extended time (several seconds). The measurement of this decay time is based on the amount of time in seconds (**Rt**) required for the sound to diminish in intensity by **60** decibels (from fairly loud to inaudible, given most rooms). The normal documentation would give a time value and a related frequency (pitch). For example: the Rt60 was 1.5 seconds at 1kHz means that the reverberation decay time for the range of pitches two octaves above middle C on the piano was 1.5 seconds.

What it's Not

Reverberation is not an echo but may be mistaken for an echo by some. An echo is a single (or sometimes multiple) well defined reflections, generally a slight amount quieter than the source sound and normally arriving at least 80-100 milliseconds after the ceasing of the source sound. When a sound person is looking for echoes and reflections in a space, often times the use of short energy bursts (hand claps) will often find reflections and echoes. Handclaps are not a suitable method for determining reverberation, as they do not create sufficient sustain to fully activate the room.

Why does it matter?

As system operators, we are constantly required to provide a listening experience that musically accurate with high energy and impact, while maintaining a clear and easily understood speech reproduction. It is possible (not easy, but possible) to design a sound system to meet these varied requirements, **however** the room conditions may create significant difficulties, due to the reverberation time involved.

The study of intelligibility gives us a method of measuring (or calculating) speech intelligibility in the presence of reverberation. The method is called ALCons (Articulation Loss of Consonants) and is widely used for speech intelligibility for the English language. Since the rating is based of the **Loss** of consonants, then the smaller the “lost” consonants the better the listener will be able understand the remaining consonants. An ALCons rating of 0-5% is considered to be excellent (almost no loss), 6-10% is considered as “good” intelligibility, 11-14% is considered as “acceptable” and above 15% is considered very poor or unacceptable intelligibility. One of the determining factors in intelligibility testing is related to the presence of room reverberation. One of the effects of poor intelligibility is a significantly shortened listener attention span. If the Alcons is doubled, a good rule of thumb is the attention span will decrease by 50%.

The doubling of reverberation time results is a quadrupling of ALCons. < **Read that again.** For example: Let's say your church has an Rt60 of 1 second at 2kHz and the music director and organist desire a longer reverb time (this would be understandable since 1 second is too short for most choral and organ works). The organist would like it at 2.5-3 seconds, but the choir director would be happy with 2 seconds. The sound system was correctly designed for the existing 1-second room and is delivering excellent intelligibility (5% ALCons) at every seat. When and if the room reverberation increases from 1 second to 2 seconds, the ALCons will increase from 5% to 20%, leaving virtually every person unable to understand the spoken word. Major problem.

How Much Reverberation is enough?

The amount of reverberation desired for any space is directly related to the internal volume, surface area and geometry of the space. However the “correct” amount of time desired as a target time to be achieved is much more complex than a single number. Not all 1.5-second rooms sound the same (based on the placement of the reflections and the room size and shape).

It is also very important to realize that the music ministry and not the spoken word drive the need for reverberation. In this day of pastors desiring to sound conversational and relaxed in their delivery, the presence of even a 1 second decay can seem longer than desirable. The same one-second reverberation time that seems “long” for the speech elements of the service will seem very “short” or dry for unamplified choral music or pipe organ works.

What is too much?

As a rule, if it becomes difficult or impossible to understand unamplified speech at 25-30' then the reverberation time is too long for good speech intelligibility. Also if these conditions exist in a fellowship hall or open assembly space, then the buildup of ambient noise will be a problem. Keep in mind that the unamplified music in the same space will likely sound very good.

Broadcast Recording Booths, ¼ second

Live Broadcast Rooms (with reinforcement), approximately ½ second

Typical 300-seat church with “good/excellent” speech oriented acoustics, 1 second or less

Typical 500 seat medium size church with very good unamplified music characteristics, approximately 1.8 to 2 seconds

Typical 500+ seat room with acoustics oriented to large pipe organ, 3+ seconds

Is there a way to hear the effect of different reverberation times on speech and music?

Yes, and given the technology of the day it is actually easy. Most digital reverberation processors possess the ability to “dial-in” a certain amount of reverberation processing, both in terms of amplitude and decay time. It is a relatively simple task to prepare a close miked recording of a familiar voice, then add reverberation to the signal. Generally, what will occur is the perception that the “dry” source recording sounds best for speech, but a music recording recorded in the same close-miked fashion will sound lifeless. The addition of 1-2 seconds of reverberation will improve the sound of the music. With the 2 seconds of reverberation still in place, play back the sound of the pastor’s voice. See if you really like hearing speech in the presence of 2 seconds of reverberation. Does it sound “normal”? If you were listening to speech with reverb would you be able to maintain concentration on the topic for 30 minutes (sermon length). Does the reverberation added to the speech distract or enhance the quality and intelligibility?

Solutions

1. Reduce Reverberation by adding absorption
2. Reduce echoes by adding diffusion (may also require absorption)
3. Improve Intelligibility by increasing loudspeaker directivity and aiming sound only at listeners (increases the direct/reverberant sound ratios)
4. Turn off any unused loudspeaker zones
5. Synchronize any under balcony or narthex loudspeakers with sound from the platform, through the use of signal delays
6. Never add electronic reverberation processors to the sound system when the room reverberation is sufficient.
7. Consider adding electronic reverberation processor for (only) the choir microphones if the speech reinforcement quality (intelligibility) is sufficient for the space.
8. Seek out a consultant or contractor to accurately measure and assess your reverberation situation. Request design modeling and recommendations based on the specific room conditions and end result desired

Conclusion

Reverberation can be a wonderful or horrible thing, depending on your application (speech or music). Virtually all rooms that are used for both speech and music are working compromises. The main point is to design a room/loudspeaker/processing combination that meets the requirements for your church. Please feel free to call us if you have questions or desire help.

[More Help Files](#)

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