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Speech Intelligibility, Part 1

The first part of this series explores the variables affecting a good sound system design.

By Ed Simon

No one has ever sung into my ear from 3″ away. I have never even put my ear in the bell of a horn being played, or listened to a stringed instrument from a foot away. I have met some good-size singers, but none with a soundstage of 20′. As a result, I really do not know how some of the studio recordings should actually sound.

EVERYBODY'S TALKING

However, every day you and I listen to people talk. We all know what they should sound like. Even more important, there is little room for argument as to whether we can understand what they are saying.

More sound systems are used for conveying speech information than any other use. The wired telephone does not have very good fidelity, but you can understand almost everything that is said. The cellular telephone can, of course, allow you to take notes and pictures, play games, mpeg audio, and video files, and even talk to another phone user. If your iPod had as low fidelity as a cell phone, you would consider it broken.

The primary use of the telephone is to communicate speech. You also use larger sound systems for movies, sporting events, paging, music, public speaking, and uncountable other uses. There are more than 2 billion sound systems in the US!

You are familiar with what happens when a speech sound system does not work. You can usually hear the person talking, but cannot understand what he/she is saying. In much rarer cases the person's voice is not loud enough to overcome the noise, and you just can't hear him/her.

Much effort has been put into understanding the requirements for good speech intelligibility and how to achieve it. The telephone is a great example of providing good speech intelligibility at minimum cost.

RULES OF THE GAME

In developing the telephone system, engineers devised a method called an articulation test to measure the performance. This test, which is done infrequently with public sound systems, is easy-to-do, can give very accurate results, and allows the knowledgeable user to make adjustments. The test is almost never done for one simple reason: It more often than not embarrasses the designer and installer of the sound system.

It is a great way to see whether an auditorium space is good or bad, and can be used to measure performance of a sound system, determining particular problem areas. This test does not require any special equipment—one or two people to speak, and a group of listeners with paper and pencils to record the results. Live speakers are preferred, as the scores increase slightly when done live, a bit more when people can see the talker. Often the test speech is recorded and played back. The scores are slightly lower, but the results can be more consistent.

There is actually a standard test method described in ANSI standard S3.2-1989 R1999. You can buy this document for $100. Of course, you could use the list of words I have provided with this article for free (**Table 1**). The expensive version has complete instructions on each aspect of the test and proven test word lists that are properly phonetically balanced to represent normal speech. I used harder words to point out problems.

The test is not complicated: One person speaks to a group of test listeners at a rate of three syllables per second, using a carrier sentence such as "Write the word ___ now." A good reader will go through a list of 50 test words in about two minutes. Too fast is just as bad as too slow. The carrier sentence allows reverb to build up and surround the test word. If you just read the words, scores will be higher.

SCORING

When you read the word list to people with normal hearing in a small nonreverberant room, scores should be 95% or higher; 100% for any size group almost never happens. The best part is that spelling does not count!

If the test word is "FIVE" and you write down "PHEYEPHJ," you are right! After completing the test, each listener is always convinced he/she answered them all correctly. That is why you never let test-takers score their own tests.

My list contains 300 words. You should test your group in a small room using about 25 words to get them used to the test and weed out the people who hear or write poorly. After all, you must be able to read what they wrote.

You can reuse the list with the same group of listeners as often as you like, but mix up the order. Scores will improve with repeated experiments, but you still can isolate problems. A score of 75% is actually enough to allow understanding of normal speech. A score of 85% or more is great. Our brains put normal words into complete sentences, so we have a built-in form of error correction. If you are up for a bit of fun, try the test with cellphones!

For a thorough test, one reader should be male, one female. Spread the listeners throughout the room. The reader presents 25 or 50 words. The listeners write down where they are and what they hear, then they move to a new position.

After you have combined at least 500 to 1500 sample words from all the listeners, you can score the tests. You are interested in two kinds of mistakes. The first involves the wrong consonant; for example, "HIVE" or "FIRE" instead of "FIVE." When scoring, you must be careful to allow for bad spelling while making sure the sound is correct.

The second mistake occurs when the vowels are wrong. So when someone writes "FAVE" or "FEVE," this is not a spelling error and must be counted wrong. Some folks assume that only consonant sounds are important in these tests. The theory is that vowels are closer to pure tones, and most masking problems do not affect them. I have found that in large spaces the atmospheric absorption of high frequencies can cause a significant loss of vowels. Yes, air absorbs sound. Available charts show you the loss for a standard distance at different temperature and humidity levels.

NO LAUGHING MATTER

If you test in a mostly empty room in the worst spots, and 15% or less of the words have consonant errors, then the communication method is just acceptable. (Some believe this could be 20% loss, but they are wrong.) An error rate of 10% is desirable when counting only consonant errors. When you include vowel errors, the error rate total should be less than 20% to be just acceptable and about 15% to be good.

Note that most words have two consonants and one vowel. If either or both consonants or the vowel is wrong, that is an error. A single test word can have more than one error in my method of scoring. If you notice frequent multiple errors in single words, you know you have a problem even before you total the test. This is how I score my tests; others may do it differently. Some just count consonant errors; others count only one error per word. Do not assume that similar sounding test names and scores will produce the same results.

The acceptable level of errors will vary according to your intended audience. Churches tend to have older listeners with less hearing ability. Sports venues have few problems if the team wins; more if they lose. Even with some articulation loss most errors are corrected by being placed in the context of a sentence. Even with a word loss of 25%, sentence recognition will still be acceptable, except, of course, in a comedy club. Missing the last word of the punchline 25% of the time might just keep you from laughing. As people's expectations rise, so should your design goal.

It is also handy to total each individual's results separately and compare them to the others. It is useful to have people change seats with each other if there seems to be a particular problem area. That way you can tell whether the problem is with the person or the room. In a symmetric room you need test in only one half of it. Very few rooms are symmetric when you consider internal and external noise sources.

If you are planning on designing a sound system, it is useful to measure the distance from the unaided reader at which the speech intelligibility is still good (15% consonant and vowel loss combined or less). Use this distance for loudspeaker selection and spacing. Keep in mind that adding loudspeakers decreases this distance, while using directional loudspeakers increases this distance.

PEOPLE ABSORB SOUND

Be aware that testing in a large empty room will give different results than when it is full. People absorb sound. They also make noise, but you assume the audience is attentive. So the lower numbers are okay under this condition.

If the room has plush padded seats and carpeting, then the lower results probably are not a good choice. The other assumption is that the listeners and readers are native speakers of the same dialect of American English. The use of my table of words is based on American English; other languages will have some differences. Not all languages use the same methods to transmit intelligence.

Do not confuse acceptable with good. If the worst seats are acceptable when the room is empty, that's acceptable. If the best seats are acceptable when the room is full, then you need to change something.

Of course, if you want to do the test by yourself, you can record the list, forget about it for a while, then play it back. Your scores will be higher this way but will still show problem areas. I have provided wave files suitable for making your own CD with this article (posted on the *aX* website at www.audioXpress.com).

OTHER TESTS

There is another, newer (1958) spoken test called the diagnostic rhyme test, which requires less training for the listeners and is simpler to score because it usually does not test vowel sounds. My lack of experience correlating it with sound system results is why I do not use it, although others certainly do.

If you prefer, there are machine-based tests to determine speech intelligibility. Two Dutch researchers, Houtgast and Steeneken, devised a mechanized method of measuring intelligibility (Steeneken, H.J.M., and Houtgast, T., "The Modulation Transfer Function in Room Acoustics as a Predictor of Speech Intelligibility," Acustica *28*, 66-73, 1973). In their speech transmission index, they amplitude-modulate a carrier tone and measure the recovered modulation. This is done for many carrier frequencies and modulation frequencies. A weighted sum of the results gives a score ranging from zero to one.

Some technical debate exists, of course, about the frequency bands of interest, the modulation rates, and the weights that should be applied to give the final score. As a result, you will find labels such as RASTI or STI-PA used for variants of the test. These tests are an extremely valuable method. However, the basis for criticism is that you can fool the test under some situations. (Of course, there is no better machine-based method, and human-based tests have far more variables.)

Instruments that can make these measurements are available today from manufacturers such as NTI, Sencore, and Goldline. These are typically DSP-based units that include STI-PA as one of their functions. Goldline is the exception, making an STI-PA-specific gizmo. You can buy a basic system for a few thousand dollars and quite a nice setup for under $5000.

Using one of these analyzers is stupidly simple. You play a CD containing a special test signal, setting the sound system to the volume normally used for speech with the SPL meter built into the STI-PA analyzer. You push the test button, wait less than a minute, and the screen displays "ERROR" or the magic number. My experience is that the number you get is a good one. When you get an "ERROR," the cause is obvious—the system was not loud enough, somebody talked during the measurement period, or a truck went by.

With very little practice you can conduct a useful survey of a room in under an hour. The only purpose-built unit to measure RASTI-PA comes with a label that sums it all up: 0.00-.30 Bad, .35-.45 Poor, .50-.60 Fair, .65-.75 Good, .80-1.00 Excellent!

I once designed and installed a sound system for a church that reputedly was acoustically designed by a noted acoustician named Sabine. The RASTI score was .9 for the seating in the main part of the nave and dropped to .70 in the worst audience seats.

After you have designed and built what you think is a great sound system, it is disheartening to have a little black box come by and tell you it won't work. Bass may be good, treble great, all the openness you could want, but no one can tell the difference between "Tire" and "Fire." Under those conditions having a tire sale could be very hazardous! At some time in the future you can expect that the safety codes for buildings will require such a test of the emergency paging systems. Right now it is an option.

There are also some circumstances under which it is desirable to minimize speech intelligibility. The best known example is the open office plan. The common US scale is the CIS rating. The very best privacy requires a 95% articulation loss to prevent overheard conversations. A bit less loss will work for most cases. The common US technique to reduce speech intelligibility is to use pink noise to raise the noise level. If done subtly, it will reduce speech recognition without being annoying.

Now that you know the speech intelligibility rating for your room, you can go to the dean, principal, pastor, or person in charge with the knowledge that the room does or does not work for speech. (Music is a different story, so don't confuse the two!) But you may wish to know why.

Table 1: Sample word list to test room performance.

1. noose	39. stride	77. mole	115. oak	153. hath	191. might	229. lens	267. tide
2. hoe	40. rife	78. gate	116. such	154. brown	192. cage	230. close	268. peeve
3. part	41. spare	79. floss	117. tricks	155. fort	193. seat	231. we	269. rut
4. grog	42. tip	80. gab	118. oar	156. coil	194. nut	232. heat	270. base
5. dive	43. rend	81. nil	119. debt	157. rim	195. rice	233. bee	271. hour
6. weighs	44. our	82. buck	120. bake	158. shack	196. slip	234. wean	272. ale
7. cuff	45. hub	83. sate	121. auld	159. buck	197. hitch	235. cops	273. seen
8. rang	46. rid	84. rid	122. fib	160. pass	198. stroke	236. boat	274. cokes
9. urn	47. feet	85. rice	123. crypt	161. perk	199. flap	237. fish	275. frog
10. peep	48. desk	86. van	124. frame	162. heat	200. miss	238. bloat	276. drop
11. hike	49. punt	87. clout	125. drip	163. seek	201. rove	239. frond	277. swap
12. sad	50. hand	88. wife	126. lid	164. spread	202. awe	240. feast	278. crook
13. ding	51. yes	89. frump	127. this	165. kneel	203. spurn	241. big	279. gain
14. rove	52. fault	90. vault	128. tar	166. source	204. fudge	242. rove	280. quit
15. then	53. hook	91. writhe	129. raft	167. ram	205. bin	243. steak	281. grass
16. shrew	54. nine	92. sit	130. catch	168. poke	206. for	244. wave	282. hitch
17. bog	55. bar	93. dock	131. ream	169. whole	207. scar	245. pith	283. hand
18. goose	56. knit	94. hog	132. cat	170. wall	208. bass	246. when	284. strife
19. lick	57. ramp	95. pit	133. dab	171. wag	209. wow	247. leaf	285. vane
20. fudge	58. board	96. wire	134. oh	172. terse	210. have	248. roust	286. hay
21. pill	59. fizz	97. pop	135. till	173. woof	211. roar	249. crane	287. joke
22. flush	60. tan	98. fit	136. clasp	174. came	212. bean	250. pest	288. cream
23. dove	61. sauce	99. change	137. tar	175. spice	213. ship	251. fig	289. blind
24. cleft	62. mush	100. stash	138. plush	176. taste	214. out	252. oat	290. tread
25. zest	63. tab	101. right	139. false	177. cinch	215. curl	253. thrush	291. rut
26. pain	64. blob	102. flop	140. mart	178. wheel	216. vine	254. tuck	292. code
27. elf	65. dog	103. prize	141. pluck	179. soup	217. lapse	255. pets	293. deed
28. false	66. reed	104. slush	142. seas	180. bland	218. tea	256. tap	294. draw
29. chore	67. slight	105. fleck	143. nape	181. wood	219. jab	257. sap	295. lead
30. heart	68. pounce	106. nigh	144. row	182. blush	220. ah	258. floor	296. odd
31. murk	69. spice	107. vote	145. ebb	183. slip	221. fish	259. grain	297. he
32. puke	70. bag	108. wow	146. sub	184. cry	222. wit	260. bin	298. oh
33. bang	71. rash	109. boss	147. tear	185. tent	223. herb	261. sweet	299. ex
34. mar	72. crib	110. wall	148. scotch	186. pave	224. cents	262. geld	300. press
35. range	73. rid	111. clash	149. kit	187. lodge	225. rash	263. fur	
36. breed	74. ban	112. eight	150. lend	188. dote	226. cloud	264. mart	
37. cross	75. knot	113. mew	151. pad	189. fleet	227. posh	265. bash	
38. fuse	76. bull	114. clank	152. top	190. purge	228. rail	266. sack	

NOISE

You frequently treat noise as three different problems: the source, the path, and the receiver. You have some control over the first two, which I will address. If you are doing community noise work, then the nonlinear response of the third is your problem.

In the common speech model, spoken words are made up of distinct sound groups called phonemes. If you can hear the phoneme being presented at a level that is not masked by noise, then communication should be good. If most of the phonemes are received but a few are missed, you can usually figure out what was meant. Noise can be from external sources such as air conditioning, traffic, or other conversations. Or it can also be self-generated from the reflection and reverberation of phonemes that have preceded the one you are now trying to receive. In extreme cases it can be distortion induced by the amplifying apparatus.

The first design issue is how loud should speech be for optimum understanding. In 1929, Vern O. Knudsen (UCLA) determined that speech intelligibility improved in a quiet room as level was increased to 70dB. It began to degrade slowly starting at 80dB. This was astoundingly good research.

Modern acoustics as a science started in 1900. The vacuum tube was invented in 1906. Here were experiments that had accurate decibel readings, used a "distortionless" amp in a sound-reinforcement system and measurements by articulation tests. This is amazingly better work than some of today's efforts.

More recent research has shown that the level of speech above the background noise is important. This ratio of speech plus noise level divided by noise level is called the signal-to-noise ratio. Most people forget that when you are measuring the speech level it is not separated from the background noise. In the old days it used to be called S+N/N. Today we usually include the reverberant tail of the target speech as part of the noise number.

The intelligibility scores with various signal-to-noise ratios have been the subject of many experiments. Obviously, if you have lots of noise at a low frequency (say 20Hz), it will not cause as much masking as noise at midrange (3kHz) frequencies. In the RASTI method when you have the equivalent of a 15dB signal-to-noise ratio for a given band and modulation, it is given the highest score of 1.00. A test in which the noise equals the signal gets a .50.

BANDWIDTH RESEARCH

Much research has been done on which bands of frequencies contain the information you need for good understanding. It should come as no surprise that the human ear is most sensitive to speech in the midrange frequencies of 1200-4000Hz.

One question of importance to system designers is how narrow the bandwidth should be to communicate intelligible speech. In one experiment to determine how narrow a bandwidth the ear can discriminate, a sine wave is compared to a narrow band of filtered noise. When the subjects cannot tell the difference, the width of the filter is noted. The other version of the experiment uses two oscillators set to the same frequency and then one is slowly changed until two tones are perceived. This bandwidth, called a "Critical Band," should not be confused with the ability to perceive pitch. Select individuals can determine pitch differences to an amazing degree.

A common misperception is that the critical bandwidth is about ⅓ octave wide. When Fletcher did the original research the bandwidth was much narrower. Modern methods (and definitions) give different results that are closer to a third of an octave over much of the auditory range. If you could just use ⅓ octave equalizers to fix frequency response errors, life would be simpler. Resonances and other problems are often narrower or wider or, even worse, not on ⅓ octave centers.

In addition, most of you would like to think that in critical listening, you can tell differences in level between two notes even when they are close together. As nice as it is to just slide a few knobs, pros will usually use fewer but more adjustable filters. A rule of thumb on large sound systems is if you are really using five or more parametric filters, you have a problem.

In other experiments, just a narrow band of frequencies carrying speech is passed and the percentage of correct words received is measured. Some experiments use the critical bandwidth of frequencies, some use ⅓ octave spacing, and a few use other bandwidths. This allows the prediction of the intelligibility results when you have less than full bandwidth communication or when noise masks some bands of frequencies but not others. It is handy to know how little bandwidth you can use to convey speech and which bands to use.

Of course, understanding which frequency bands contribute to intelligibility has been the subject of research for almost 100 years. That is why the wired telephone uses 300–3000Hz. It is cheap to implement and the second best choice of frequency bands to allow effective communication.

Many experiments have resulted in establishing a number of tables of speech recognition percentage versus a given frequency band. These have been incorporated into different standards. There is an ANSI standard S3.5-1997 R2002 that defines a method for predicting the Speech Intelligibility Index (SII, a more accurate name!) which correlates well with the results of the articulation tests for predicting speech intelligibility. The SII is scored from zero to one.

It is possible to estimate the speech intelligibility by measuring the noise (including reverberant tail) in ⅓ octave bands, calculating how much effect each band of noise will have on the speech spectrum, and coming up with a single number score. There are programs that allow you to do this if you have all of the measurements. Some software allows you to estimate this based on the building information. You could refine this to perfection if you had identical humans talking and listening, the noise source was completely constant, you had full and accurate data on the room materials and construction, and you had no other room effects. That is why you use estimates or well-educated guesses in many cases.

A good rule of thumb is that when the speech is 6dB louder than the noise, speech is good; 15dB is great. When you measure the noise use the "A" weighting and slow response on your sound level meter. That combination will give you one method of approximation as to how noise is perceived as interference. There are other scales used for better frequency weighting of psychoacoustic measurements, but the dB is the one I use the most so I will stick with it.

A method by Kryter (1962) is often simplified to look at the signal-to-noise ratio in octave bands, each band scoring its highest value (one) when the sound level *peak* was 18dB above the noise in that band. The lowest score (zero) occurred when the noise was 12dB louder than the speech. Each octave band had a maximum score depending on frequency (250-.06, 500-.15, 1K-.23, 2K-.32, 4k-.25). The final score gives an articulation index, in which .5 is just acceptable and .8 is pretty good. There is some argument as to which variant of the scale is most accurate and also as to exactly where the quality is acceptable.

SLUMBERLAND

There is a second factor that comes into play and Knudsen nailed it: a minimum level at which people pay attention! When the volume of the speech is below 70dBa, people fall asleep. In high schools and churches, I have set a noise level of less than 35dBa, and still people's heads will nod when I drop the level below 70dBa. It works almost as well as a light switch!

In a large room people cannot talk at 70dBa. If you want that level for maximum speech intelligibility, you will need amplification. The simplest amp is the megaphone, a beautiful piece of acoustic design. You can build yours as a straight conic section, an exponential, or, for a real tweak, use a tractrix! I will stick with the straight cone, because rolling a piece of cardboard to this shape is easiest. Bad news: you need to do a bit more to meet modern expectations.

The conclusion is simple. The noise level in an auditorium should be as low as possible, but do not spend money getting it ridiculously so. A person talking normally without amplification can be 50dBish without really trying too hard. A great signal-to-noise ratio is 15dB. So a noise level of 35dBa can be acceptable for medium-size rooms. A larger room may require less noise if no amplification is used. It isn't easy, but it is achievable. Besides, once the room is right, amplification can be added to overcome the noise.

NOISE SOURCES

The most common source of noise is the ventilation system. Most large modern rooms use a moving air (ventilation) system. Older rooms may use just steam or hot water heat. In steam-heated rooms, just replace the noisy valves regularly. In ventilated rooms the more the air moves the more efficient the transfer of energy. To save money, smaller ducts resulting in higher air velocity are sometimes used, thus more noise.

There are "low noise" outlets for air handling. These have a larger open area than normal to allow for slower airflow for the same volume of air. There are also "lined ducts" which have sound-absorbing material on the inside. The idea is to reduce the noise traveling in the duct. The best attenuation in an air duct is, of course, a right angle bend with absorbent material. The high frequencies travel into the absorbent wall and are diminished. Obviously the bigger the duct, the less flow is required to get the same volume of air motion and lower noise.

The second most common built-in noise sources I have encountered are noisy lights, which have bad—or, in some cases, wrong—ballasts. There are ballasts made for outdoor lighting, and can make much more noise than the ones designed for rooms. These outdoor ballasts are cheaper, but you risk rendering a room useless. Just replace the ballast.

The third in-room noise source is electronic devices. Both stationary devices such as computers, light dimmers, and so on, and portable ones such as video games and cellphones make noise. How annoying are cellphones ringing during public performances! I once went to the theater and the entire time someone was playing a portable video game. Signage and announcements may help prevent these noises and help keep the peace.

Most of these fixes are difficult to apply after a room is built but should be addressed during the design stage. The after-build fixes are usually limited to changing noticeably noisy diffusers, sometimes adding lined bends, and fixing broken parts such as squealing belts or bearings.

Another source of noise can be traffic, which is why carpet in the room(s) above or the hallway outside is a good idea. If you reduce the sound generated, less is transmitted.

GEE-FORCES

Using a bit of attention, you can identify and sometimes even control the sources of noise. The next step is to fix the path by which noise gets into the room. The easiest way for noise to enter is through holes in the walls—often referred to as doors, windows, or "Gee I never noticed that."

There are many versions of doors; obviously an open door transmits the most noise, thin veneer wood doors transmit a bit less. A heavy metal door much less, but if the door has a large gap around the frame a tight wood door would be better. This is where a good threshold is important.

Windows can be thick glass, or even double pane. Closing them greatly increases their ability to block noise.

The most common "Gee" is the invisible gap. Many rooms have ceilings of "acoustical" tile, which is designed to absorb sound, not block it. Plaster would block more sound, but then you would have other problems.

The problem with the ceiling tile is simple: Some sound goes through it. It is usually not the actual top of the room. There is a plenum space above the ceiling and below the floor above which may be used as part of the air handling system or just a space to run wires and pipes. You actually must look at the wall above the ceiling. I hope you will find the wall actually goes up to the floor above. Often it does not! Also, ensure there are no gaps between the wall and the upper floor. With a corrugated floor system, there could be many gaps.

Even if the walls are properly extended to the floor above, check the "penetrations" where the pipes, wires, and steel go through the wall. They should be filled with a rated fire-stopping compound. If not, this should be fixed. Old newspaper is not good here. In a recent room I filled the gap around the fire sprinkler head with foam to reduce the noise coming in by 3dB (**Photo 1**). The small gap reduced the effectiveness of a sound-rated door with seals, double-glazed windows, alternate stud walls, isolated floor, and all the other measures by half!

You may also need to look under items such as stages to be sure all your "Gee" gaps are filled. Do not forget that some things that look solid pass sound as if they were not there! Use your fingers to tap on what look like solid surfaces—a hollow ring will be a hint things are not as they seem.

I recently ran across a room in which the studio floor floated above the concrete floor on a resilient system. Unfortunately, the isolated floor extended outside the studio to the hallway. In the studio, when somebody walked in the hall you could hear and feel it!

PHOTO 1: Gee gap sprinkler head.

In a purpose-built room you often have two sets of wall studs, one set for each side. That way the fiberglass inside is not bypassed by solid contact. Of course, someone will drill holes to pass wires, or mount fixtures bridging the gap. Look for these things, too.

There are other issues such as wall thickness and construction that come into play during design and building stages. These are usually not inexpensive to fix later. My experience is that even with good design and construction, unless a room was purpose-built and frequently inspected during construction, you will have problems.

If you can find or calculate the ratings of all the building materials you can calculate what the losses will be before a room is constructed. To do this you must convert from decibels to the actual value of attenuation, then multiply this by the percentage of the total surface area and sum all the surfaces. When you turn this loss back into decibels, you will have the isolation for the room, except for what you forgot and the holes that will remain unfound. (You forgot that AC outlet wall box, I bet!)

A common misconception is to completely cover the walls, floor, and ceiling with sound-absorbing material. This will keep the energy from bouncing around and reduce it a bit, but it is better to keep it out. A completely "dead" room is not as good as one with the right kind and amount of "liveness." But in rare cases that may be your only resort to reduce a problem. It almost never will fix it.

I once visited a television production facility that was having too much noise go from its machine room into the edit suite. An editing suite is a special case of a room in which the occupants wishing to make sound judgments are more sensitive to noise than usual. There was a hole in the wall for an equipment rack between the two rooms and all the windows had at least 2″ of gaps above and below the glass. It was a design style! I probably could have charged them a healthy fee if I did not break up laughing. Oh yes, they had paid someone else for the acoustic design.

To check whether a room is quiet enough, you should have a sound level meter. There are a number of inexpensive and surprisingly accurate ones available. When you use the meter you will notice the meter reading bounces around a bit. The better meters do this a bit less. Do not use the highest or lowest number. With some experience you will see that this is a number that it all seems to swing around. This is often about 10-12dB lower than the *high* number when measuring speech.

Do not be tempted to use the "C" scale because it is "flatter." The "A" weighted scale (slow) is much more useful for these purposes. You can use the "C" scale to see whether you are fixing low-frequency problems, particularly if you have an inexpensive meter that does not have a very sensitive lower range, but be careful you are not chasing something that is barely heard instead of what counts!

If you ever plan on building an auditorium or buying a sound reinforcement system, be sure the designer or seller actually owns a meter. If they are in the business and don't. . . WOW!

If you stop the noise from coming into a listening room, you also keep it from leaking out. Noise is not the only problem to worry about. . . as you'll see in next month's part 2 article. *aX*