THE MANY VOICES of NRC

Why all ratings are not the same.

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High volume rooms tend to have a lot of hard, sound reflecting surfaces and at the same time hold lots of people. The architectural ceiling and wall systems specified for these rooms are intended not only to deliver aesthetic value to the room, but additionally to deliver acoustic properties to the room.

The standard specification for the acoustic property of these architectural ceiling and wall systems is the NRC rating. But not all NRC ratings sound the same. Even if the NRC rating is the same, different systems installed in the same room will typically cause the room to sound different. And so, for any given NRC, the sound of the room will still vary depending on which ceiling and wall system is selected.

ROOM ACOUSTICS WITH NRC

In general, in most large rooms, many people are talking at one time. Their voices mix together into the reverberation of the large room to create a hubbub, a din of noise called the background noise floor. In order to be understood, any single speaker's voice must reach the intended listeners, located 3 to 6 feet away, with a sound level that is about 10 dB louder than the background noise floor. To achieve this effect, the room needs a total of at least 400 square feet of 100% absorbing material in the room per talking person.

For example: The result of 100 people in a large room might be an equivalent of 15 people talking continuously in the room at normal voice levels. About 6000 Sabines (square feet of NRC 1.0) or equivalent is needed in the room.

A large room might have a floor 80 by 80 feet and a ceiling of 40 feet. The floor and ceiling space is about 6400 square feet each and the walls are 12,800 sqft. The total surface is 25,000 sqft and the typical NRC for shiny surfaces is about 5%. The room provides 1250 Sabines.

The floor might be carpeted, with an NRC of 30%, providing 2000 Sabines. There might be 150 people in the room, each providing about 4 Sabines each for a total of 600 Sabines. There might be 300 soft chairs in the room, of which 200 are unoccupied, providing 3 Sabines each, for an additional 600 Sabines. Totaling all, we might have an acoustic compliment of about 4500 Sabines due to furnishings.

Since 6,000 Sabines are needed and 4500 Sabines exist in the room, the project still needs 1500 Sabines. It's usually easier to add acoustics into the upper wall and the ceiling areas of a room. If an architectural ceiling system is specified with an NRC of 0.5 it must be 3000 square feet in size to deliver 1500 Sabines. If the architectural ceiling system has an NRC 1.0, less area is needed, only 1500 square feet.

By knowing how many people are talking at one time and estimating the amount of absorption that already exists in the room, the amount of additional acoustics needed in the room can be quickly estimated.

THE OCTAVES OF SPEECH AND NRC

The NRC is the standard used for architectural acoustic products. It is a number, an average of the absorption coefficients for acoustic materials in the middle 4 octaves of the speech spectrum. The NRC does not take into consideration the material's effect on the lowest or the highest octaves of speech.

When people are talking they produce a wide variety of sounds, throughout the frequency range of sound. The lowest tones are found in the humming part of speech. The highest tones are found in the clicking parts of speech. Between these two ends of the speech spectrum are the high vocal, vowels and the hissing sounds. The frequency range of the speech spectrum can be overlaid onto a piano keyboard to more clearly illustrate the tonal nature of the 6 ½ octave sonic spectrum for speech.

THE TONAL ASPECTS OF NRC

NRC is the average absorption coefficient in the mid-treble range of sound. Because it is an average, it does not indicate the differences that might exist in the actual absorption coefficients, octave by octave. Shown in the table and graph are three hypothetical sets of absorption coefficients. Each of these sound panels have the same NRC but each has a different timbre.

The NRC does not determine the strength of the reverberant buildup of noise in a room. The absorption coefficients used to define the NRC determine how long which tonal range lingers in the room.

	NRC	250 Hz	500 Hz	1k Hz	2k Hz
Product A	0.5	0.5	0.5	0.5	0.5
Product B	0.5	0.2	0.4	0.6	0.8
Product C	0.5	0.8	0.6	0.4	0.2

A) The room fit with Product A will have a uniform decay of sound in each of the 4 octaves, with all tones damping out at the same rate. It will have a balanced sound.

B) The room fit with Product B has weak attenuation in the middle tones and strong attenuation in the high tones. This room will have a dull, hollow and yet hushed sound.

C) The room fit with Product C has strong attenuation in the middle tones and week attenuation in the highs. It will sound splashy, zingy, harsh and bright.

FIGURE 1: VOICE AND NRC OCTAVE BANDS OVERLAID ON PLAYING KEYBOARD.

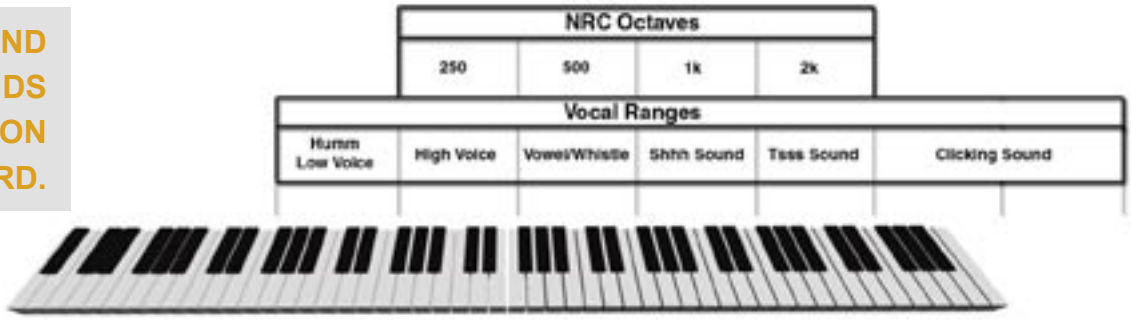
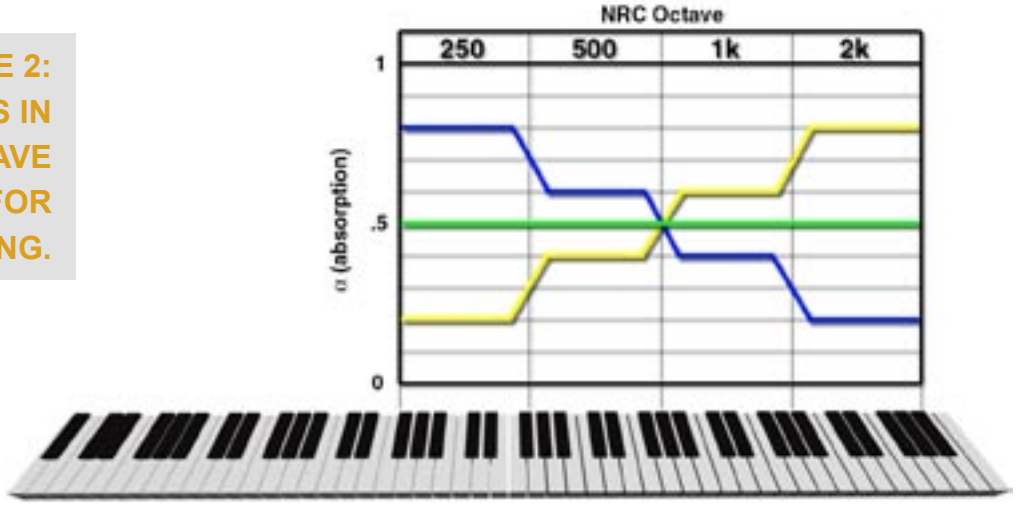


FIGURE 2: VARIATIONS IN OCTAVE TO OCTAVE ABSORPTION FOR SAME NRC .5 RATING.



THE DIRECTIONAL ASPECTS OF NRC

NRC is measured in a reverb chamber, a marble faced room that reverberates any sound for 15 seconds. By measuring how long the reverberation lasts with and without the acoustic panel, the acoustic properties of the panel can be determined.

Reverb chambers generate random sound. That means they only measure what sound panels do when they are impact by sound equally from all directions. The resulting absorption coefficient at any octave is actually an averaged absorption coefficient for sound impacting the panel in all different directions.

Sound panels in general absorb sound that impacts their surface squarely and do not absorb sound that grazes their surface. There are two basic types of architectural acoustic ceiling systems; sound panels and sound baffles.

TERMS AND USAGE

SABINE - A measurement of sound absorption. One sabine is the sonic equivalent of a 12" x 12" open window – Sound enters, and does not return.

NRC - A measurement of a material's ability to reduce sound energy. Calculated by averaging sound absorption over the approximate tonal range of the human voice.

TREBLE - High frequency sound. Treble begins approximately 2 octaves above middle C on a piano.

dB - A relative measurement of sound pressure level. 60 dB is the level of conventional speech. 100 dB is a loud rock concert. 40 dB can barely be heard, while 125 dB causes hearing loss.

ABSORPTION COEFFICIENT - The efficiency of a material's ability to capture & reduce sound energy. An absorption coefficient of 1.0 is equivalent to an open window.

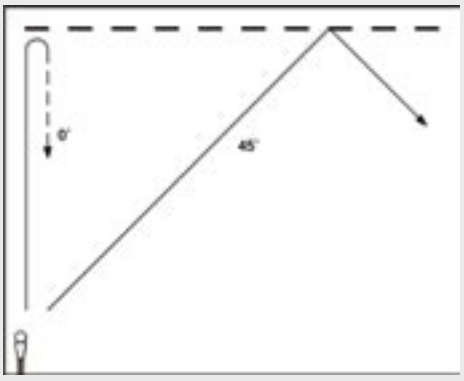
ATTENUATION - Reduction of perceived or actual power in a system. In acoustics, this relates to intentional reduction of sound levels.

SUSPENDED SOUND PANELS

The most familiar architectural acoustic ceiling device is a suspended acoustic tile or sound panel mounted on the sheetrock ceiling. The table shows what happens when sound panels are laid out flat, with their surfaces in the horizontal plane, near the ceiling. This very typical architectural acoustic ceiling system mainly attenuates the sound that impacts the system vertically. The horizontal, grazing impacts are very slightly attenuated. Angles are taken off the perpendicular to the surface of the material.

FLYING SOUND-PANEL SYSTEM

ABSORPTION VARIES WITH ANGLE



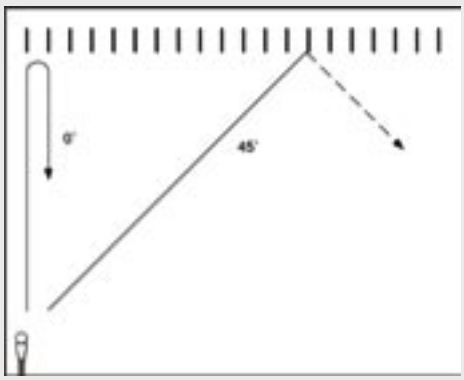
NRC 0.5	250 Hz	500 Hz	1k Hz	2k Hz
Random angle	0.5	0.5	0.5	0.5
0 degrees	1.0	1.0	1.0	1.0
45	0.4	0.4	0.4	0.4
90	0.1	0.1	0.1	0.1

SUSPENDED SOUND BAFFLES

The other basic architectural acoustic ceiling system is the baffle system. The grid for the baffle system is still horizontally distributed but the sound panels that fit into the grid are hung vertically. Sound passing upwards is not attenuated but sound intermeshing the baffle system at a grazing angle is heavily attenuated.

FLYING SOUND-BAFFLE SYSTEM

ABSORPTION VARIES WITH ANGLE



NRC 0.5	250 Hz	500 Hz	1k Hz	2k Hz
Random angle	0.5	0.5	0.5	0.5
0 degrees	0.1	0.1	0.1	0.1
45	0.4	0.4	0.4	0.4
90	1.0	1.0	1.0	1.0

THE BANDWIDTH OF NRC

NRC is the average absorption coefficient in the mid-treble range of sound. It does not address the bass range of sound nor does it address the higher frequencies of sound. Two products with the same NRC could have the same mid-treble range absorption coefficients and they would cause the room, in general, to sound the same in the mid-treble range. But these same two products could easily have very different absorption coefficients in the bass range and high frequency ranges of speech, the 125 Hz, 4k and 8k Hz octaves.

	NRC	125 Hz	250 Hz	500 Hz	1k Hz	2k Hz	4k Hz	8k Hz
Product A1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Product A2	0.5	0.2	0.5	0.5	0.5	0.5	0.7	0.9
Product A3	0.5	0.7	0.5	0.5	0.5	0.5	0.2	0.0

Different products with the same NRC can produce different amounts of bass attenuation. Here in the Table is shown 3 hypothetical products, each with the same NRC rating and absorption coefficients. Yet in the lower vocal octave, the 125 Hz octave and in the upper two upper vocal click octaves, the 4 and 8k octaves of speech, the absorption coefficients are different. It is the absorption coefficients octave to octave that determines how long a particular range of sound lingers in a room and therefore, how loud is in the background noise.

A1) This room is fit with a uniform absorption coefficient in all octave bands. It has a comfortable, uniform type of residual sound.

A2) This room is weak in low frequency attenuation and strong in high frequency attenuation. Midrange in this room sounds fine generally but it has a deep, rumbling, thunderous background and a lack of air, of any sparkle.

A3) This room is over damped in low frequency range. Midrange in this room sounds fine generally but the sound in the room lack lacks solidity, it is thin and weak in the bass range and tinny, overly bright in the higher ranges of sound.

NRC VOICED ROOMS

The basic goal in voicing a room for speech is to create a space where the background noise level due to the build up of reverberation is at least 10 dB lower than a person's speaking voice, octave to octave. That is accomplished if the total acoustic material in the room provides 400 square feet with an absorption coefficient of 1.0, or equivalent, for of the speech octaves, for each hypothetical continuously talking person.

Different architectural wall and ceiling systems will compete for selection on the project. Those who meet NRC criteria are in the running to be selected. Despite having the same NRC, how the room sounds will significantly depend on which system is selected and how it handles sound, octave by octave throughout the entire speech frequency range.

If the project doesn't sound right after it is installed, it might not be because the NRC is off or that the installers did something wrong. It might be that the make up, the internal octave to octave features of the selected product's NRC did not match the internal, octave to octave features of the sound being generated in the room.

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