Free Space Listening
Listen To the Music...Without Hearing The Room

Dennis Foley & Mike Sorensen

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Books written by Dennis Foley & Mike Sorensen can be obtained either through the author's official website:

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Advance Praise for Acoustic Perceptions

Listen To the Music...Without Hearing The Room by Dennis Foley & Mike Sorensen

Dennis and Mike are the bedrock of the Acoustic Fields room acoustics design team. The foam from Acoustic Fields, absorbs more evenly and smoothly than any foams we have used in the past. The 2" thick version is now a permanent part of our vocal room and covers over 50%.

The carbon absorbers, absorb bass like I have never heard before. They are freestanding units, that tamed our control room's, two - 18" subs in the front of our room, which we always thought sounded good. We now have definition, and attack / decay, like we never imagined possible.

Don Salter, Owner of Salt Mine Studios, www.thesaltmine.com, named Major Label News Top Recording Destination in the United States 2012.

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Foreword

My name is Dennis Foley and I am an acoustic engineer with over 30 years' experience in the business. My technology has been used in Electric Lady Land Studios, Sony Music of New York, Cello Music and Films founded by Mark Levinson, and Saltmines Studios in Mesa, Arizona, along with hundreds of others.

I teamed up with Mike Sorensen 15 years ago thanks to his incredible talents as a structural engineer. Mike has been in the business going on 30 years and is a fountain of knowledge and a true pioneer. Together we've had the pleasure to work on some incredible room acoustic products, brought positive change to the listening environment of countless studios and worked with some great engineers.

The aim of this book is to share the fruits of that wisdom with you so you can find actual solutions to your room acoustic problems rather than the sticking plaster solutions offered by some companies… which frankly do not work as claimed, especially when it comes to bass absorption.

So first let me tell you a story of how this all got started. Are you sitting comfortably? Good, then let's begin.

I got started in this business designing class A office buildings. Designing class A office buildings requires attention to many details. In order to understand the acoustics of each room, you must focus on the usage of that room. Office buildings and the rooms within them must focus first and foremost on vocals. In particular, at least back in the time period our foam technology was developed, the sound energy of main concern was the male vocal. Office buildings and rooms within them were mainly occupied by men.

We had men on phones, giving meetings, and meeting with clients. Vocals became our primary focus and we needed a lightweight material that could absorb and reduce reverberation times but do it in a manner that favored the vocal frequency range which for our purposes which were the frequencies from 100 Hz. – 500 Hz.

MUST FOCUS ON THE HUMAN VOCAL RANGE

We had the standard acoustic foams back then that are available today. We had the Aurelex, Sonex, mineral wools, and fiberglass insulation that are so popular today. We ruled out the fiberglass and mineral wools right away because of their hazardous nature to work with. Fiberglass and mineral wools had fibers and had to be assembled with masks and protective clothing. They were cheap and economical but that is not what we were about. We wanted performance and ease of installation. Cost was a concern, but not our main one. Performance had to come first.

PERFORMANCE FIRST – COST SECOND

Using standard Aurelex and Sonex foams were our next choice. After measuring many office buildings, we knew that we had to come up with smooth absorption from 100 Hz. – 500 Hz. We installed complete rooms with both types and did our measurements. Most of the room's surfaces had fabric covering over the installed foams since the appearance of existing foams was not of high enough quality for a class A office building. We even had employees work in the rooms and give us their feedback on how they thought the room sounded and how was it to actually work in.

ABSORBS 6 TIMES MORE AT 100 Hz. AND 10 TIMES MORE AT 250 Hz.

Our tests, both subjective and objective, revealed certain parts of the audio spectrum that were not being absorbed. We quickly realized that the Aurelex and Sonex foams did not go low enough to absorb unwanted energy particularly in the 100 Hz. – 250 Hz. range and if they did absorb energy from 100 cycles to 250 cycles, they did not absorb enough of the energy needed for proper vocal intelligibility, especially with multiple vocals within the room. The existing foams worked well from 250 Hz. and higher, but they didn't go low enough with enough absorption power to really get the low end of the male vocal range under control to provide the necessary amount of clarity and definition required in our office environment. We decided to pursue the development of our own foam technology that would go lower and absorb more energy at the frequencies below 250 cycles.

ACOUSTIC FIELDS' FOAM CELLS ARE CLOSER TOGETHER ALLOWING FOR MORE ABSORPTION

To increase absorption at lower frequencies, we did not want to take the usual approach and increase foam thickness. We use the 2″ thickness as our maximum foam thickness and worked within that space requirement. If we increased foam thickness to 4″ which would accomplish our lower frequency absorption goals, we would be sacrificing valuable physical space. At the price point of our buildings, we needed to have maximum absorption power in the smallest amount of space.

ULTRA SMOOTH AND GRADUAL SOUND ABSORPTION CURVES – MORE REALISTIC VOCALS AND INSTRUMENTS

After numerous attempts, we discovered a way to increase the cell density of our foam and to make the cells more uniform in shape and more consistent in their density across the foam surface. Our foams are denser and heavier than existing foams currently in the marketplace. This density is a requirement to achieve the superior absorption results we achieve below 250 cycles. Not only did we achieve the levels of absorption that we designed for, we discovered that by achieving this goal, the overall absorption curve was much smoother and more even.

ALL PREFERRED OUR FOAM TECHNOLOGY

After we created the foam, we installed it into numerous office environments and did our testing. Without exception, everyone preferred working and speaking within the rooms that had our new foam installed. We continued to work on the smooth absorption curves that our foams produced and keep that smooth absorption curve throughout different foam thicknesses. Today our foams are available in 1/2″, 1″, and 2″ thicknesses.

VOCALS AND MUSIC SOUND BETTER

After many installations within the office building scenario, we started installing our foam in rooms where music was played. To our surprise and amazement, the lower and smoother absorption curves we had created with our foams worked well with music, especially vocals. More subtleties were revealed in the vocals of music presentations and there was an evenness to the musical presentations that other foams did not produce regardless of thickness used.

Over the past 30 years I have learned so much but top of that list is 1) if vocal and mid-range definition and clarity are a concern, you must try our foam and 2) if you have tried all the bass absorbers that are out there and you still have that room modal issue that is driving you crazy, you must try our carbon (charcoal) absorbers. It will be the last low frequency absorber you will ever need to own.

We hope you enjoy this book as much as we have enjoyed writing it and the journey we have gone on to reach this point in understanding room acoustics. Use this book as your guide and if you have any questions we are always available to offer advice and help. You can reach us at info@acousticfields.com or call us at 877-593-8802. Enjoy!

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E - BOOK INTRODUCTION

The four main sections of this e-book are as diverse as they are practical and interesting.

The Acoustic Perceptions section examines the urban myths that are associated with room acoustic technologies and shows why definitions and perceptions have been distorted by the large manufacturers to selfishly promote their products. There are many urban myths when it comes to room acoustics. Those that are not informed will fall prey to these myths and not be able to realize the full potential of their rooms and sound systems within them. For example, many manufactures distort the definition of low frequency to the point that they call foam wedges and boxes filled with building insulation, low frequency absorbers. We examine these myths and try to find cause and examine effect, so you can make an informed decision on technology purchases. We have all bought something that claimed to be this or that, but when we put it into our room, we still had the problem that we bought the unit to solve for us.

Our Acoustic Technology section examines past and current efforts at dealing with sound absorption and sound diffusion in our professional recording studios, listening rooms, and home theaters. Technology has grown rapidly especially when it comes to electronics. There are advances in amplifiers, digital to analog converters, and processing speed and power have increased exponentially. Unfortunately, room acoustic technologies have not kept up with the electronics. Products that absorb or diffuse sound energy are basically the same technologies that have been around for years. This is good because we all know what works well and what does not. For those things that don’t work well, we examine many new and different approaches to dealing with room acoustical issues.

The Room Set Up section examines what size of room to use, for what purpose and gives assistance on where to place speakers and listening position. In small room acoustics, room volume starting on the low side of 1,500 cu. ft. and going upward to 6,000 cu.ft., we have many acoustic variables that must be addressed. We have the low frequency pressure issue which is related to room dimensions and room volume. We also have the reflections that occur from each and every room boundary surface. Positioning our speakers or sound generating devices into the room in order to arrive at the best balance of all the conflicting variables requires a starting point based on science, but a final position based upon the individual subjective impressions of the listener. The room set up section gives you many starting points to begin your adventure.

Finally we have the “How To” section which explains how to use and even build sound absorbing, sound diffusion, sound reinforcement and sound isolation technologies. This chapter explains the actual reasons why you need to do things that will help you to accomplish your acoustical objectives. There are some step by step processes explained, but the main reason for this section is to explain the theory behind each process and provide some application techniques that will go a long way towards your acoustical understanding.

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Chapter 1: ACOUSTIC PERCEPTIONS

Acoustic Perceptions covers things that people think are true and are not. The articles in this section discuss the demands rooms place on our sound and the myths created by manufacturers to take advantage of individual's lack of acoustical knowledge. One such myth is that foam and boxes filled with building insulation are bass absorbers. They are not. In Acoustic Perceptions, you will find out why this is not true along with other commonly held belief systems that are not quite true.

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How Can All Recordings Sound Good?

What Is Good Sound?

I am in and out of full time and project studios almost every week. All the engineers who I speak with think that their sound is good sound. How can this be? They all sound so different to me. They all have different rooms, monitors, microphones, you name it. Does all of it qualify as good sound? The answer is that there is no such thing as "good sound".

Many Different Monitors

Each recording is played back on different monitors. Monitors are as different in sound from each other as are microphones. Obviously, small monitors sound different than larger ones, but controlling for size, we still have many different sounds from many different manufactures no matter what the size. Some monitors are active some are passive. One can even hear the difference between a two way and a three way. The monitors add their own sonic signature to everything.

Separate Speakers

A lot of times engineers use separate speakers for playback and recording. I have seen them using separate speakers for recording, mixing, and listening. I see large full range monitors used for monitoring recordings and then see the recording played back on a much lower quality sound loudspeaker for mixing. If you go to the engineer's home, you will see an audiophile playback system. Is this good sound?

Different Rooms

The rooms in every studio in which the recordings were made are vastly different. Full time studios have dedicated rooms. There are separate rooms for drums and separate rooms for vocals. The nice thing about the dedicated room is that you can tune it over time to achieve the sound you are after. One can learn the room sound after recording in it over time and thus find the correct microphone positions within the room. Only trial and error over an extended time will find these locations.

Too Many Choices

Smaller project studios which are limited on space must make do with one room performing many functions. One room must record vocals and instruments. This is never welcome. Vocals and instruments require different approaches to room acoustical treatment. I have even seen one room that was the control room, vocal booth, and drum room all in one room. Is this good sound?

Good Speakers / Good Sound

Are today's speakers up to the task of producing good sound? If good sound is so different because of so many variables, maybe we need to look towards the speaker's performance as our good sound indicator. If we examine the frequency response curves of each different speaker manufacturers, we see different response curves. Some have attenuation in their curves to compensate for room boundary effects. Some mid ranges are more forward than others. Is this good sound?

Headphones Only

Why do engineers who record classical music use mostly headphones? I have never seen one use monitors during the process. I have seen them using monitors when they do a final or close to the end playback. They are always using headphones. Does this process make for a good recording? Since classical engineers use headphones, should they be our new good sound reference. There are many who think this way.

Playback / Recording

Should we have separate playback rooms within our recording studios? Should that help us with producing good sounding recordings? Is there a playback standard sound quality we should strive to record for that will have a great sound in a playback system, hi-fi or otherwise? Do we need to produce a recording that takes into account the environment that the recording is to be played in? Would this approach give us a good sound standard to go by? Who is John Gault?

Room Sound

Every room I am in has different levels of room sound in it. Most professionals have a basic understanding of acoustical treatment but most do not completely understand the impact of room acoustics in their mixes. They continually live with and work around this resonance or back wall delay issue without dealing with it from an acoustical perspective. Ask any engineer what issues he or she is having with the room and they will tell you in great detail. Ask them what they have done to resolve those issues and you get a blank stare or an explanation that will not come close to a remedy for the sonic issue.

Low End Issues

The low end of most rooms blurs and smears the mids at certain frequencies and at those frequency harmonics. Most engineers work around this elephant in the control room. Is this part of the process of achieving a good sounding recording? Are we supposed to work around something to achieve something else? Maybe in other parts of life but in recording and playing music, we have the technology to deal with these issues. We have the capacity to solve these resonances. The recording should be about the music and not the room.

Middle And High Frequencies

Middle and high frequency reflections from all room boundary surfaces are present in almost every studio I have been in. These reflections have to add their own stink to the mix. We have reflections from side walls, a rear wall, and don't forget about the ceiling. We have reflections from the console and equipment that we must use to perform our craft. These reflections must be delayed in time and strength to minimize their impact at the monitoring or mix position. Every studio uses a different approach to this treatment. Is this good sound?

Opinions Vary

The term good sounding recording is a little like an opinion. Everyone has one but most are different from each other. The opinion is based on that individuals experience and frame of reference. It is highly subjective. We need a "good sound" standard to be established and then adapted by all to raise the sonic bar to a certain level and then we can exceed that benchmark by producing a new term with no standard: "great sound".

* * *

Try Harder To Understand Acoustics, Please.

Piano Woman

I just left a customer, well at least I thought possible customer. Isn't this the basis for our business appointments? Customer x has an acoustic issue and company y is there to design a solution for the issue. That is the basis for our meeting and spending time together. In fact, if it wasn't for that reason, we may never have met at all.

Acoustic Issue

The acoustic issue is usually described as "It sounds bad" or "The sound in the room drives people out of the room when I play piano". There are others such as its too loud in this part of the room and you cannot hear anything at all in this part of the room like you can the other part. After all of these comments, I am not so sure I want to go into the room.

Referral

I was referred to this customer by a dealer. She had a grand piano in her room and it was a larger room actually a good size for just a piano. Unfortunately, the room had to be a living room, a dining room, and a music room for the piano. One of the comments above was from this customer. It does not matter which one.

Need Surface Area

When I spoke with the customer on the telephone, I informed her that acoustic issues would take wall surface area to fix and would she be willing to install absorption technology over those wall surface areas. She said she understood and had no issue with that. She did not have an issue with that. I never thought to ask about the husband. It never even occurred to me. I figured if the wife was fine with wall surface treatment the husband was good, too.

Room From Hell

When I walked into the room, my worst fears were realized. The room was good size with 25′ ceilings but the piano was in the corner. To make matters worse, one of the corner walls was glass. I should have run as fast as I could at that point, but I remembered my conversation with the woman customer on the telephone about willing to treat offending surfaces.

Issues Described

After about 15 minutes of explaining the issue and the treatment, I settled on a room tuning approach. The customer had no idea on what type of sound she wanted, but she definitely did not like the sound that she had. I decided to let her tell me what she liked after I brought in some acoustic foam to assist her in her tuning efforts. This is 2″ open celled acoustic foam.

Starting Point

I estimated she would need about 10, 3′x 5′ pieces strategically placed to produce a noticeable difference in the rooms decay times. It would not bring the reverberation times down far enough into the acoustically acceptable range, but there would be a distinct audible difference to the lay person. This was my hope, since the woman was a musician.

Plan In Place

We all decided on an approach. I would bring the 10 pieces over and place them in her room around the piano. She could then practice or play the piano and listen to the result. She could add or remove units at will and try to find a sound that was more to her liking. It is difficult to try and figure out what people consider good sound. There are too many human and subjective variables to consider.

A Four Unit Start

I did not have 10 with me but I did have 4 in my vehicle. I positioned the foam pieces around the panel in the room corner covering the one glass “wall”. I instructed her to take her time with the foam and I would be calling her next week to deliver and set up the remaining pieces for her to complete her room tuning process with. They both agreed and on my way I went.

Call Back

About two miles down the road, I received a telephone call. It was the client and she said that her husband was upset because he found the 4 panels too visibly obtrusive. I said that I would return since I was still in the area and we could discuss this issue. I headed back to the appointment.

Role Reversal

After I arrived, I listened to the husband tell me that numerous foam panels on the wall would destroy the balance of the room. He stated that panels on those two walls would be overwhelming and bring a lop sided balance to the room when one was looking out the window. Everything the husband said was what I would have expected from the wife. I thought I was in a parallel universe. I explained that 4 units would just be a beginning and that we all agreed to try 10 total. If you find 4 obtrusive, what will you think about 6 more? I picked up my foam and left, mumbling to myself, “Please, try harder to understand acoustics”. Well, something along that line.

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Watch Out For Room Pressure Zones

Pressure Zones

The pressure zone of a room is defined as that pressure area that exists below the frequency of the lowest room mode. This pressure zone is dependent upon the room’s dimensions. The room’s dimensions will tell us what our lowest resonant frequency is going to be. Anything below that frequency we are entering the pressure zone.

Pressure Zone Pressure

The move into the pressure zone is a gradual slope within the frequency response of the room. The rate of this transition depends on the strength of the resonance. Inside our room’s pressure zones, waves of energy do not exist. They energy in the room is raised or lowered through the diaphragmatic action of the speaker driver. There are points of pressure maximum and pressure minimums within these pressure zones.

Look Below 100 Cycles

If the room is considered acoustically a small room, then we need to look at 100 cycles as the frequency where our pressure zones can be considered acoustically useful. The longest dimension in our control rooms should be at a half wavelength of the designed for lowest frequency we need to hear clearly without room resonance distortion. If we use 20 cycles as our designed for lowest frequency, then half a wavelength would be 28′. With this dimension, we would have no speaker response within the pressure zone.

Room Modal Response

Modal room responses are the track that the room’s frequency response “rides” upon. Under every trough in our frequency response curve lies a room mode. Each room mode has an amplitude and width, starting at one frequency and ending at another. This is the domain of the mode with the modal response frequency at the center point in the mode.

Q Value

Modes can have a high Q value which would be a squashed bell shaped curve and a low Q value which will result in a more peaked and narrow bell shaped curve. It is desirable to have each of these modes underlying the room's frequency response to be at least 10 Hz. apart in order to not increase our pressure issues in different room locations.

Locate Room Modes

Looking at the frequency response of the room we now need to place that energy picture with all the underlining modes within the physical room. Let's go room mode hunting. Lets first start in the room's corners. Next, all floor and wall boundary intersections. Third, the walls and ceiling join points and the floor to ceiling area. The strongest axial mode will between the two farthest apart room surfaces.

High And Low Pressure Areas

Between each room modal pressure area, there are areas of high and low pressure. Depending on the frequency of resonance, there will be areas of high pressure at the mode frequency and then radiating out from that high pressure area in a series of lower pressure rings as we get away from the modal frequency. This radiating effect is similar to throwing a stone in calm water. Higher pressure waves begin at the stone/water entry point and radiate out from this center point losing intensity as it moves away from the source.

Anti-Node

A loudspeaker placed into a pressure anti-mode would fill that anti-mode with pressure as sound waves generated from the loudspeaker. If we place a listener in this anti-node position, they would also hear an amplified sound. This frequency of resonance would produce no sound for a listener in an anti-node. Having all these modes in certain room positions, makes finding the correct location for both listener and loudspeaker spatially dependent.

Reflections

Reflections from room boundary surfaces can also factor to our response graph effect frequency response. If we look at the floor bounce, we see a dip in the frequency response curve of a typical room. This usually occurs around 200 cycles. The ceiling adds another bounce at 200 – 300 Hz. Increasing the same frequencies that the ceiling bounce caused. The back wall increases the hatching of our frequency response curve. Adding in the side walls, we have an all boundary response curve with many more jagged edges especially above 100 cycles.

No Cube Shaped Room

It goes without saying that we do not want two identical dimensions within our room. If we take a cube room, we have all axial modes at full strength. They will superimpose themselves upon each other and this will produce strong resonances. There will be greater spaces between modal frequencies because there will be less frequency distribution than would be the case if the height, width, and depth would be different dimensions.

Non – Parallel Walls

Non parallel wall surfaces will reduce reflections and smooth out our room frequency response. This approach will not make the number of room resonances smaller. Only room dimensions can have that impact. One can reduce some impact of resonance modes to a certain degree with non parallel surfaces. However, no standard formula exists to determine what impact and where non parallel walls will have that impact. Only the experience of the room designer can help here.

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Who Knows What Good Sound Is?

Different Sounds

As I go into many project and full studios, it is always amazing to me how different each control room sounds. Each engineer has selected what he or she thinks will produce the desired sound when it comes to equipment and especially the speakers. Engineers will keep using the same monitor that they have been using even though a newer monitor may bring different variables to the monitored sounds and perform better.

All Sizes And Shapes

I see many shapes and sizes in different control rooms. In full time studios, we see both large and small monitors. In project studios, we mostly see smaller monitors. There is also, mostly in full time studios, a smaller speaker that is designed to sound like speakers found in computers, radios, and other common listening devices. The thinking is that this quality level and speaker size is what a large segment of the marketplace listen to music on.

Classical Recordings

The classical recording process is different. The classical recording process uses very small speakers, namely headphones. Headphones are used because they provide the detail necessary to monitor the sounds. They also provide isolation from outside noise. If monitors are employed, they are larger ones that represent a higher quality sound level. The classical recording artists and engineers focus on the producing a classical sound in the recordings, so electronic signal manipulation is frowned upon.

Acoustical Pallet

Each speaker or monitor produces a different color if you will upon our acoustic palette. The engineer will choose this or that monitor that will create the sound the engineer wants to produce and would be considered by the engineer to be good sound. The engineer must create sounds with a big picture in mind. He or she must fit the electronic pieces together to form a larger picture.

Mid-Range Music

The music is always found in the mid ranges. It is that middle frequency range where our vocals lie. It is the area where layers and layers of sound are stacked upon each other and all must be able to be heard. A speaker must be able to produce this middle range energy and do it in a manner that will create an emotional connection between the music and the listener. It is even welcome to select a monitor that has more of a forward sounding mid-range.

No Standardization

All of this subjectivity and impression creating lends itself to a lack of standardization in the recording, especially monitoring process. Most engineers do not care about how a monitor works but rather really only care about that monitor working for them and helping them to create their sound. In a playback mode, they want to not hear all the little sounds that took to make the recording but rather the sum of all of these parts to produce a musically sounding piece of work.

Hi- Fi Everything

The hi-fi person wants to hear everything. Hi-fi people want a speaker to be revealing and produce resolution and detail. Hi-fi people want to hear all of the parts. The recording engineer just wants to hear the music, not all the parts. Each uses a speaker to accomplish what each one considers to be good sound. It is all about what each person wants to hear and that want is based on many different variables.

Manufacturers Part Of Problem

All of this subjectivity enters into decisions manufacturers make. Manufacturers do not assist in the sound quality producing process. They will design a loudspeaker to fit into a particular price point or even appearance point. Sound quality may be a sixth or seventh priority in the total loudspeaker design considerations. Marketing and salability overrides sound quality.

Room Sound / Speaker Sound

How the speaker sounds in the room is another variable. Near field monitoring will only do so much to eliminate the room sound. The room is always in the mix and must be adjusted for. Fighting a bad room can only add more noise and confusion to our mixes, especially in the low end. Rooms and speakers need to be sized matched in order to avoid room distortions. Large drivers in small rooms goes against both common and acoustical sense.

Recording Standards

There needs to be a better definition of what a good recorded sound is. When I play back any recorded music within my listening room, I am always grabbing for a knob on my EQ at the listening position. Every recording has some acoustic abnormality that needs to be addressed. The issues are usually focused on the low end of the recorded source. There is usually a need to reduce through EQ some part of the low end frequency response, so that the low frequency energy produced by the speakers from the recording will fit into the room.

THX Equipment Requirements

THX uses this standardization process to apply to the speakers and amplifiers that they want to produce their source data. They require that amplifiers have a particular or minimum power handling capacity to be able to cover large transient ranges from gun shots to explosions. Speakers reproducing the THX format must have a full range frequency response handling capacity and match the amplifier power ratings. This certification process specifies the necessary performance minimums of the equipment but does not really do anything about what the room sounds like.

Standardization Need

We need some type of acoustic standardization for our sound engineers to follow. We need to raise the minimum performance levels and standards of our recording engineers, so that we are all at least starting from a similar page. I am thankful that there are always engineers who have read farther into the acoustic book. Their recordings really do sound good.

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Good Room Sound Has Many Demands

Listening Experience

Most individuals that want to build a room to record sound energy within have not done much listening in actual rooms. They have spent time sitting near field in front of their monitors but they really do not know how a room sounds. Their listening framework consists of all of their experience through the tears, sorry years, of listening to many different speakers within many different rooms. Familiarity breeds comfort, even if some comfort is missing.

No Pain, No Gain

Engineers who receive recognition and fame may have earned that recognition and fame for a single hit or song. Their overall knowledge level about good room sound may not equal their recording skill set. Marketing creates hype with flash and sizzle that no engineer can keep up with in order to try and make a living in the business. If it is not good sound, they may not know and do not want to say. Unrealistic expectations, combined with this marketing hype, create a need to go along with the status quo and not upset the apple cart, even if the majority of the apples are spoiled.

Many Variables

There are so many variables that must be considered, it is difficult to get a good consensus on what a good sounding room is. Room size, equipment, and the quality levels of musicians are critical. What materials do we use within the room to create the sounds at the microphone position we need for that particular instrument? Where do we locate the microphone, once we have designed the rooms for minimum resonances at the microphone position?

Peer Pressure

Marketing programs by large corporations create a following that then turns into peer pressure. This peer pressure turns into expectations and maybe these expectations are realized but mostly they are not. We all have heard how foam can stop excessive low frequency energy within our small rooms. Nothing could be further from the truth, but they say it anyway. Unfortunately, people literally buy into it.

Real Room Acoustics

A room designer must wade through all the noise to find the truth. He must deal with all of these human perceptions and myths and construct a room that has some basic consistencies to it. There must be some givens in the room design equation that must be met and there is no compromise on these variables. We must start with room size.

Size Does Matter

There is a minimum room size we must have to start. It is a room size and volume that can deal with room resonances and not make things worse for recording or monitoring. There is a ratio of room sizes that lend themselves to good acoustics. One of the most important dimensions is room length. We must have at least 30′ in room length to have a room that will have a chance of measuring down into the 20 cycle range. There is no exception to this requirement.

Room Height

Room height is another no compromise situation. The parallel surfaces between the floor and the ceiling are big contributors to low frequency build up and a whole host of middle and high frequency issues. There must be adequate height in our golden ratio of height, width, and length, to be conducive to minimizing those issues. We must have a minimum height of 12′ to accomplish at a minimum these acoustical objectives. There is no exception to this requirement.

Wall Construction Techniques

The wall construction methodology must use block or brick. Wood frame is not acceptable to producing real quality sound. Frame does not produce any isolation nor does it produce any real quality sound. Frame construction moves too much. Sound pressure energy can cause frame construction to move or vibrate just like a speaker does. The wall goes diaphragmatic and begins producing sound of its own. The vibrational plates of frame construction add to the vibrational levels within the room and will contribute to the room’s sonic signature. Walk into a wood framed room. Now, walk into a brick room. It is not difficult to hear the difference. Lower structural vibrations are always conducive to a better sounding room.

Low Frequency Absorption

Low frequency absorption must have the necessary rates and levels of absorption to insure all low frequency resonances are under control. Proper low frequency management techniques must be employed at the proper room position to absorb the necessary magnitude of the resonance. Foam will not work and do not believe the marketing slogans. Foam is only applicable above 100 Hz. no matter what the manufacture claims its low frequency absorption capacities are.

Middle and High Frequency Absorption

Middle and high frequency absorption technologies must also have the necessary rates and levels of absorption in order to maintain the musical integrity of the reflection we are controlling. We do not want to over absorb the reflection. We just want to minimize its strength to reduce its impact at the monitoring or listening position.

More Not Better

Most middle and high frequency technologies in the marketplace today over absorb energy to reach high absorption coefficients in order to sell more product. More is not necessarily better when dealing with reflections. We do not need to destroy energy through too much absorption in order to manage it.

No Compromise

Everything in life is a compromise. However, when one is concerned about and places a high value on sound quality within a room, there are areas that cannot be compromised. Designers must stick to their beliefs and tell a client to choose another room if compromises for the chosen room look longer on a list than does the equipment. Sometimes, one must just say no.

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Don’t Get Trapped In Acoustic Urban Myths

Art And Science

Acoustics is both a blend of art and science. Sometimes there is more art when there needs to be science. Here are some examples of art replacing science.

Small And Large Rooms

As I work back and forth between large room reverberation times and small room resonances, one gets the opportunity to speak with many individuals associated with the audio and video equipment within those large and small rooms. There is a understanding and general agreement about their current acoustic issues but a lot of misunderstanding on how to solve the issues and with what materials to use.

Egg Carton

One popular misconception is about room treatments. We all remember the egg carton. It was the cure all from sound isolation to bass absorption. It was a natural diffusor. It does look like some type of exotic, two dimensional diffusor, but its ability to provide any diffusion is negligible, if any at all. It has absolutely nothing to contribute to sound isolation other than how can I remove this from the job site. It has no mass for sound isolation and did not absorb or diffuse any amounts of sound energy.

Carpeting

Carpeting is another standard room item that has taken on all kinds of mythical proportions. Remember, when you saw it on walls in studios. Right idea, wrong material. Although those shag carpets of the 70′s might have had higher than normal carpet absorption coefficients, carpet was given more acoustic credit than it deserved. It is nice to have carpet on the floor in a control room. It would not be wanted in a live room where cellists and acoustic bass ground their instruments to the floor. Carpet in this case can damp the resonance of the acoustical instrument. Once again, as with the egg cartons, no mass for sound isolation and really not a consistent and predictable wall treatment for reflection control.

Furniture

Furniture is not acoustic room treatment. A couch is not a “bass trap”. A couch can have an impact on middle low frequencies, but will do nothing for a 40 Hz. wave and all of its fundamental cousins. It can because of its size have an impact on reflections, but that impact depends on its covering type. If it is fabric we are probably fine, leather surface treatment may even add to our reflection issues.

Bass Traps

Treating the low frequency resonances in small room acoustics takes up a lot of space. This is partly true when one look at the small room project studio. A 12″ deep “bass trap” does take up a lot of space if your room is only 10′ wide. If your room is 20′ long, it is not that much space for the benefit received. Contrary to common marketing practices and claims, foam will not stop low frequency energy. Here’s a good tip: If you can pick up the low frequency absorbing unit by yourself and move it easily around, It is not a very powerful absorber at lower frequencies. There simply is no better way reflected in the current technology to absorb bass wave energy without using mass.

Room Shape

Room shape is critical. A rectangular room offers predictable and consistent reflections that one can then apply consistent and predictable treatment to. Room resonances are highly predictable in a rectangular room and are readily determined by the dimensions of the room. One can apply low frequency resonance control to a rectangular room at the corners and at all room boundary intersections.

Size Does Matter

Room size does matter in the recording process. One cannot avoid the laws of physics and squeeze a smooth frequency response out of smaller rooms. It is just not possible. Well, it can be done but one may have to make the room smaller by applying low frequency treatment in the ceiling area. No one wants to hear that. Sometimes, we must talk our clients out of using that small room for anything but storage for a future room build that has the necessary dimensions to minimize room resonance issues.

Speaker Positioning Does Matter

Speaker or monitor positions do matter. A speaker is a device that produces acoustic energy and then interjects into a box or room. The acoustic energy produced travels at the speed of sound which is a constant. In order to achieve stereo imaging, we must have both distances from all room surfaces in some balanced dimensional pattern. Speaker to speaker distances must be balanced and first side wall surface reflections must be equal on both speaker sides. Not only do we want the direct sound to travel straight to our listening or monitoring position, but we also want the side wall reflection arrival times to be the same at the listening or monitoring position to create the proper stereo image.

EQ Given Too Much Credit

Equalization will not solve all your issues. One needs to get it right in the room. Choose the right microphone and place it in the correct room location and contribute these processes to achieving the best sound you can without adding any electronics to it. If you have a purer original signal then less electronic manipulation is needed with the board. Less is always more in this process.

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Bands And Rooms Have Same Needs

Band Articulation

Bobby Owsinski talks about 3 quick things a band can do as a group to improve quickly. He talks about dynamics, attack and releases, and turnarounds. All three of these have application for bands but they are also applicable for room acoustics.

Band Dynamics

Dynamics is the difference between the loud and soft passages in your music. If you play softly and then loudly, that difference is your dynamic range, if you will, as a band. Variable loudness playing can allow your vocals to be heard more when you are playing softly and then can allow for more emphasize when you need to convey more emotion by raising your vocal loudness level. If you start soft, you have more “headroom” with dynamic range. If you start loud then you must get louder for dynamic impact or stay at the same volume. Neither is welcome for good quality sound recording.

Room Dynamics

Dynamics in room acoustics works in a similar way. Your room should allow for dynamics to be represented completely. Quiet passages must be heard. Over absorption can smother quiet passages. Too much diffusion can produce a separation in vocals and instruments that can be confusing. Comb filtering can blur and smear any difference in volume between quiet and louder passages. Our room must be able to hear both quiet and loud passages with the same clarity.

Sound Isolation

Proper sound isolation techniques employed in your room, will make lower noise levels within the room, so that quiet passages and lower volumes can be heard. Barrier technology is not cheap, but quiet rooms are a great joy. There is no substitute for the quiet in a room that is measuring between 35 – 40 SPL. I was in a room once that was at 28 SPL continually. There were 4 SPL meters that had LED displays that one could read easily. They would move back and forth with 28 SPL as a low. I can still "hear" that room. I will never forget it.

Quiet, Please

Can you imagine playing a soft passage in this room and then a louder one? With a start point in SPL of 28, a loud passage would appear at say, 38 SPL. This would be real room dynamics with a range more conducive to human hearing. Start your car and let the motor idle. Do not move the car. Listen to music with the engine running. Turn the engine off. Listen to the same music. Now you hear what I mean. If we lower the noise floor, we allow for more headroom.

Low Frequency Control

Low frequency control is another part of dynamics that must be dealt with. There is a lot of important sound energy from 30 – 60 cycles. Your room must provide the necessary acoustic "room" for acoustic and electric bass notes. Both of these instruments represent dynamic ranges from soft to loud. Within those two domains are layers of energy that your room low frequency absorption must be able to differentiate. Your room must allow for the dynamics of each low frequency layer of frequencies to be heard in its entirety. High sound pressure areas in the room must be treated with low frequency absorption that addresses not only the pressure's level but it must also absorb this excess low frequency energy at a high rate.

Attack And Release

Attack and release are another live sound area that can be related to a band and a room. Bobby tells us that a bands ability to begin a phrase and end it is critical to producing a good sounding recording. Vocals must begin and end with the proper phrasing. Instruments must begin and release correctly and on time in a regular and predictable time. Bobby cites the Eagle's Hotel California as a good example of attack and release, especially with the guitars.

Attack And Decay

Attack and release in room acoustics translates to attack and decay with musical sound energy within our room. Attack must be defined. We must have low SPL levels within our room using barrier technology in order to hear every attack note at its certain pressure level. We must also have a room that has the correct balance of rigidity in room wall construction and surface materials on these walls. Sound energy takes on the characteristics of the surface it strikes. Strike glass, receive glass in your room sound. With these two conditions in place, it is possible to hear the attack of a note and the following decay without it getting smothered by another attack and decay sequence.

Balance Needed

The room must have the necessary rate and level of absorption at all frequencies to maintain a balance between attack and decay energy requirements. Sound absorption technology used within the room must be smooth in absorption rate so that there is no over absorption occurring at any frequency. Middle and high frequencies must have proper spectral balance between reflections and direct sound. Low frequency absorption rates and levels must be in place to provide enough absorption levels and rates for attacks to occur and then decay on their own volition.

Band Turnarounds

Turnarounds are that few bars between each part of the song you are playing. Bobby cites the area between the “verse and chorus, chorus and verse, verse and outro, and chorus and bridge.” it is a critical part because it is played differently from the rest of the song. A drummer can begin a roll and end segueing into the next section. Other band players may continue to play over the roll. If everyone has their start place and end place, all can be heard in the song.

Places, Please

In room acoustics, all sound absorbing and diffusing technology must be placed in the proper place or surface area within our room, so that the room’s turnaround is predictable, tight, and consistent. Location of different technologies in different room positions will produce different “sounds” within the room. One can produce a wide and deep sound stage by using sound diffusion technology on the front and rear walls of a listening room. In a control room, diffusion on the rear wall can negate the delay in our signal from the rear wall to our monitoring position.

Diffusion Friendly

Diffusion both horizontal and vertical can add sound stage depth and height in a playback environment. Small room playback environments need to create an acoustical space within a small amount of square footage and room volume. Diffusion, and in particular quadratic diffusion, can give us the sensation of a larger room by front and rear wall placement. Side wall absorption, provided it is done at the correct rates and levels, can contribute to vocal and instrument separation along with increased definition.

Dynamics – Attack – Release

Dynamics, attack and release, and turnarounds are three things Bobby Owsinski tells us will help a band show immediate improvement if followed. These three variables can also be applied to the science of room acoustics. In room acoustics, attack and release becomes attack and decay. Turnarounds become the predictable and consistent room acoustic behavior

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Painting Pictures With Sounds

Auralization

Auralization refers to the process of interjecting sound energy into a room and then taking the measurements of that sound’s behavior in the room. We can use this measured behavior to predict how energy will sound like when we play it in the room without any equipment or room treatment placed in the room. We can find the sweet spot and we can actually define the physical dimensions of it. If we change room surface treatments, we can “hear” their impact on the total room sound.

Middle and High Frequencies

Auralization works well for frequencies above 125 Hz. and is also best in large room configurations. I have never been able to find the real definition of what constitutes a large room. For that matter, I do not think I have seen a definition of a small room either. One can use it on smaller rooms and it will assist one with about three different variables that relate directly to our sound presentation.

Direct Vs. Reflected Sound

The first variable we will look at is the ratio of early to late arriving sound. Direct sound is the sound that leaves our speakers and travels the straightest and most direct path to our ears. It is non reflected sound, so it has not struck any room surface and thus finds itself now contaminated by the room. Direct sound is the most wanted. Reflected energy from our room boundary surfaces contains room sound. Measuring the delay from the reflected to the direct, can tell us many things.

D50 – Speech Intelligibility

There is a term called D50. This is the definition and measurement when it comes to speech intelligibility. In order for speech to be heard within a room, we must have a scale or ratio of direct to reflected energy to assist us with defining speech intelligibility. D50 represents all delayed sound arriving within 50 ms of the direct sound. This is our window and reference for speech clarity.

C80 – Music clarity

C80 is defined as the music clarity index and includes all reflected and delayed energy arriving within 80 seconds of the direct. LFC refers to the lateral energy fractions or the impression of spaciousness or “air” in our sonic presentations. This LFC measurement is based on the ratio of laterally arriving reflections between 5 and 80 ms.

T Time – Not Golf Game

The center of gravity or T time is an interesting measurement. This the physical field in which the sound energy is concentrated within. The echo gram will show us a low value if the arriving sound is concentrated in the early part of the echo gram and a high value if the reflections are less strong and the decay of these is slower.

G10 – Pressure Number

G10 is the pressure measurement. G10 is the measured sound pressure with the room as it is compared to the direct energy from our loudspeakers. We measure for G10 by using 10 feet from a omni- directional source. This will give us an idea of how loud the sound will be. This is mainly a large room measurement.

Listening Position

Auralization takes all of these parameters and focuses this data on the listening position. We can now look at the listening position and see the ratio of direct to reflected energy. We can also see the speech intelligibility index along with music clarity, T times and pressure plots. All of these variables can go along way to telling us how the room will sound before the building is even built.

Speaker Locations

We can look at speaker placement and room surface treatments. For example, if we are using speakers that are different in configuration, we can map their spread and look at their impact on the listening position. If we are using dipoles, we can visualize their spread pattern and see where the direct and diffused sound fields are with respect to the listening position. We can map the behavior of different set ups.

Reflection Minimized Area

We can actually listen to all of these variables in real time. We can see how the variables change over time. We can see how the energy from the speakers combines with the given dimensions of the room to pressurize the room. For example, our goal at the listening position is to create a reflection minimized area (RMA) around the listening position. We will be able to see that area by observing the sound pressure levels around the listening position.

Binaural Hearing

Since our hearing is binaural, we can take the binaural impulse responses of the left and right ear and combine them with music in real time, we can measure the difference and be able to hear more accurately the ambiance of the space. If we compare an anechoic music sample which is a music sample that does not contain any room sound with the actual binaural room response, we can hear the impact of the room and the coloration the room produces.

Low Frequency Auralization

Auralization can assist us in predicting room coloration and how to deal with them. It is a process that works well above 125 Hz. but not so well below. Once again, low frequency energy has escaped the predictability that modern technology has given us. We now need auralization for low frequencies. What good is a reflection minimized area if it is smothered by room resonances created by low frequency energy?

Auralization software can help us in determining how our room will sound at the listening position by analyzing the direct vs. reflected energy. It can also tell us pressure levels and the impact of certain acoustical treatments. It is effective from 125 cycles and up and is used mainly in larger room configurations.

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Church Acoustical Measurements

Acoustic Measurements

Using acoustical measurement techniques is imperative for large room acoustics. Sound energy is injected into the room using an active monitor and the signal is then measured for different variables. One of the most important variables with churches is reverberation times. We have the spoken word and the musical word. Even though both have their own individual acoustical needs to sound well, there must be a balance struck between the two when we are talking about reverberation time.

Speech And Music Reverberation Times

For speech, we like reverberation times around one second. Remember, our T60 times means the amount of time it takes our signal to decay from its current reverberate signature down to 60 dB in the room. This defines the speech intelligibility range we need to achieve. Music, on the other hand, likes longer reverberation times. Musical energy requires reflections, voice energy does not.

Church Measurements

We recently measured a church in our community for reverberation times because they were having a problem with hearing both music and vocals. Things had gotten so bad that they moved the choir from the rear of church loft down to center stage. Here is the report the testing team generated.

Background

Reverberation time is a tool used to evaluate the acoustics of spaces. Reverberation time is a measure of how long sound stays present within a space after it is made. More specifically, reverberation time is defined as the time required for the level of sound in a room to drop 60 dB after the signal is turned off.

Preferred Reverberation Time

The preferred reverberation time for a space is dependent upon its physical volume, as well as its intended use. For instance, for speech, we normally want a relatively short reverberation time within a space. If the reverberation time is too long and if the speaker does not speak slowly, a listener will actually hear sound from more than one word simultaneously.

Garbled Sound

The result is a garbled sound that is not easily understood. On the other hand, if music is played within a space with a long reverberation time, the musical notes tend to blend together which is more pleasing than a dry dead sound. So the use of a space has a lot of bearing on what reverberation time is most desirable.

Music And Speech

It is our understanding that a balance between speech intelligibility and musical quality is desired. For the sanctuary, a reasonable reverberation time design goal should be between 2.0 and 2.5 second for mid-frequency sound (500 to 1,000 Hz) to provide reasonable speech intelligibility and musical quality. The reverberation time within a space can be controlled by the ratio of sound-absorptive surface area to sound-reflective surface area. The recommended reverberation times are shown in Figure 1.

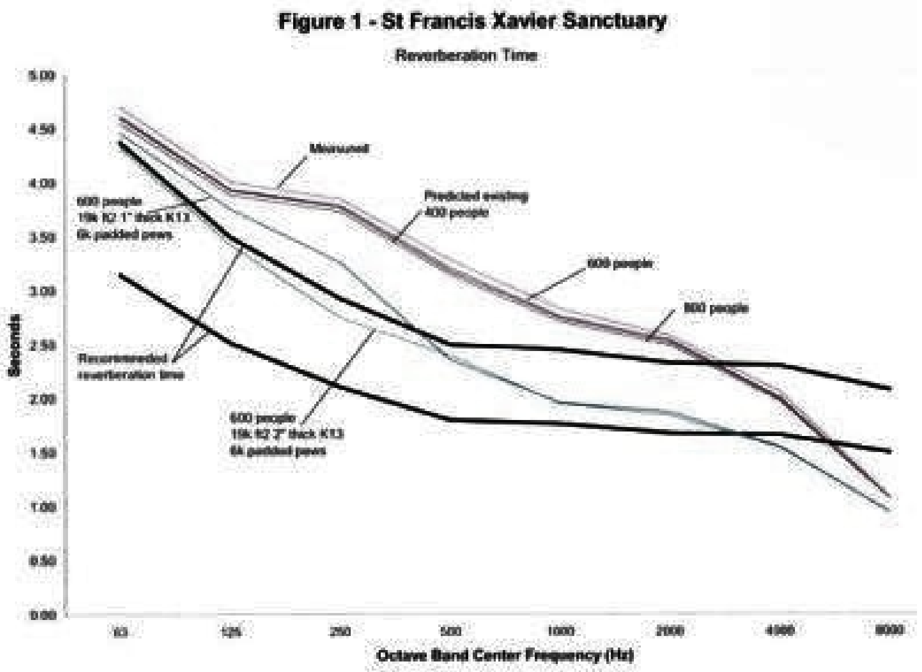

Figure 1

Sanctuary Results and Recommendations

The reverberation time was measured in the sanctuary and the average measured reverberation time is shown in Figures 1. A loudspeaker was used as a noise source and a microphone and real time analyzer were used to measure the reverberation time. The measured reverberation time was used to verify the reverberation time model.

Reverberation Times Too High

As you can see in Figure 1 the existing reverberation time in the sanctuary above the recommended range. We recommend applying acoustical treatment in the sanctuary to reduce the reverberation time. There are many types of acoustical treatments including: wall panels, stretch fabrics, baffles, lapidaries, open wood system, perforated metal systems.

Cellulose Spray On

We recommend spray-on acoustical treatment which is available as a relatively soft cellulose fiber-material or as a cement-based plaster. Sprayed acoustic material is applied by many local insulation contracting companies. The sprayed material should be applied directly to the ceiling and walls to provide the recommended surface area.

National Cellulose Corporation

One product is K-13 from National Cellulose Corporation. The cost is \$2/ft2 for 1″ thick treatment and \$3/ft2 for 2″ thick treatment. It comes in six standard colors and costs \$5,000 for each non-standard color. The cost of a lift is additional as is the cost if a significant covering up that is needed. Figure 1 shows the impact of adding 27,000 ft2 of 1″ thick and 2″ thick spray-on acoustical treatment.

Ray Trace Analysis

A ray trace analysis was performed and the direct and first reflection paths are shown in Figures2, 3 and 4. Reflections are beneficial when the distance of direct path and the reflected path are less than 55 feet. Reflections cause an echo, which reduces speech intelligibility, when the distance of direct path and the reflected path are more than 65 feet.

All Surfaces Contributing

As can be seen, the back walls, ceiling and most side walls do not provide beneficial sound reinforcement. This makes it more difficult to hear a person talking without a sound system. A reflective ceiling cloud could be installed above the chancel to provide some constructive natural sound reinforcement. Reflective cloud can be constructed or purchased from Kinetics and Wenger.

Loudspeaker System

It is very important that the sound system is directed on the audience with as little spillover as possible. We generally recommend that a central loudspeaker cluster be located up high and directed down onto the audience. All side walls that are at or above the height of the loudspeakers will not provide beneficial reflections – the higher the loudspeakers, the more beneficial wall area.

Human Hearing Localization

In addition, because our ears are horizontally aligned, we distinguish noise sources side to side more than up and down. Hence, a loudspeaker above or below the speaker sounds like it is coming from the speaker which is not the case for loudspeakers located horizontally away from the speaker. An alternative to a central cluster, for very large reverberant churches, is a distributed system. This system would have loudspeakers along the walls throughout the sanctuary.

Human Hearing Disadvantage

The disadvantage is that it is apparent that the noise is coming from the side loudspeakers and not the front of the sanctuary. If acoustical absorption cannot be added, this is a reasonable alternative. The ceiling does not need to be treated if all of the side walls are treated and the loudspeakers have minimal acoustical energy going towards the ceiling. We recommend applying acoustical treatment on the following surfaces, in order of importance:

Room Surface Treatment Priorities

1. The rear wall – it causes long delayed reflections and the perception that the sound source is behind you. (~ 3,000 ft2)
2. The rear walls of the side wings. (~ 2,700 ft2)
3. The side walls of the side wings. Treating the rear half is most important. (~ 6,250 ft2)
4. The side walls of the main sanctuary. Treating the rear half is most important. (~ 7,200 ft2)
5. Absorptive seating will provide a more even reverberation time that is not as dependent on the number of people in attendance. With 600 people in attendance, absorptive seating will provide ~ 6,000 ft2 of absorption.

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Church Acoustics

Look To The Past

Let's define our large rooms with an eye to the past. Let's look back at buildings that were built 50 years ago and had to deal with speech and music. We could have one person speaking at a time or we could have many singing at a time. Churches built 50 years ago, would have to be able to deal with both of these acoustic scenarios.

Old Churches

We recently measured a large church in our town. It had 100′ high walls with a 200′ length. The front section of the church was wider than the rear section, but the rear section was longer. It would be like placing two rectangles of the same size together. One would be positioned horizontally and the other positioned vertically, joined together forming a T configuration.

Alter And Stage

Inside the first rectangle, we have the stage or alter where the priest is positioned. We also have the choir upfront. It used to be in the rear of the church but the choir could not get up the steep steps into the choir loft. Perhaps people were in better shape 50 years ago or there were more young people in the church because now, no one goes up the steps.

Large Dome

In this front section, high above in the ceiling we have a large dome. The dome is 40′ in diameter and 100′ off the floor. It has numerous small, stain glass windows that are recessed into the dome. The dome itself is 15′ in height or depth depending on one's vantage point. It looks like a large mixing bowl covering the stage area. There are 900 seat spaces for the audience, all on solid wooden pews.

Rear Section

The rear section of the church has the same 100′ high ceilings. Each side wall in our rear church section has numerous stained glass windows that run the full length of the side walls beginning about 15′ from the floor. The ceiling is a vault type with some type of panels installed into it. They look acoustical in nature.

Thick Walls

The building itself is concrete on the inside with some type of plaster interior coating. The same coating is also on the church outside. It could be a adobe type mixture which is a common building material used in the southwest. The walls are 18″ thick and provide for am ambient noise level within the church with no humans present of 50 SPL. The street that is just five feet away is the main street for downtown Phoenix. There is traffic with buses and a train passing by 10′ away on an hourly basis.

Human Carpet

There is seating for 1,800 with an average attendance of 400 people on a slow service and about 900 on a good day. Easter and Christmas have full attendance. The seating is hard wood pews. There are no cushions on the pews so the only sound absorption from the seated area will be humans themselves. Each person has the absorption coefficient equal to that of 10 sq. ft. of carpeting.

PA System

Our PA system is a Bose system that has, in typical Bose style, a multiple small speaker array. Each vertical speaker is about 10″ tall and there are two positioned one on each side of the front of the church. They are installed with the base of speaker starting at ear level. Each small driver in each array is positioned to spread sound out left and right of the total length of the speaker.

Past Band Aid Solutions

For the last 10 years, the church has tried many acoustical fixes. They have tried multiple speakers in different areas of the church. They have turned off the left side of the PA system and are now just using the right side. At church service, most people sit on the right side of the church close to the PA. It is kind of a near field listening position. They have even tried using “acoustical paint”, whatever that is.

Reverberation Times

The real problem and the one that they now realize that they must do is to treat the room surfaces. They have tried everything else and now have worked their way back to the room sound. Treating the high reverberation times within a brick, hard wall, surface is the new priority. They have tried multiple speakers placed throughout the church and they are now forced to address the real acoustical surface issues.

Common Mistakes

This is a common mistake made by churches. They are told that placing multiple speakers in multiple locations will flood that area with direct sound and the wall reflections and high reverberation times will be smothered by the direct energy from the multiple speakers. This approach only works when outstanding reverberation times are not too far from acceptable ranges. Once reverberation times exceed normal ranges by 200-300%, one must treat the offending surface areas.

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Sound Transmission Class (STC) Unraveled

STC Defined

STC or sound transmission class is a rating system used mostly in North America to measure or rather assign a number to the ability of a barrier or partition to inhibit sound energy from passing through it. Outside North America, they use a term called SRI or sound reduction index. STC is an average of measurement numbers that use 16 different frequency bands that begin at 125 Hz. and go through 4,000 Hz. The numbers are then assigned their respective positions on a sound pressure level curve that is derived using a complex algorithm. This algorithm produces one number which we call the STC rating of the structure or barrier. Unfortunately, the nature of the frequency range covered does not tell the whole story.

How It Works

If we have a noise source that we are trying to isolate from entering our room, and we measure the noise source to be at 80dB, then we have to decide what dB level we want in our room. If we want a noise level within our rooms of 50dB, then we need a barrier that can reduce our pressure levels by 30dB and we would seek a barrier with an STC rating of at least 30. However, this number is frequency dependent. Our barrier may attenuate 30 dB at 3,000 cycles but only 15 dB at 125 cycles. STC is an accurate number when the sound energy we are trying to isolate from is spread out evenly across the frequency spectrum and does not go below 125 Hz.

Whole Story

If we are concerned with the human vocal range which is from 1oo Hz. – 800 Hz. one can see that an STC measurement has value, since the STC measurement frequency bands fall within that range. If we are trying to isolate human vocals in an office setting then an STC value of a considered barrier, will have some validity. However, if we are dealing with frequencies that fall below 125 cycles, such as large trucks and explosions in our home theaters, then we need to be more careful and consider how our barrier will react to frequencies below 125 cycles.

Old School

The STC rating system was developed back in 1961 and has not been updated since that time period. During that time period we did not have the lower frequency energy issues we have today with home theaters and more people. Computer processing was almost nonexistent and if it was processing power was low. STC ratings that were assigned during that time period are still used today even though the products they are assigned to from then are nowhere close in composition to their original form. A good rule of thumb is to not trust ratings that were assigned before

2,000 because testing equipment was not that sophisticated and the margin of error could be as high as plus or minus 6dB. It is best to use STC in combination with other measurements.

Newer Rating Systems

The American Society for Testing Materials. The ASTM measurement system has three basic divisions: STC, CAC, and OITC . The CAC is the ceiling attenuation class which is for ceiling structures. The OITC is for outdoor / indoor transmission class that measures the sound transmission between outdoor and indoor structures. OITC uses a noise source spectrum that takes into considerations frequencies down to 80 cycles which is far more useful in today's world. The IIC or Impact Isolation Class is a number that tells us how well a floor attenuates sounds from footsteps and dropped objects. Similar to STC, the IIC is formulated using frequencies from 100 Hz. – 3,150 Hz. The same lower frequency limitations apply as with the STC number especially if the stereo system on the floor above is full range.

Noise Criteria

NC or noise criteria number is a popular index. NC is a measure of just the noise itself and not the ability of a structure to inhibit it. It operates beginning at 63 cycles and moves up through 8,000 cycles. To arrive at the NC number, we look at one third bands for a given spectrum of noise. The noise spectrum is specified as having a NC rating that is the same as the lowest NC curve that is not exceeded by the noise spectrum.

STC – A Mixed Blessing

An STC number or rating has to be examined closely. If we choose 125 Hz. as our frequency for discussion and one barrier allows more energy to pass through than the other barrier, the former will achieve a higher STC rating. This occurs because remember from our prior discussion that 125 Hz. is the lowest frequency examined for an STC rating. Any amount of energy that passes below our lowest measured value will produce a higher STC rating and manufacturers have abused this simple issue.

Do Your Research

Most manufactures have data that indicates how their products perform below 125 Hz. It is just that an STC rating has been around for so long that there is no other standard present. One needs to look through the numbers to find the actual performance and isolation value. If a manufacturer does not have the supporting data below 125 cycles, one should look to ones that do.

New Standard Needed

STC or sound transmission class rating is a system for rating a structure's ability to stop or hinder the transmission of sound through it. It is an old system established back in 1961 and is overdue for a change. A new system should be developed that will address frequencies below 125 cycles and will also be able to address spikes in sound pressure levels across the frequency range determined. One thing is for certain, whatever system is devised needs to go lower and include more current.

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The Low Frequency Conspiracy

Audio Term Confusion

There is much confusion in our audio world. It is confusion over the meaning of certain acoustical terms. They are commonly used terms and they are consistently not understood. Some of this misunderstanding is a natural occurring thing when one is dealing with terms and their meanings. Some of this misunderstanding is intention and caused by companies that produce room acoustic products.

Low Frequency Abuse

The most abused area of the frequency spectrum is from 20 Hz. – 100 Hz. This is the frequency range that should be associated with the term low frequency or low frequencies. The next frequency range is termed middle lows. This term is covered by the frequency range from 100Hz. – 600Hz. These two terms and their associated frequency ranges can overlap in the literature. I have seen 200 Hz. and even 300 Hz. referred to as a low frequency. They are not and never will be.

Manufacturers

Why does this occur? Most of this confusion is fueled by room acoustic products companies that are trying to sell room acoustic products to the uniformed. It is appealing to someone who has not done their homework to buy a box of foam and place it in his room corner to act as a “bass trap”. The only thing trapped in this example is the customer’s money. It takes 11.3′ of foam to absorb a 100 cycle wavelength completely. What chance does foam have against a low frequency, 40 Hz. wave that is 28′ long. The answer is none at all.

Middle Frequency Products

Most room acoustic products companies manufacture products to absorb or diffuse low, middle range through high, middle ranges. This represents the frequency ranges from 100 Hz.- 6,000 Hz. This is their area of focus from a manufacturing and marketing perspective. This is where their research and development monies are focused. There are some well designed technologies for this frequency range. However, they have forgotten about the most important one: low frequency absorption.

Low Frequency Energy

Managing this low frequency energy that exists from 20Hz. – 100Hz. is not an easy task even when building a new building? It is even more difficult to design for in a freestanding unit that one can place in a room. One must use mass and large amounts of surface area when compared to middle frequency treatments. It takes a focused and concerted effort to achieve real low frequency absorption that can assist us in our rooms below 100Hz. Most manufacturers will claim that their product absorbs low frequencies. However, if you examine their definition of low frequency, if you can find it, one will see that the definition suffers from frequency bracket creep.

Frequency Bracket Creep

Frequency bracket creep occurs when manufacturers add frequencies from the low mid section into the low frequency section. They take the upper limit to real low frequencies which are 100 cycles and raise it to 200 Hz. by borrowing a 100 cycles from the middle lows. Sometimes they borrow another 100 hertz and now we have a low frequency performance definition of 20Hz.-300Hz. This is the reason customers purchase these low frequency absorbers and install them and are not satisfied because their bass traps do not absorb any bass.

Mislabeling Madness

To help clarify this marketing mislabeling madness, let examine each term and define it correctly through example. If we take the frequency spectrum and break it down into sections, it will be easier to understand. Once understood, they can be used correctly. Each one of our frequency spectrum sections will be termed bands. We have five major bands that comprise our human hearing range that operates from 20Hz.- 20,000Hz.

Low Frequency Defined

Low Frequencies occur from 20Hz. – 100Hz. This is the foundation that our mixes and music rest upon. It is the full and large sound from our kick drum. It is the bass guitar lowest string providing a track for all the other instruments to ride upon. This is the area of the frequency spectrum that has the most energy. One must manage this energy so that it doesn’t smother other neighboring frequency bands. It is also the frequency range that is the most difficult to design sound absorption products for.

Low Mids Defined

Low Mids are next in line. Our low, mid band spans from 100 Hz.- 600 Hz. This is where all of the magic occurs. Bass guitar takes on layers and definition. The snap of a snare and the richness of an organ chord held for 8 measures lies in this region. Low mids add a certain fullness to our instruments and especially our vocals. The low mid range in our vocals is critical and often missed in today’s project studio recordings.

Mids Defined

Mids follow low mids. Mids include all frequencies from 600 Hz. – 1,500 Hz. It is the region where our male and female vocals lie. Tenor sax and clarinet also live here. Our hearing is naturally tuned to this band, so getting it correct in our mixes is critical if we are going to help the listener of our music emotionally connect to it.

Upper Mids Defined

Upper Mids reside from 1,500 Hz. – 6,000 Hz. This is the area on our electronic equipment that is labeled presence. It places the vocals front and center in your face or can slide them back into the background. It is the area for harmonies to live in and it is also the area for their separation and clarity to shine through. Chimes, piccolo, and flute live in the upper mid area.

Highs Defined

Highs exist from 6,000 – 20,000Hz. This is the area that listeners and engineers are referring to when they say that the recording is too “bright”. Highs can be divided into different bands themselves. Frequencies in the 10kHz. Range add a crispness or clarity to our highs. Frequencies below this just add to the overall brightness level without offering any crispness or clarity. A cymbal crash, the sting of new guitar strings, and a gong crash produce energy in this high band.

Lows Defined

Low frequency energy below 100 cycles is real low frequency energy. If a manufacturer does not have a product in their product line that absorbs below 100 cycles, then you do not have a real low frequency absorbing device, no matter what you want to call it. Claiming that 200, 300, and even 400 cycles in low frequency only confuses the issue with uniformed customers. Let’s stay with the facts. The facts are always friendly.

* * *

These Speakers Sound Great!

Great Sounding Speakers

Have you ever heard anyone say that certain speakers sound great and others do not sound great? I am certain all of us in the audio business have heard this statement before. What goes into this statement and what does a great sounding speaker sound like. I think the real answer is somewhere between measurements and perceptions.

Hearing Test

The first measurement we could look at would be the hearing capacity of the listener. Does the listening have the physical ability to hear everything that the speaker can produce? Is the listener able to process that so important 500 – 3,500 range where all middle range information lies. Can the higher frequencies be heard or are they attenuated by aging of the listener. Assuming all parts are there and in good working order, we can now look at the speaker measurements.

Speaker Measurements

Do our speaker measurements glide smoothly across the frequency spectrum or do we have a 300 cycle bump because of the crossover. Is the cabinet resonances properly damped so we actually hearing speaker only sound as much as that is possible. Do all crossover points in each of our drivers work together so there is a seamless blend of middle and high frequencies?

Speaker Combinations

Is the low frequency bands properly balanced to mix and match with the middle frequencies. Or are we running smaller monitors that maybe go down to 50 Hz. and have no low frequency extension to them because of their size. Are we using the two smaller monitors in conjunction with a sub woofer? Is the sub woofer crossed and positioned correctly within the room in which it is placed.

Not One Size Fits All

Is the speaker the correct size for the room. Will it provide too much energy for the room to handle at average or higher sound pressure listening levels. If our listener thinks more is better, than having a six foot tall speaker in a room that is 7 tall, may cause sonic issues. Critical matching of driver diameter and number of drivers to room size is very important to sound quality perception of any speaker size.

Room Sound

When someone says that speaker sounds great, those words must be qualified by saying, “in this room” The room contributes at least 50% to the sound the listener is hearing. It is not just this speaker sounds great it is this speaker sounds great in this room. Low frequency resonances, speaker to room wall distance, listening position to speakers, and comb filtering from our room can set the stage for audible room sound in our mixes or playback presentations.

Room Size

Room size is critical. There is simply no substitute for selecting the proper ratio of height, width, and depth that will produce the least amount of low frequency resonances. Not only the amount of resonances but where they are located within the room. One must find these elephants and tame them through proper low frequency absorption techniques. Resonance blur and smear our presentations with excess energy that can smoother and blur our music presentations. A microphone placed in a room resonance may not “hear” any of the frequencies you want to record because the pressure level of the resonance is smothering everything you want to record.

Speaker Boundary Interference

Where is our speaker that sounds great located? If it close to a room wall surface, we will have condition occurring termed speaker boundary interference. The distance of the speaker to the wall and listening levels is a critical factor in determining room frequency response. If the speaker is placed too close to the wall, we can have low frequency energy levels increased at our listening position. If the listener like bass and the speaker/wall distances are more on the bass heavy side, he may consider that sound to be good speaker sound. Instead, It is bad room sound.

Near Field

If our speakers that sound great are set up in a near field set up, then we have less room reflections to deal with at the listening position. With less room reflections at our listening position, we have less room sound and more direct energy from our speakers. If a near field set up is used we hear mostly the speaker. Sitting and listening near field is a good way to really listen to a speaker. If it sounds great near field, it will probably be a great speaker.

Comb Filtering

Comb filtering is another room distortion that can cause our speaker and room sound to not get along at all. The problem with comb filtering is that you may not know that you have it. If you measured the room, you would know. The display of a comb filter looks like hash marks that resemble the teeth in a pocket comb. Comb filters hide and distort frequencies that are mainly located in the middle frequency range where most vocal information lies. They are a series of reflections between two closely located surfaces that get together and make their own sound.

Many Factors To Great Sound

If someone says that this or that speaker sounds great, we must make sure the listener can hear everything reproduced by the speaker. The speaker must also be able to reproduce all the energy required in a seamless and timely manner and presentation. The position of the speaker within the room and the size of the speaker to the room all can contribute to speaker sound quality perception. Speakers and the walls in the room can cause issues along with room size and comb filter distortions. These speakers sound great, must be followed by “in this room”.

* * *

Waves And Rays

Science Fiction?

Waves and rays sounds like something out of a science fiction movie. It conjures up images of Star Wars episode with lasers and energy waves blasting into space or at each other’s space ship. Nothing fictional about these two terms. Waves are lower frequency sound energy and rays are the term used for higher frequency sound energy. Waves are energy below 3oo Hz., rays anything above. Both terms are used when referring to sound energy within our listening, home theater, or professional recording environments. Waves of energy are felt through our bones, not heard with our ears, like rays.

Hearing Range

Human hearing has a small range of frequencies to it when compared with other animals. With this limited range of hearing, it is fortunate that our brains have evolved to interpret this data in the many ways that it does. The lower limit of human hearing is usually represented by 20 Hz. A 20 Hz. wavelength is calculated by dividing the speed of sound which is 1,130 ft. / sec. by the wavelength 20. Using this quotient, we find that a 20 cycle wave is around 56′ long. The upper end of the human hearing range is usually represented by 20,000 Hz. Dividing 1,130 by 20,000 produces a wavelength at 20,000 Hz. of .06 of an inch. We have 56′ on the low end up to .06″ on the high end. We need to break this down into two groups to examine their impact on creating a resonant cavity within our room.

Waves Vs. Rays

How do we break down this wide range of wavelengths into categories that we can use to our acoustical benefit. We let the dimensions of our room tell us what the wavelength breakpoints will be. Rays of sound energy obey the law of physics that states angle of incident equals angle of reflection. Let’s take a 200 Hz. wavelength. We know how to calculate its length. We take

1,130 and divide by 200. This gives us about 5.5′ in length. This wavelength of 200 Hz. will strike the walls or ceiling in our room and whatever angle it strikes at on that surface it will rebound or reflect from that angle of incident at the same angle.

Room Dimensions

Most of our rooms are wider or longer than 5′, so we have many reflections going on from wavelengths that fit into our rooms. Even a wavelength of 100 Hz. which is 11′ long, can fit between two walls and obey the law of angle of incident equals angle of reflection. However, let's take a wavelength of 60 Hz. which is 1,130 / 60 or 19′. With a 19′ length, we have a different situation. If our room is 12′ wide, our 19′ wave will not correspond to angle of incident equals angle of reflection. This is where we apply wave theory and not ray.

Too Long For Room

When wavelengths do not "fit" into the dimensions of our rooms, they can cause many issues. Think of lower frequencies as sumo wrestlers in your studio apartment. They are large and long waves that do not have the space to move around freely. Since they are too large for the room, they are always trying to leave the room by going through walls or finding openings to escape through. Most stay in the room and vibrate which is their way of showing discontent. It is similar to a woman who is a size 16 dress, wearing a size 8. All parts are trying to escape the confines of the dress. Men at the gym wear tight shirts to show off their muscles. One could say their muscles are trying to escape the confines of the shirt.

Resonances

Waves create resonances within our rooms because the room dimensions are smaller than their associated wavelengths. This inability to "breath" or travel freely to one's full length is like a 7′ tall man in a Volkswagen Bug, it will not be happy. It will excite certain resonances within the room. The frequency of these resonances is determined by the dimensions of the room and the length of each frequency within the room. Resonances are not wanted acoustically and can blur and smear other shorter frequencies to the level that we may not hear the shorter frequencies or they may be too pronounced. Either way, it is something we do not want; as we try to acoustically balance our rooms.

Region A

To make this division between waves and rays easier to understand, we divide our room's frequency response into four main regions. Let's call them regions A, B, C, and D. Region A is all wavelengths that meet the criteria of 1130 / 2L where L is the longest dimension of the room. These frequencies are not boosted by any other frequencies because there are none that are lower. Region A is the lowest of all the frequencies that will fit into your room based on its dimensions.

Region B

Region B is the region where the dimensions of the room are compatible with the wavelength of sound we are looking at. The lower frequency boundary for this region is 565/L. The upper limit to region B is not an exact frequency but includes calculations using reverberation times and room volume to calculate. The upper limit of region B is where we have the cutoff or room crossover frequency occurring.

Region C

Region C is termed the transition region since probably they could not figure out what to call it. We are still in the wave acoustics area to predict behavior of these frequencies. However, both waves and rays are present in this third region. It is a difficult region dominated by wavelengths often too long for ray acoustics and too short for wave acoustics.

Region D

Region D is all about higher frequencies that do correspond to angle of incident equals angle of reflection or specular reflections. This is the region where we can use geometric acoustics. We can use ray acoustics in this area to predict behavior of these specular reflections. This is the area where sound diffusion and sound absorption technologies usually refer to when they talk about how effective their technologies are.

Waves And Rays

Waves and rays are different creatures. Waves are felt through bone conductance and rays are received through our ears. Waves are like the waves on a beach and rays are the white water after they strike the beach. Waves cause “bass boom” in our rooms and rays are responsible for reflections that can confuse our wanted direct energy from our speakers. Both waves and rays are responsible for room sound. Both must be managed through proper room acoustic technologies and proper room size

* * *

Don't Be An Audio Fool.

Two Channel Set Up Misunderstandings

I see and hear many things when it comes to the set up of two channel stereo that makes me wonder if individuals that own these systems have done any type of study at all on how to set up a system properly. I see speakers set up in corners, next to glass windows, and even furniture in front of speakers . I have even seen the left channel set up in one room and the right channel set up in another. Let's examine some two channel set up requirements that are a must have if one is to realize true stereo playback fidelity.

Step One: Room Size

The dimensions and associated volume of a room must be given first consideration. There is a ratio of room width, length, and height that is more favorable to minimizing low frequency resonances and low frequency resonances must be dealt with. Room modes can smother and blur the low middle and middle frequencies. This is the emotional connection range where our vocals are. Nothing can be allowed to interfere with the frequency range from 100 Hz. – 500 Hz. and low frequency room modes can impact this frequency range in a big way. Choose a rectangular room. They are more predictable for our room tuning process when low frequency room modes are an issue.

Room Size Don’ts

Stay away from rooms with concave and convex surfaces. Parallel walls are fine assuming they are not made of concrete or other hard surfaces. Do not use a room that has the same length, width, or height. This would be considered a cube and the detrimental acoustical issues this room size configuration produces are too numerous to even discuss. Oval rooms are also sound prohibited. Follow the ratios given in the literature for room dimensions. They have been tested and will save you time, energy, and much frustration.

Step Two: Optimum W, H, L Ratios

What is the correct room size? There is no right or wrong answer to this question. There is a series of room ratios that do allow for low frequencies to be present without causing too much trouble. The dimensions of the room allow for the low frequency room modes to be spaced far enough apart that their presence is more easily managed. One may even elect to move a wall to make a room smaller or larger to fit a better dimensional ratio. A good starting height, width, length ratio to follow is 1, 1:19, 1.34.

Step Three: Low Frequency Management

Once you have chosen your room dimensions or they have chosen you because you must pick between two possible rooms or maybe even these in your home or studio, it is time to address the low frequency issues that you have. Take the time and measure your room to find out what the problem frequencies are. Software is readily available to assist you in this area. Most rooms will require some type of broadband and frequency specific low frequency absorption. Do your research and find the companies that build and design products that address your specific concerns.

Low Frequency Management Don’ts

Do not buy into manufacture’s claims that foam and boxes filled with building insulation will absorb low frequency energy. Low frequency wavelengths are long and powerful and it takes a specially designed absorber to handle them. Membrane or diaphragmatic absorbers work best for this frequency range. Do not think that one or two units will solve all your issues. It may take 8-10 units correctly positioned to have the acoustical impact your desire. Stacking foam or building insulation in the room corners is nonsense when it comes to low frequency energy management.

Step Four: Speaker Positioning

There is a “correct” position for your loudspeakers within any given room. This position produces the smoothest frequency response for the given room size. It takes time and measurements to find, but it is there. Start with the “rule of thirds”. Divide your room long way into thirds and start by positioning your speakers along the first third division line. Measure the frequency response at that position. Start with your speakers at least 4′ from the side walls. Move your speakers forward 6″ and measure again. Move your speakers back 6″ and re-measure. Look at the three measurements for patterns and adjust accordingly. Take your time and perform listening tests at each chosen position. Move the speakers inward towards the center 6″ and measure again. Move them out towards the side walls, re-measure.

Speaker Positioning Don’ts

Do not have unequal distances between the side walls and your speakers. Sound energy from your speakers is an electromechanical signal that travels through the air at a constant speed. If the distances from the side walls are unequal, those side wall reflections will arrive at unequal times at the listening position and mix with the direct sound from your speakers producing an image shift from the wanted center position. Make sure the side wall materials are the same composition. Never, and I repeat never, place your speakers next to a glass window, even though you will see this set up in magazine ads by speaker manufacturers. I guarantee none of the designers of those speakers wanted that position for their creations.

Step Five: Listening Position

Choose a chair that does not have a high back. Your ears receive information from front, rear, and side walls. With a high back chair, that information will be blocked and not heard. Measure the distance between your speakers and position the chair, so that it is the same distance from each speaker as the distance between your speakers. You are forming an equilateral triangle with your speakers and listening positions as the indices of that triangle. As you listen more to your system, you may want to move your chair back to widen the sound stage. This is personal preference, but using the triangle approach is a good start.

Listening Position Don’ts

The inside of the triangle that is formed with your speakers and listening chair is sacred ground. Do not have anything in this area. If you must place your equipment between your speakers on the floor, make sure it does not rise very high. Keep it as low as possible. Do not have a coffee table in front of the listening chair. Reflections from it and your equipment can be audible. Keep chairs and ottomans away from this area.

Step Six: Active Listening

Since you are setting up a stereo system, you need to play a mono signal through your speakers first, to make sure you have a centered image. We know that a stereo signal in a true stereophonic sound system has two independent audio signal channels, and the signals that are reproduced have a specific level and phase relationship to each other, so that when played back through a suitable reproduction system, there will be an apparent image of the original sound source. Stereo will replicate the aural perspective and localization of instruments on a stage or platform.

Use Mono Test Signal

Therefore, to make sure we have the correct balance between listening position and speakers, we need a mono signal to use as our focusing energy to make sure our image between the speakers is centered and focused. Mono or monophonic describes a system where all the audio signals are mixed together and routed through a single audio channel. Mono systems can have multiple loudspeakers, and even multiple widely separated loudspeakers. The key is that the signal contains no level and arrival time/phase information that would replicate or simulate directional cues. A mono signal will better show any speaker set up issues.

Mono Throughout

Put on the mono recording and sit in the listening chair. Close your eyes and the image you hear should be about the size of a tennis ball centered directly in the middle of your speakers. If it is there, put on your favorite stereo recording. The image should fill the distance between each speaker and hopefully extend farther left and right of your physical speaker positions. If is not, we need to move our speakers and listening position.

Basics First

Setting up a two channel system requires many steps to insure that you realize the full potential of your stereo system. Start by choosing the proper room size to minimize low frequency issues, select and position the necessary low frequency absorption technology, and correctly position your loudspeakers and listening position for a smooth frequency response. As you spend time with your system, there will be other issues to address, but initially following the above steps is a good start.

* * *

The Inside And Outside Of Our Rooms

Room Shell

There is much confusion these days about the two separate and distinct functions that must be assigned to our listening, recording, and home theater rooms. Our rooms are really two rooms in one and must be viewed and designed accordingly. In our music rooms, we must deal and address the sound energy that comes from other sources outside our room and we must deal with the sound energy that is created within our rooms. Both of these issues require different approaches and different sciences to maximize each of their respective functions.

Reflection, Absorption, Diffusion

With sound energy, we can only do three things. We can absorb that energy, reflect that energy, or diffuse it. We use sound absorption and diffusion technology inside our rooms, but we use reflection to keep sound generated from outside our rooms from entering our rooms. The sound energy created outside of our rooms is reflected back to the source using the proper barrier technology.

Problem Identification

Sound energy created from outside our rooms, from whatever the source, must be made to stay outside where it belongs. We accomplish this goal through a process of identification the energy issues and then applying the correct science to deal with what we have identified. We do not need to be that concerned with what is causing the sound energy from the outside of our rooms, but we do need to identify the amount of the energy and at what frequency that energy occurs at, so we can correctly apply the correct science.

Build A Wall

Once we have identified the amount of invading sound energy that is occurring from outside sources, we need to construct a barrier between the source of the noise and the inside of our rooms. If you want to stop sound pressure energy from reaching your room, you build a barrier between the source of the noise and the inside of your room. Barriers can be designed to stop just about all levels of unwanted noise, if one has the space and budget to accomplish the sound transmission loss goals.

STC – Sound Transmission Class

Barrier technology is assigned a value termed the sound transmission loss ability of a particular structure. The STC or sound transmission class rating of the barrier will determine how much energy the barrier will stop or not let through it. Concrete has a higher STC rating than frame and wood construction. This higher number means that the barrier can hold back larger amounts of sound energy. The type and STC rating of the chosen barrier technology depends on the amount of energy that we must keep out of our room environment.

Measure Twice Cut Once

It is critical to measure the amount of energy we are building our barrier against. We want to build a barrier that will accomplish our objectives without overbuilding. Every dB of energy that we must construct a barrier against cost money. Our barrier must achieve the desired result without breaking the bank. We need just enough barrier to stop the noise, without over spending. Testing noise levels over different time frames is the only sure way of assigning the correct barrier to the noise level and not over spending.

Sound Absorption/Sound Diffusion

The inside of our rooms requires the use of sound absorption and diffusion technologies. The inside of our rooms are pressure chambers. Sound is interjected into our rooms with speakers, vocals, and instruments. The size and volume of our rooms determines how all of that energy will behave or not behave. Some wavelengths will fit into your room, some will try and fit, but will tell you when they don't.

Low Frequency Issues

Low frequency energy is the most problematic of all the frequencies within our room because of its long wavelengths. Long wavelengths need long spaces to run in. If they do not have the required space to move around, they get mad and produce resonances. Resonances are low frequencies way of expressing their discontent with the room size one has placed them within.

Sound Absorption

To manage the excess energy from within our rooms, we use sound absorption. We can absorb low, middle, and high frequencies. Low frequency energy is the most destructive and the hardest to absorb. It requires larger and more powerful sound absorbing technologies placed at certain locations within our rooms. Low frequency resonances can build up in room corners, and all room boundary intersections such as the ceiling and wall, floor and wall intersections.

Room Boundary Reflections

Reflections from sound energy from our room boundary surfaces are our biggest issue within our listening and recording rooms. Room boundary reflections can interfere with the direct sound from our monitors and can cause distortion at the microphone positions. To manage these reflections and reduce their impact, we can use sound absorption or sound diffusion technologies. Sound absorption reduces the signal by changing sound energy into heat. Sound diffusion will take the reflection and spread it out into a series of smaller reflections.

Two Schools Of Thought

When we think of our listening, home theater, and professional recording studio rooms, we must think about different technologies. We must think barrier technology to keep unwanted sound energy generated from the outside of our room, outside where it belongs. We will build a barrier to reflect the unwanted sound energy back to its source. The sound energy produced within our rooms will be kept inside our rooms with the use of barrier technology, but we will use sound absorption and sound diffusion to manage low frequency resonances and middle and high frequency reflections from our interior wall boundary surfaces that sound producing sources with our rooms generate.

* * *

Mixing Issues And Solutions

Mixing Issues

I have spoken with many engineers lately about issues they confront during the mixing process. I asked them to talk about issues that they commonly face and what they do to resolve the issues. The discussions focused mainly on equalization, compression, and time based effects.

Equalization

All the engineers had issues with equalization. Balancing the frequencies using equalization was a common concern. One of the main concerns was using automation to compensate for an improper equalization. With an improper frequency balance, you have some frequencies that are masking others. Using automation by turning up the volume of the track that has been smothered will be a temporary fix. When the content of smothered track comes down, you now realize that the track that was turned up is now too loud.

Automation

Most engineers agreed on the solution. The solution was to use equalization to balance the frequencies between the tracks that are in question. Most agreed that this was not an easy solution or process but that the trade off in time and effort was worth the results. This process was viewed as a check against doing the wrong thing. One engineer said that if you think you need to automate every word in a vocal track, you should be looking at equalization to solve the issues instead of automation.

Old Mix Review

One engineer suggested pulling up your old mixes and get rid of all the automation. Spend time with equalization and you will quickly see that a well balanced mix can be achieved without using volume automation. All commented that automation has its place because you cannot always use a compressor to level out vocals that are extreme in nature. Sometimes you want a vocal part a little louder than other parts and that automation should be used mostly to create certain sonic effects by changing levels, using panning, and with some plugins.

Reverberation Levels

Adding too much reverb or delay was another issue that seemed to be common among the engineers. Most made the comments that too much reverb was the indication of an unprofessional mix. Usually too much reverb is used to try and solve pitch issues or as some stated to make the vocalist sound better. Vocalist wanted more reverb, especially if they were the engineer.

Reverb Necessary Evil

All agreed that the best way to use reverb and everyone agreed it was necessary, was to find the correct amount of reverb that sounded good at loud volumes and then lower the volume until it sounded good all through the mix. Some suggested bringing the reverb down to the level of barely audible. Spend time listening at this low level with the send bypassed. Most believed that this method added thickness and a richness to the mix without adding any undesirable effects. Most said that this approach also worked with the delay.

Big Picture First

If you solo a track and use EQ on it it will sound one way. If you then put it into the mix, it can sound thick or muddled. All agreed that one needs to do the majority of your processing with the entire mix playing. Examining a solo track or a couple tracks is acceptable but keep the entire mix in your mind and focus on the total mix.

Middle Frequencies

When you ask someone to listen to your mix and they tell you to turn it up because it will sound better. Obviously, these comments lack the experience of a professional mix. Professional mixes sound good at soft and loud levels. This is the result of the engineer understanding that our ears can hear more of the middle frequencies than it can the low er and higher frequencies. This is probably due to our need to hear vocals for communication purposes as a species. It takes more energy to produce low and high frequencies than it does to equal the apparent loudness of our middle frequencies.

Focus On Vocals

As you turn down your mix, you will notice that the vocals jump out in the mix since they are focused in the middle frequencies. Pay attention to the lead vocal as you turn up the mix. The drums and bass energy will start to take over the vocals. If you mix loud, you cannot balance the mid-range correctly. If you listen at higher volume levels, everything seems to smooth out but more difficult to hear the mid range. When you turn the volume down and listen at lower levels, the issues in the mid range stand out.

Mix At lower Levels

Mixing at lower levels is the solution. If you need to check the low and high end, one can turn it up for this purpose but once checked and verified, lower the volume levels. Less is more and this philosophy should also be applied to the use of effects and processors. Use small amounts of EQ and small amounts of compression. Train your ear to hear the subtle differences in music and add or subtract small amounts of processing just enough to compliment and not dominate.

* * *

Room– Resonating Chamber

Room Is Chamber

What is a room? It has four walls, a floor and ceiling. It is a box or chamber. In this chamber, we introduce sound energy when we speak or play instruments. All of the sound energy sources within our room have specific low frequency energy and a highest frequency energy that they produce. This is called their frequency response range. Once this energy is interjected into our room, it must all fit into the room or chamber. Let's look at each surface of our chamber.

Two Parallel Surfaces

The two side walls of our room or chamber are part of a resonating system. in fact, they are a resonating system all by themselves. The sound energy that enters our chamber strikes one wall and that energy then in turn, strikes the opposite wall. After the sound energy strikes the second wall, the process is repeated with third, fourth, and fifth order reflections. As these waves and rays of energy make this journey of reflection multiple times, they start to combine. If the wavelength of the sound is a factor of the physical distance between the walls, a resonance is created. This resonant is termed a standing wave.

Maximum / Minimum Pressure

Each standing wave and there as many of them as there are distances between room walls has a maximum sound pressure region and a minimum sound pressure region. The maximum region of pressure will be that area that is closest to the wall boundary surface. The area of lower pressure or null will be middle distance between the walls. If we double the chosen frequency, we will have another area of maximum pressure and another area of minimum pressure created just as in the first example. If we triple the example frequency, the same thing happens. Now, we have three areas of maximum pressure and three areas of minimum pressure.

More Modes

These examples are for one set of parallel surfaces and are termed axial modes. We have two other mode producing energy situations that we must take into consideration. The oblique and tangential resonating system involves energy moving from different surfaces other than a single, parallel neighboring wall. These two new modes produce their node creating energy in the same way as axial modes but involve different surfaces.

Tangential / Oblique

A tangential mode occurs as a result of four different surfaces. We can have a tangential mode created with the two side and front and rear walls. The oblique modes occur when the energy travels between six different surfaces. All of these surface areas assist us in reducing the intensity of each reflection and thus mode. An axial mode only has to travel between two surfaces, so axial modes have the highest pressure of the three modes in our room or resonating chamber and are the most troublesome to deal with.

Low Frequency

Our low frequency energy waves must fit into our chamber. At 40 cycles, our low frequency wave is almost 30′ long. If we have a room that is 30″ long then we have a room that can receive the full length of the wave without it striking a room boundary surface. Most rooms do not have a 30′ dimension to work with. Most rooms are much smaller. Smaller room sizes forces the low frequency wave to “cramp up” and cause resonances within the parts of the room that the wavelength does not fit.

Vocals Fit Well

Our vocals have a less difficult time. Our vocal range is 75 Hz. – 800 Hz. With higher frequencies we have shorter wavelengths. Shorter wavelengths will fit more easily into smaller room dimensions. Vocal resonances within a room are rare unless one is recording a large number of individuals such as a choir or other larger mass amount of individuals and the room is not large enough. Vocals also do not produce the energy that say a kick drum would produce. Vocal cords are much smaller moving diaphragms than a kick drum head.

Pressure Piles

Pressure build up at certain positions within our room or chamber. The corners of our room or chamber are areas of higher pressure build ups. Along with the corners, we have any floor/wall or ceiling/wall intersection where energy likes to accumulate. Throughout the room’s center area these pressure piles build their way along and carry through the room or chamber center. Each resonance or pile of energy has its own bandwidth or frequency range.

Mix Colorations

All of these pressure piles produce colorations to our sound energy that enters into our chamber. Room modes produce resonances that can exaggerate certain frequency ranges that are part of the frequency response of the resonance. If your microphone is placed in the pressure maximum area of the mode, it will be smothered with resonances and you will be not recording certain frequencies at the microphone position. If that resonance’s frequency response is in the same range as an instrument or vocal you are trying to record, you will be fighting the resonance through your whole mix. If you place your microphone in a pressure minimum area, you will not hear everything that is produced by your chosen sound source.

Cubism

A resonating chamber or room that has the length, width, and height all equal would be cube. With a cube all axial, tangential, and oblique modes will coincide along with their fundamental frequencies. Low frequency pressure build ups within the “cube” would be almost impossible to control. One could make the cube larger to increase pressure handling qualities or one could make one or two room length, width, or height dimensions even smaller provided the appropriate type of low frequency sound absorbing technology is used.

Resonating Chambers

Our rooms are resonating chambers. The amount of energy created from our instruments and vocals must be taken into consideration and the correct size of the room must be coordinated with the intended use. Too much of the wrong type of energy within the chamber sets off a series of resonances. Modal issues can impact the information received at the microphone position. Proper room acoustic treatment can assist in minimizing room resonances, but there is no substitute for getting the room size correct from the beginning.

* * *

Surround Sound Perceptions

Sweet Spot

If you set up your two channel system and sit in the “sweet spot”, you will be sitting at a spot that is equal distant from the left and right channel speakers, which are equal distance from each other. The speakers and the listening position form the apexes of an equilateral triangle. If you face forward, using your nose as the center line, you have about 30 degrees to the right of your nose and 30 degrees to the left of your nose, into which the stereo image is perceived within by our ears. This is the “sweet spot”.

Localization

Our localization for two channel sound occurs within this 60 degree arc. Stare straight ahead. If you wear glasses, move your eyes from left to right stopping at your glasses edges on both sides. This is the visual of the “sweet spot”. We can resolve differences within this arc of a few degrees. The human localization antenna is very fine tuned and can separate down to degrees within this 60 degree arc. This localization process only works with speakers in front of listener. If you place speakers behind the head or listening position such as in surround sound rear and side channels all this localization ability goes away.

Multiple Mono Sources

When we have multiple mono sources such as in surround sound, we will have just as many different tonality changes as we have speakers emitting energy from behind our side, head mounted ear canals. The speaker positioning in relation to our ears and head causes these tonal changes. If we use a symmetrical approach to these rear speaker positioning, the thinking is that this will yield more accurate surround sound monitoring. Taking the surround sound data and then putting into two channel stereo produces level and frequency issues.

Thomas Holman

Thomas Holman in his book entitled tells us that 5 channels are not enough to produce the natural ambiances generated by sound that is direct and reflected energy from behind our ears. Holman believes that to really create the energy fields that are ambient sound and non-localized by our hearing mechanism requires at least 10 channels of information. Today, we have 5.1. Holman believes we need at least a 10.2 system comprising 10 discreet channels and two LFE or low frequency enhancement channels.

David Bell

David Bell was another surround sound guy who said that we should position loudspeakers hanging from the ceiling pointed away from the listening position. Speakers positioned in this matter would fire into diffusion treated surfaces. This positioning has the speaker null or back side of the speaker facing the listener and the speaker face firing into a diffusor which spreads the energy directed into it out in a fan like array into the room. This procedure creates the ambiance through diffusion and does not need to rely on the room boundary surfaces producing enough reflections in the right amount and level to create the ambiance required from our surround channels.

Surround Sound Realism

Multiple channel surround sound is always more realistic than two channel surround sound. Thomas Holman proposes dipole rear channel speakers that are placed above and behind the listening position. Dipoles positioned in this matter would present their nulls at the listening position. This would allow for the listener to not hear any direct energy from the side or rear channels but instead allow the listener to hear more of the reflected energy off the room boundary surfaces. This reflected energy creates the ambiance.

Control Room Dipoles

In the control room, the side of the dipole speaker that faces the hardest surface would produce the sound of the highest frequencies. One must be careful in using a dipole arrangement for the surrounds and insure that all reflective surfaces in the control room are evenly distributed. Obviously, this technique would lend itself better to a home environment where these reflective issues would be more evenly distributed. It would also be difficult to achieve a flat response at the monitoring position with so much reflected energy entering into the mix.

Dolby

Dolby uses multiple sources that distribute the surround energy. The direct energy from mono sources would be heard as direct energy with a tendency to favor the speaker closest to the listener. The direct energy from the speaker closest to the listener would sound brighter because that energy is entering the ear canal first without the benefit of a reflected upon wall surface.

Lifelike Sound

The sound effect of many multiple mono sources spreading their energy across the room surfaces can be very lifelike. The precedence effect would assure that the front main speakers would contain and localize their information and not get smothered and confused with the rear channel data. Vocals would still be centered on the screen and any “front of the house” information would stay in the front of the room closest to the screen. This multiple, discreet channel set up would not be conducive to a home theater environment where space and esthetics are always a factor.

Low Frequency Enhancement

We all know by now that the .1 or .2 behind the number of channels in a surround application stands for the low frequency effects channel information. This information is usually below 80 cycles and is normally produced by sub woofers. With the cut off frequency being 80 cycles, localization becomes difficult which is the intended effect. Below a cut off frequency of 50 cycles, localization is not possible. Positioning of all low frequency effect channels is critical so that room modal responses are not excited.

Proper LFE Placement

To compensate for room modal response excitation, we need to distribute our low frequency generating devices in a way in our rooms that will lend itself to minimizing these resonances. Dolby suggests that one sub woofer be located one third the distance across the room from the side walls and another placed one fifth of the distance across the room from the opposite side wall. This asymmetrical low frequency generating device layout prevents the symmetrical driving of room modal issues.

Surround Sound Perceptions

Surround sound is a blend of many perceptions. We have front channels that must focus vocals and front image issues. We have surrounds that must create the ambiance of the real world in free space and then we must be bring this creation into a small room environment and make it sound realistic. To create this “realism”, we can use dipole or individual discreet channels with the proper amount of acoustical treatment. Care must be taken in locating any low frequency source within the room in order to minimize room resonance issues.

* * *

The Subjective Act Of Monitoring

What Is Good Sound?

Most recording engineer's I know will work on a monitor or loudspeaker that achieves the sonic results that the engineer thinks is the desired sound. There are many factors that come into play on this choice, but most important is the experience the engineer has with that particular speaker. I know some engineers who will stay with their old monitors no matter what advantages the new technologies present. They know how their monitors sound and translate and they do not want anything to interfere with this process.

Different Speakers

I also know engineers that use different speakers. I see engineers using large, full range monitors for recording. These are large units that can have 15″ – 18″ low frequency drivers, and with multiple mid range drivers and high frequency tweeters. Mixing goes in a different direction. A mixing loudspeaker will be smaller and of lesser quality. In most engineers' homes, I find a speaker that falls in between these two extremes in terms of size and quality.

Classical Recording

The classical recording world is all about quality. There is really no need in the classical recording world for the speaker to produce a "buzz" of its own for the musicians as in the popular music world. In classical music, the loudspeaker is relegated to a secondary position in the signal processing chain. Headphones for more clarity, sound isolation, and less room sound are desired. Use of electronic processing is also not as prevalent as it is with pop music. Why is there so much subjectivity in a situation that requires so much objectivity?

Loudspeaker Manufacturers

The loudspeaker industry could be partially at fault. If you ever look at the frequency response curves of today's loudspeakers, one can see many inconsistencies comparing response curves. I do not think it is the loudspeakers. Engineers use speakers as just another tool in their acoustical palette. If one needs to focus on the middle frequencies, then there is a loudspeaker with those characteristics. A good detailed monitor for middle frequencies is critical because in the middle everything is competing for space to be heard in. Each piece of music that is recorded will have certain sonic objectives and speakers are one of many acoustic tools that the engineer will use to achieve the engineer's results.

Popular Music

With popular music, the final product must be viewed on a macro level, but one must use a micro approach to get this larger picture. Each track must be focused upon, so that the whole mix produces the sound the engineer is after. The sound the engineer has in his head is what the translation goal should be along with the clients. The client is using the particular engineer because he or she likes the engineer's sound and that "sound" the client will go a long way to achieving or even creating the sound that the client wants.

Sound Not Looks

Most engineers I know do not care about how a speaker really works. They are only concerned if that particular speaker will fit into their acoustical requirements. They also have different speakers at home than those they have at work. Hi-fi speakers are chosen for home because they are not so analytical and reproduce sound that is more compatible with the acoustics of the room. Sometimes I see consumers who use studio monitors because they want to hear everything that is in the music and not the room.

Too Much Subjectivity

All of this subjectivity does not go a long way to achieving any objectivity or standardization towards good quality sound. Individuals want to hear certain things and certain sounds. Do we have a perfect monitor that everyone would consider as the standard? Probably not because individuals would still use whatever monitor they needed to achieve the sound that they wish to create. The Yamaha NS10M would not have the popularity over all these years if the trend was moving away from it.

Wrong Trends

Recording equipment is expensive. Using a full working studio with multiple rooms is not cheap. The equipment that is used in these studios is getting expensive and the trend does not seem to be working its way to cheaper gear that would be more excessive to more people. Software has become cheaper but the gear to play it on is not. Monitors are always a part of a larger budget and must have their place in the overall studio cost structure. Speaker manufacturers have keyed in on this phenomenon.

Marketing / Performance

Most speaker manufacturers design a speaker that they think they can sell at a particular price point. They pick a price range they believe is empty and fill it with a speaker that is designed with components to fit into that particular price point. This marketing philosophy does not lend itself to moving the science of speakers and in particular studio monitors forward. There is little technical improvement in monitors. Sound quality may not even be the selection priority. It could be because of appearance, weight, or features and benefits.

Where Is The Standard?

We need more objectivity in the recording process especially when it comes to our monitors or loudspeakers. They are the final link between our ears and all the electronic data that was used to create the recorded signal. We need a standardization for both recording monitors and playback speakers. A well defined reference for sound quality must come from both engineers and speaker manufacturers. From what I see manufacturers doing, it must be the engineers that put this standard into place.

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Chapter 2: ACOUSTIC TECHNOLOGY

Audio technology is constantly moving forward and backwards. The goal is to get not too far ahead or too far behind. Digital technology can add or subtract quality from our recordings and its use can depend a great deal on the skill set and experience of the engineer. Analog can be good for the original source recording and the horsepower of digital can be a great asset in processing that original signal. This section focuses on the current state of electronic and acoustical technologies.

* * *

Charcoal Based Low Frequency Absorption

Diaphragmatic Absorbers

Diaphragmatic absorbers are powerful, low frequency, absorbing technologies. One must build a solid, sealed box that has a front wall that can “move” in reaction to sound pressure waves. This front wall movement slows the wave down, so that it can enter the inside of our sealed cabinet. Yes, the cabinet is sealed without any air holes. Low frequency waves that are 40 and 50 feet long do not care about some 1/4″ air holes in any type of absorber. With low frequencies we are dealing with waves of energy not rays.

Cabinet Construction

The cabinet that supports the front wall must be as inert as possible and not move. It must be rigid, so that only the front wall is moving in response to the sound pressure exerted upon it and not the sides or cabinet rear wall. Rear wall construction must be thicker than the side walls in order to obtain the proper rigidity ratios between the sides, the rear wall, and front wall. Since the side walls are shorter in length, they possess more rigidity and thus we need to add mass to the rear wall to keep our rigidity ratios between the surfaces correct and balanced. Viseo-elastic damping compounds between the cabinet’s layers of materials is a good way to minimize cabinet sides and rear wall vibrations and maximize cabinet rigidity.

Resonant Frequency

To achieve the proper resonate frequency of our diaphragmatic absorber, we must calculate cabinet material density and the depth of the cabinet itself. We are designing a cabinet that has a certain density in the materials we are using and has a certain depth inside the cabinet. If we do our calculations correctly, we build a cabinet that has a certain resonant frequency. This resonant frequency number is our sound absorption baseline. Any frequency above our diaphragmatic absorbers' resonant frequency will be absorbed and any frequency or wavelength striking our cabinet that is below our resonant frequency will not be absorbed.

Inside The Cabinet

Inside the sealed cabinet is an air space. Conventional thought usually declares that one should fill this cavity with a fiberglass, insulating material, or some other foam based product. I have even seen spray foam used inside the cabinet. None of these materials address the issues necessary to achieve a low frequency absorber that absorbs greater than the physical dimensions of the cabinet tell us. They are cabinet fillers which are supposed to minimize the cabinet's internal resonances. Minimizing the internal cabinet resonances is short sighted and does not take into account the power that a diaphragmatic absorber is capable of. We need to lower the internal cabinet's Q value to a level that will radically increase the unit's absorption capabilities.

Q Value

A cabinet's Q value is a ratio of how well the given space we are discussing performs in relation to the size of the space. A cabinets Q value is the bandwidth of our resonating system or diaphragmatic absorber internal space. With traditional cabinet fill materials such as foam and fiberglass, all we are doing is minimizing the cabinet's internal resonances. Granted this minimizing does increase the cabinets bandwidth and thus performance but not to the degree necessary for frequencies below 80 Hz. If we are going to achieve the high rates and low levels of absorption necessary in our diaphragmatic absorber in the smallest cabinet size possible, we need to increase the cabinets Q value through a process termed acoustical compliance enhancement or ACE.

Acoustical Compliance Enhancement

Acoustical Compliance Enhancement is a process where we make something perform better than its physical size and contents tell us it should perform at. If you take a car with an engine that uses fuel and air through a carburetor into the engine, that engine will produce a certain amount of horsepower for the size of that engine. If we take that number and use that number as a benchmark, we can increase the horsepower of that engine by adding fuel injection and replacing the carburetor. We have not changed the size of the engine, but simply the method in which the engine receives its fuel and air for combustion. We have made our engine more efficient without increasing its size.

Activated Carbon

Acoustical Compliance Enhancement or ACE is the same process one can use to increase the cabinet's internal Q value or bandwidth of our diaphragmatic absorber. Instead of replacing a carburetor with fuel injectors, we use a substance called activated carbon inside the diaphragmatic absorber. Activated carbon or charcoal has a high degree of porosity and is a powerful absorbing material. It is used to filter water and air. Activated carbon granules look like miniature meteors. Each granule of charcoal has numerous holes or pores in it. Each pore is a perfect place for sound to enter into and be absorbed. Each activated carbon granule has many pores and these pores translate into a large amount of surface area. If we could unfold one gram of activated charcoal it would equal anywhere from 500 to 1500 m2. One teaspoon of activated charcoal powder (about 3.3 gm.) has about the same surface area as a football field. This surface area translates into a tremendous potential to “absorb” large amounts of sound energy.

Diaphragmatic Absorption

Diaphragmatic absorption is a sound absorbing technology that has been around for years and is used extensively in professional studio and home theater construction. A diaphragmatic absorber is a sealed box that has a surface that vibrates in sympathy to sound pressure waves. Inside that sealed box is placed building insulation type materials and even construction foam which assists in minimizing internal cabinet resonance but does nothing to actually make the absorber more powerful. One can increase the performance of a diaphragmatic absorber by using a different fill material called activated carbon.

* * *

Stop Noise By Building A Barrier

Noise

Noise is everywhere, but we cannot let it in our studios. We must reflect or absorb it away. In order to do this, we must build a protective barrier between us and the noise. Here is how to begin.

Quiet, Please.

One must make their rooms as quiet as possible. The act of quieter is a component in your system much more powerful than your monitors or board. The room is an extension of the instrument or vocal that is vibrating within it. The room must not speak and if it does, we want to bring it down to the level of a whisper. No whispers or sound from the outside either.

Need Different Technologies

We achieve this quiet through the use of different technologies. Our outside room shell is a barrier between our music room and the outside world of noise. The inside of our room must deal with low frequency resonance control and reflections from all room boundary surfaces. It is this balance between barriers and inside room treatment that must be dealt with.

Barrier Technology

Barrier technology does two things. It reflects outside sourced sound energy that strikes it, back to the outside. It also takes the energy that is generated from within the room by instruments and vocals and bounces it back into the room. It sends the sound energy that leaves the room back to its source direction by striking the inside of our shell barrier. We must use special care in addressing this relationship between the room and our shell.

Air And Noise

Noise is transmitted through the air. It strikes our shell barrier and parts of that energy is sent back using the reflection process. When it strikes our shell or barrier it is now vibrational energy and our structural goal is to minimize the transmissions of that vibrational energy through our barrier. We measure the amount of vibrational transmission that is lost within our structure design.

Design Goals

Our goal in our professional studio is 25 – 30 dBA. Any noise above that range will begin to appear in our microphones when recording. This noise level can degrade the clarity and definition of our recordings. Their low level tone and timbre that may be masked by any noise levels higher than 25 – 30 dBA. I see studios with 50dBA of computer and fan noise and monitoring limits of 90 dB SPL. This mixture produces a signal to noise ratio of only 40 dB. We must work and balance both inside and outside noise levels.

Balance Needed

This balancing act must occur prior to building the structure and before choosing a location. It is highly advisable to call in an acoustical engineer prior to selecting the site and definitely before building the structure. It is much easier to change a line on a drawing than to knock down a resonance producing wall dimension.

Modern Day Construction Techniques

Most current building types are lightweight in construction and situated in near proximity to a noisy source. This lightweight construction found in new buildings does not follow the three requirements of any good studio construction. In all studio construction and location techniques, we need mass, rigidity, and space. The lightweight construction is cheaper to build and that is the main reason people buy them. It is not the reason to use that room for music playback and recording.

Space, The Final Frontier

All good sounding recording studios have one thing in common, plenty of space. This space is the result of a high ceiling. The parallel surfaces from floor to ceiling must be separated with space. The floors are reflective at lower frequencies, so there is a strong need for proper studio design to avoid vertical room modal issues.

Lots Of Space

Space is also required for microphone placement. Moving instruments and microphones around a room requires space. Instruments find their own acoustic home and microphones must follow them. Microphones must have the necessary space for positioning correctly and not be next to any room boundary surface. In the studios we have been working with, it appears those that have at least a 20′ height allow for adequate microphone positioning above the instruments and away from room boundary surfaces.

Floor Concerns

Floors are another concern. All barrier technologies require mass and mass has weight. There are no general guidelines to illustrate this principle but one can break the weight factor down into a square foot calculation for discussion purposes. If we take a room 30′ long, 18′ high, and 12′ wide, we can look at over 40 tons of mass required for both ceiling and floor isolation. This would equate to around 140 pounds per square foot. Barriers need mass to work.

Mass Support

The mass requirements in room acoustics need strong structural support. The newer, cheaper, build construction of today's buildings will not support the additional weight that is acoustically required. Every dB of isolation costs money and if we have to reinforce the existing structure so it can support the barrier technology mass, we are increasing our costs and time frames exponentially.

Start Fresh And At Beginning

All of these variables must be addressed at the project beginning. We must decide on our space requirements inside and then the structural isolation components for the outside barrier technologies. We must look at site locations that are away from noise producing sources. It is always a balancing act with all parts working together. It is for this balance that one hires a professional to achieve in the correct proportions.

* * *

Diaphragmatic Absorption – Better Than Ever

Time Tested Technology

Diaphragmatic absorption has been around for a long time. If you have a drywall covered frame wall in your house or studio and you probably do, you have a diaphragmatic absorber. A diaphragmatic absorber is a sealed unit that has a front wall, internal cabinet fill material, and a rear wall. The sides, top, and bottom round out the unit's construction. It does not need holes to work. A 40Hz. wavelength that is 26′ long does not care about any holes, no matter what their size.

How Does It Work?

Sound energy strikes the face of our absorber and gets slowed down in the process. It would be similar to running a marathon and getting a cramp in your leg. You may finish the race, but you will not be operating at maximum strength when you cross the finish line. Once we slow down the long waves of low frequency energy, we can more easily manage them before they enter the inside of the cabinet where they will meet a zone of severely reduced pressure. It's like a pilot leaving the earth's atmosphere and entering outer space.

Theory

A diaphragmatic absorber has a front face that, you guessed it, acts as a diaphragm. A diaphragm can be thought of like a speaker. A speaker moves back and forth to create energy. The face of a diaphragmatic absorber moves back and forth in order to absorb energy. Obviously, the speaker moves back and forth because it is driven by electrical current. The face of a diaphragmatic absorber moves in response to sound pressure exerted upon it by low frequency energy waves. It does move but you can't see the movement.

Engine Important

The internal cabinet fill creates a sound absorbing environment that will assist us with our performance. Once inside the cabinet, the energy level of the wave is further absorbed by its energy changing from mechanical to heat. Once it is converted to heat, it is lost forever. We want to heat things up as much as possible with our internal cabinet fill material. We want to make it run through the Arizona desert in the summer without catching fire. We do that by making it more efficient.

Slap In The Face

Once low frequency energy strikes the face, it starts the absorption process. The movement of the front wall or diaphragm slows the low frequency wave down before it enters the cabinet. When it enters the cabinet, the magic happens. The inside of the cabinet has a filler type material that has a high degree of absorption. It is too much absorption in a small area. It is too much, but it needs to be. Its goal is to lower the cabinet's Q value.

Q Value

Let's think of Q value as a process that takes an existing space such as the inside of the cabinet and makes it work much better than its size would indicate that it could. The internal cabinet fill material provides so much absorption in the small space of our absorber, that one could use artistic license here and say that the internal cabinet fill material sucks the air out of the cabinet and creates kind of a vacuum. This lowering of a cabinet's Q value is done through a process called acoustic compliance enhancement.

What Frequency To Work At?

To calculate the resonant frequency, the frequency our absorber will begin to absorb at, we use three main variables. We need the cabinet diaphragm (front wall) density or weight. It must be a certain weight to work well with the other variables. We next look at cabinet depth. The depth of the cabinet is critical in determining how low we can absorb at. The internal cabinet fill must be of high enough absorption performance that it absorbs all the internal cabinet resonances and then some more. We want it to over react act like using a roll of paper towels to soak up a glass of water that was spilled.

Formula Required

There is a formula that we use to plug all of these numbers into and get the general resonant frequency of the cabinet. The greater the density of the front diaphragm, coupled with the cabinet's depth, goes a long way to determining how low of a frequency the absorber will work at. The internal cabinet fill has a direct impact on the rate of the cabinet's absorption. The cabinet face density and the cabinet depth, determine the operating frequency of the unit. What you put inside the cabinet, determines how fast the diaphragmatic absorber absorbs all the energy above the designed for resonant frequency.

Three New Ways

We can improve upon the traditional diaphragmatic absorber technology in three critical ways. We can take a Buick which is current technology and make it run like a Ferrari. If we have two diaphragms or front walls, we get twice the impact of just one wall. Remember, the goal of the front wall or diaphragm is to slow the wavelength down by moving in sympathy to the pressure exerted upon it.

Air And Mass

If we have two walls, we can slow down the energy at a faster rate. If we carry this further and adjust the densities of each new wall to move together in a sympathetic movement, a synergy effect happens where two walls do not just work twice as well but work say, 5 times better. Calculating the proper air space that is required between these two front is paramount so they work with each other and not against.

Better Cabinet Construction

If we increase the density and rigidity of the cabinet, we also can impact more positive change. Our structural design goal with the cabinet is to make the cabinet as rigid as possible, so that it will not flex. If the cabinet does not flex, the front two walls are the only thing moving. We want the front walls to move not the cabinet. The cabinet is the backstop for the reduced energy to strike.

Cabinet Must Not Move

If we use multiple layers of material in building the side walls and top of our unit, we can achieve structural rigidity. Using a process termed constrained layer, mass damping, we sandwich different layers together with different densities. Between each layer of material, we place a damping compound that minimizes layer to layer vibrational transmission. We must also perform this layering technique on the unit’s back side. Increasing cabinet structural strength, forces the front walls to do more good work.

Activated Carbon Engine

Once the energy enters the cabinet inside, it must meet more than traditional building insulation material. If the inside of the cabinet has a very powerful absorber in it, that is powerful on its own without being in the cabinet, then we have created a large reduced pressure area inside our sealed box. This large internal cabinet lower pressure area is achieved using activated carbon or charcoal.

Looks Like Miniature Meteor

Activated carbon has numerous pores that sound can enter and be converted to heat. This is a similar process to open celled foam. Sound enters the open cells of the foam and is converted to heat. The fly enters the meat eating plant and is digested. One can achieve large rates of absorption that will be at levels higher than the designed for resonant frequency of the absorber.

Two Doors Instead Of One

Traditional diaphragmatic absorbers have one front wall or diaphragm. They also have building insulation material inside of them. Usually, the same material and thicknesses are used to build the cabinet itself. They work well for the amount of real estate they occupy, but with a major engine overhaul, can really take off. If we use two walls instead of one and design the two walls to work with each other, we have begun the overhaul. Next, we make our cabinet very rigid with vibrational reducing technologies.

Two Walls Working Harder

Since the cabinet moves so much less than the front walls, the front walls performance increase drastically. Inside the cabinet, we get remove the standard building insulation material and replace it with activated carbon or charcoal. Charcoal is super absorbent. We use it to filter air and water. Now, we are using it to filter sound. We change the internal cabinet fill material (building insulation) from 2.5 lbs/cu.ft. to 10 times that. We use it to filter air and water. Now, we are using it to filter sound.

Old And Now New

One can take a time tested and proven method of low frequency absorption, namely diaphragmatic absorption, and overhaul its engine with structural and internal modifications to make it work many times better. One can achieve lower levels of absorption with much higher rates of absorption at those levels. Our absorber runs faster and absorbs more energy all within the same amount of real estate as standard diaphragmatic absorbers

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Speakers Vs. Microphones

One Sound Family

Our speakers and microphones are part of our signal chain. The microphone is at the very beginning of this chain and our speakers are at the other end. Microphones take acoustical energy and convert it to electrical energy and then we process this energy through our equipment. Our speakers then take this electrical signal and mechanically move to produce analog energy that our ears can hear. All of this connectivity ends when we place our speakers and microphones in our rooms.

Microphone

When we use a microphone in the recording process, we are continually dealing the sound of the room in which it is placed. Care must be taken to include the vocal or instruments information with the correct amount of room sound for a balanced blend of room and music. With vocals we want no room sound or a very small amount. With drum sound, we want the sound of the room. Room sound is usually not welcome in our recordings except when recording drums.

Drum Sound

Our typical drum room has high ceilings and is a larger room. It is a larger room because larger rooms produce a larger sound at the microphone positioned. Most recordings like to have a larger sounding drum. If the engineer gets the drum sound correct, everything else in the mix falls into place much easier.

Speakers Smaller Rooms

Our speakers do not like larger rooms. Larger rooms require bigger speakers in order to produce the necessary amount of energy to fill the larger space. The larger the room, the more detail we loose in our sonic presentation. Larger rooms require larger drivers which loose detail as they increase in size.

Hardwood Floors

When we place our microphone in the drum room, we notice that our drum room would have hardwood floors and not much room treatment on the walls. Reverberation times would be higher than most rooms because of size and lack of absorptive room treatment. If the drum room had carpeting, it would probably be removed and any existing absorptive room treatment would be removed from the walls to increase room reverberation times.

Carpet On Floors

Our speakers do not like hardwood floors. Any hardwood flooring will produce reflections at the listening position and we do not want any reflections at our listening position interfering with the direct sound from our loudspeakers. Carpeting or some type of rug treatment over the hardwood floor is desired.

Find The Reflections

The microphone is our drum room likes reflections. Reflections represent the sound of the room. The time signature difference between reflections from our drum room wall and ceiling surfaces is the sound of the room size that the microphone wishes to capture. All of these reflections occurring at different time intervals all add up and contribute to the room’s total reverberation times. Different drum room reverberation times, produce different drum sounds in our mix.

Less Reflections Please

Our speakers have to be placed in an area of our room that is free from room boundary reflections. Our goal at the listening or monitoring position is to have the direct sound, the sound that travels from the speaker to the listening position in a straight line, reach our ears first before the room reflections. We want some reflections to follow the direct sound to add realism to our sound stage, but our goal is to hear more of the direct sound which contains the essence of our music.

* * *

Equipment And Room Distortions

Distortion Everywhere

We have distortion in our equipment. Some of it is wanted and self induced. The unwanted type must be managed and controlled. Our small room acoustical environments also have distortion. It is not electrically induced but it is distortion none the less. All room distortions are unwanted by their very own definitions.

Distortion Definition

The term distortion is a term that refers to a change from the intended designed for signal and the unwanted sound. Distortion is this difference. It is the change in the original wave form as it moves through the circuitry of a unit or though many units chained together. If the waveform is changed in such a way that it is flattened from its original bell shape, we call this distortion clipping because it “clips” the top of the waveform off.

Wanted Distortion

In our equipment there are two main categories that distortion falls into. Let’s call it wanted and unwanted. Wanted distortion is sought after. We twist this knob or that one to try and alter the waveform to produce a desirable, unique, and different sound quality to an instrument or vocal. We can overdrive an amplifier with a guitar to achieve a certain guitar sound.

Unwanted Distortion

The unwanted distortion occurs when we have hum or static in our system. This unwanted distortion comes about because of the misuse of electronics in the signal chain. If an electronic circuit in one of our pieces of equipment sees a signal that it can’t handle and then starts to overload, we will get electronic distortion. We have all heard this with ground looping issues. The original waveform that was originally designed to produce by the equipment has been distorted through overloading the circuit.

Longitudinal Waves

Sound waves are classified as longitudinal waves. They oscillate or expand and contract like a caterpillar moving across the floor. This raising or lowering of the caterpillars body produces higher and lower pressure regions. Each of these pressure areas minimum and maximum have opposite polarity. The pressure on one side is increasing and the pressure on the other side is decreasing.

Room Modes

Our small room acoustical environments have distortions. Rooms have a certain dimensional ratio that produces room modes. These modes or resonances are the room’s way of reacting to certain frequencies or wavelengths. Certain room sizes like certain frequencies while disliking others. When a room modal resonance is excited, it can blur and smother other frequencies. A microphone placed in a room mode may "hear" some of the intended sound to be recorded, but may miss other frequencies completely.

Axial Modes

Room modes come in three main flavors. There are axial modes which are the resonances that occur between two parallel room boundary surfaces. Axial modes are the most powerful of the three forms of modes. Axial modes occur between the ends of our rooms, the sidewalls, and the floor and ceiling. There are also the associated harmonics that go with each fundamental resonance.

Tangential Modes

Tangential modes are half as strong as axial modes and occur between two sets of parallel surfaces. Tangential modes are formed by four traveling waves that reflect from four walls and move in a manner that is parallel to two walls. Even though they are only half as strong as axial modes the frequencies that they occur at along with their harmonic trails interfere with our middle frequency ranges where our vocals lie.

Oblique Modes

Oblique modes involve eight traveling waves that are reflecting from all six room boundary surfaces. They are half as powerful as tangential modes and half one fourth the energy of an axial mode. Axial and tangential modes give us the most difficulty when we are trying to manage them. If one treats for axial and tangential modes first, the oblique modes will usually become a non issue.

Speaker Boundary Interference Response

Our speakers and our room walls create another distortion. It is called the speaker-boundary interference response. This is a distortion that is produced as a result of the direct sound from our loudspeakers interlacing with the reflected sound from our room surfaces. This particular type of distortion occurs at lower frequencies more than middle and high frequencies.

Virtual Images

The room's boundaries that are close to our loudspeakers create another speaker if you will. The sound leaves our speakers and strikes the nearest room boundary surface. That energy is then sent back to the speaker through reflections. This process continually repeats itself and we have the speaker producing energy and then all of these virtual reflected energies producing sound. Thus our sound at the listing position will be coming from our speakers and the room boundary interference "speaker".

Comb Filtering

Comb filtering is another room caused distortion. Comb filtering is basically a reflection that interferes with our speaker direct sound. The direct sound from our loudspeakers is the sound that travels in a straight line from the speaker to our ears. It is the sound that we need to hear so we get our mixes correct. Reflected energy from our room surfaces contains all the room sound.

We do not want room sound in our mixes, so we sit near field to try and take the room sound (reflections) out of our mix.

Comb Filtering Evil

When reflections interlace with the direct sound and we take a picture of this phenomenon, we see a series of peaks and troughs closely grouped together to form a “comb”, just like the device we use on our hair. You know the thing we use to keep next to our pens in the pocket protector. This comb filter does just what the name implies. It imposes its comb like teeth on our audio signal and can filter all of the clarity and definition from our music. A comb filter can also mask whole instruments or vocals, especially harmonies and rhythm sections.

Natural Diffusion

Sound that occurs in our lives that is not absorbed is reflected or diffused. Diffusion is everywhere in our world with sound bouncing and moving off all objects on earth. Our ears are specifically designed to deal with diffusion of energy and our ears localization systems work in a diffuse sound field. When we take a space of air and build four walls with floor and ceiling, we contain that air space and then we minimize the diffusion that occurs naturally in our world.

Diffusion Is Air

A diffuse sound field has “air” in it. Air is that space between each attack note. It is also that space where the note decays in. It is in the reduced and focused reflections from the walls that it works its magic. Diffusion takes a reflection and reduces it in magnitude without altering the signal’s phase or amplitude.

Equipment And Room Noise

Our electronic equipment produces both unwanted and wanted forms of distortion. Bending waveforms does have its sonic limits. Unwanted distortions that are produced electronically are unwanted because they hurt our ears. Our rooms can also be a source of this acoustical pain. Reflections mix themselves up with the direct sound and then we have this dance of direct/reflected energy. It is a dance between the direct which is the music and the reflections which represent the room sound. If the dance gets to heated, we get comb filtering. Our room is a box and we must let fresh air in our box. One could tear the walls down or simply add acoustic diffusion to create more natural air.

* * *

Perforated Panel Absorbers Vs Diaphragmatic Absorbers

Perforated Panel Absorbers – Hybrid

Perforated panel absorbers are a type of hybrid absorber. They are a cross between a membrane absorber and a diaphragmatic absorber. They are probably equal in performance to a membrane absorber but not capable of going as low as a diaphragmatic absorber within the given panel depth requirements. By definition a perforated absorber has perforations on the front panel, that allow for air movement through them into the cabinet insides. A diaphragmatic absorber has a face panel that does not have any perforations and is solid. Even if the cabinet fill material is the same, the diaphragmatic absorber will always go lower than a perforated absorber. What is a PPA?

PPA Construction

We take a box and build it out of plywood, mdf, or wood. The face of the panel has a certain thickness that can be increased or decreased to work into sympathy with the perforated holes. The perforated holes have a certain diameter and they act as miniature Helmholtz resonators. They are classified as a resonate absorber and each perforation or hole is the opening of each individual resonator directly behind the hole. If sound strikes the perforated panel in a perpendicular manner, then all the resonators are in phase and maximum absorption occurs. The sound that strikes the panel's face at an angle will be reduced in sound absorption rate and level.

PPA Performance

To calculate the frequency of resonance of the cabinet, we need to look at the number of perforations or holes in the face as it relates to the total panel surface size. We also need to look at the diameter of the hole, the front panel thickness, and the total depth of the panel itself. If we increase hole perforation, percentage, and the depth of the cabinet absorber, we lower the cabinet's resonant frequency in a linear manner. The opposite also occurs in the same linear fashion. A perforated cabinet with a depth of 5 5/8″, a .25% perforation, and a 1/8″ hole diameter, we can get down to 90 Hz.

Diaphragmatic Absorbers

Diaphragmatic absorbers do not have holes or perforations in them. In fact, when most people see a diaphragmatic absorber they look for the holes for sound to enter through. When they do not see any, they wonder how it works. It works by first slowing down the lower frequency wave when it strikes the front wall. Then the wave enters the inside of the cabinet where there is an internal cabinet fill material. The internal cabinet fill material does two things. First, it absorbs the resonances that are inherent within the inside dimensions of the cabinet. Secondly, it works in harmony with the overall unit to produce the design resonant frequency of the cabinet.

Larger Densities

Diaphragmatic absorbers are noted for their ability to go much lower than a perforated absorber. Both share the need to calculate the cabinet depth to produce the units resonant frequency. However, the densities used in the build materials of diaphragmatic absorbers is much higher and with that increased density of materials come lower resonant frequencies.

Front Wall

A diaphragmatic absorber has a front wall that moves or "vibrates" in sympathy to sound pressure that is exerted upon it. When sound pressure energy strikes the front wall of a diaphragmatic absorber is moves in sympathy to the amount of pressure exerted upon it. this movement slows the pressure wave down. A diaphragmatic absorber is really a series of small barriers all assembled into a single box that are systematically designed to slow long wavelengths down. Once inside the cabinet, it is impacted by the internal cabinet fill and also the density of the cabinet itself.

Two Walls Better Than One

The cabinet, front wall, and fill material must be designed carefully to increase performance by lowering the start frequency of resonance of the unit. The front wall density is critical in the calculation. Along with the density of a single wall in the front of the unit, we have discovered that you can increase the overall unit's performance by adding a second wall. Both walls must work together and move in sympathy with each other to produce the maximum amount of friction to slow lower frequency wavelengths down.

Rigid Cabinet Construction

To encourage both front walls to work together at their maximum capacity, our cabinet must be rigid and as inert as possible. To accomplish this, we borrow from speaker construction technology and use a cabinet that has multiple layers of materials with damping compound in between each layer to minimize vibrations and encourage rigidity. This increased rigidity in the cabinet over the front walls, forces the front walls to move more than the cabinet. It is similar to a speaker, with the front wall acting as the speaker or diaphragm by moving. However, the front wall of a diaphragmatic absorber moves because of sound pressure, usually from a speaker on it and not from electricity moving through a coil.

Internal Cabinet Fill

The literature tells us to use fiberglass or some type of building insulation inside the absorber to absorb internal cabinet resonances and to impact overall unit performance. If you use those materials, you will get the performance the tables and charts indicate. However, if you pay more attention to the inside cabinet fill material and choose one that has a higher level of absorption than either fiberglass or building insulation, you can increase the unit's performance by a larger factor. This is the reason for activated carbon inside our absorbers. We can lower the units overall absorption capacity level and have a much greater impact on the rate of absorption.

Same Class – Different Performance

Perforated panel absorbers have holes in their face and diaphragmatic absorbers have a solid face. Diaphragmatic absorbers are good for going after frequencies below 90 Hz. Perforated absorbers are lighter in weight than diaphragmatic absorbers and are for absorbing in the low middle and higher critical band. Both need internal cabinet fill and benefit from material that has a high absorption rate and level other than that produced by mineral wool or building insulation.

* * *

Electricity For And In Our Recording Studios

Grid Noise

We all know that the energy we receive from our local utility is full of noise. There is a whole industry out there of power conditioning companies who will for a fee provide you with a filter to take this noise or that noise out of the grid system for you. Gear companies will even provide you with gear that has its own power supply, so that their equipment does not have to use that noisy grid energy. Even power fluctuations can occur at different time periods during the day depending on the specific demand on the grid itself. Our studio usually runs at 121 volts during the day but in the evening it can go to 123 volts and even 125 volts after midnight.

Equipment Energy

Once we have the issue of producing clean energy for our studio resolved, we can deal with the noise produced by the electronic equipment that will reside within our studio. Each unit in the signal chain has some type of electronic signature. Noise energy can be transmitted through the power wires of our studio to other units or even be distributed through the air. Remember, amplifiers do what they were designed to do, they amplify both pure signal and don't forget about the pure noise.

Equipment Is Amplifier

The electric guitar is a good receiver/amplifier because of the way the electronics are made inside the guitar. The pickup of the guitar is a coil of copper wire which receives the signal and then sends it to an amplifier which is another device that has coils encasing a piece of iron to guess what, create an electromagnet. Thus, both the pickup and the amplifier share the same electrical DNA by acting like transformers which radiate and receive electrical fields. There are also pickups that have two or more coils.

Humbuckers

Humbucker pickups are known for their unique sound quality. The famous Humbucking pickups have two coils that are wired out of phase with each other. Thus, the noise that is shared with the coils is in phase and eliminated from the system. This is a common electrical technique for dealing with noise within the lines of our electrical systems. Computers also share this same genetic code.

Noisy Computers

Laptop and desk computers also have coils within them. Look at any circuit board and one will find tiny cylinders of copper wound wire. Electrons are flowing through these coils to assist in the production of video images. Even the popular flat panel, LED and plasma, have coils inside of them. There is always a light source behind the panel screen that produces the color images. This process of providing the energy for the screen light and then the panel itself also produces noise. Watch how you run your cables together. Keep all power cables well away from video and audio signals. If they do have to cross, make sure they cross perpendicular to the audio and video cables.

Dimmers

Dimmers are a device that must be used with caution. Watch the quality level you use in your studio and do not use any dimmers that were made for your home. They produce too much noise because of the electrical process they use to "dim" your lights. These residential dimmers to not vary voltage to dim your lights. Instead they take a knife to our 60 cycle electrical wave and divide it into pieces. They use small pieces of the wave for dim light and the entire wave not chopped up for the brighter light. Always use what is called a Variac dimmer. They do not generate the high frequency noise that will travel through the air, but keep the transformers away from your gear just to be safe.

Cable Connector Mount

The way your cable connector is mounted to the gear chassis will also play a factor in how much resistance to noise the unit has. Our electrical goal is to create an electrical bypass so that the noise will exit the cable and flow into something else other than be transferred to our unit. If the noise gets into the unit, it is much harder to find and eliminate within the circuitry. This is called the PIN-1 nomenclature used within the electronic literature.

XLR, RCA, Firewire, USB

XLR, RCA, Firewire, and USB are all connectors that can have issues with this dilemma. The shield / pin-1 connector must be routed directly to the metal chassis. Some connectors are isolated from the gear chassis because it is easier to make in the manufacturing process. Manufactures run the signal path from pin-1 through a printed circuit to save space and money, but this process amplifies all the noise before sending it to ground. Keep the ground out of the circuitry.

Noise In / Noise Out

We must be conscious of the noise within the power that comes into our studio and then once inside, we must be careful with the noise that power can create within our gear. Computers, cable connectors, and even dimmer control devices must all be examined for noise producing capabilities. Watch for the transformer concept with pickups and the ground connection on all our gear's metal housing.

* * *

MIM – Musical Instrument Museum

MIM – Scottsdale, Arizona USA

The MIM is located in Scottsdale, Arizona and is exactly what the name implies. It is a museum of musical instruments from the entire world. We have musical instruments from Asia, Africa, and South America, to name but a few. The MIM also has a guitar section featuring guitars, banjos, and other stringed instruments from around the world. There is a special emphasize in display areas for American guitars and the famous artists that have used them. Audio is readily available.

Inside Music Theater

Inside the Mim is a 300 seat venue with a stage. On the stage, they have a single, Yamaha piano that plays by itself. It plays classical pieces that last about 8-10 minutes each. The sound energy coming from the piano appears to be amplified at the piano itself. Probably with some speakers under the piano bed where they cannot be seen. There is no one in the audience except me. It is just the piano, the room, and me. I have waited for this day.

Theater Dimensions

I asked for some specifications on the room such as dimensions and volume, but they did not have anything other than the standard marketing literature. I would estimate that the stage could fit 8 grand pianos, side by side, across it. I used the existing piano as my unit of measure. Let’s call it 50′. The stage was made of wood and clear coated finished and about 18″ tall. The room was about 100′ long and best guess would put the height at 20′. Above the stage, was a single speaker positioned horizontally at top stage center. I did not see any other electronic sound reinforcement.

Stage Wood Walls

The stage front wall was beautifully curved wood sound redirection panels that were vertically positioned. The convex shape would lend itself to sound redirection principles. We want to take the energy created from the stage side walls and redirect that energy at multiple angles back out into the audience area.

Wood Diffusion Surface

Directly above these wood sound redirection panels was a series of wood strips, maybe 3″ wide, that were in layered and positioned on top of each other. The strips wrapped around to form a wave of wood strips that was about 10′ tall. It wrapped around the room until about room center.

Marble Side Walls

Continuing along the bottom half of the side walls, in the area where the seats are located is a stone plated wall. I am guessing that it is some type of marble or granite that has a semi gloss type of polish to its surface. It is light colored and its surface is a raised type of surface. Each stone panel is either recessed or protrudes past the one in front of it and behind it. This uneven surface configuration is aesthetically pleasing but also aids in higher frequency diffusion.

Sound Absorbing Technology

Above the stone surface area, which is located directly left and right of the seated area, is another series of slats that have fabric covered spaces between them. The slots or fabric covered spaces are all the same length, which leads me to believe that these slots form the opening to a Helmholtz resonator. They appear to be around 3′ long with a 2-3″ opening, which is then covered with black fabric. With this size opening, using quarter wavelength theory as our guide, we are looking at a absorber with a resonating start frequency of around 90 cycles.

Rear Wall

The rear wall is similar to the front wall directly behind the stage and off stage right and stage left. There are large, vertically placed, convex shaped, wood panels that go from the far left of the rear wall to the far right. There is a control room window that occupies the top right position of the rear wall area as you stand up in your seat and face the rear wall. The rear walls and front walls redirect the sound energy into the audience.

The Ceiling

The ceiling system consisted of rectangular shaped panels which appeared to be covered with some type of fabric. They averaged about 20′ in length, 6″-8″ deep. They were probably 6′-8′ wide. They were placed next to each other from front of the room to the rear and each panel's angle was adjusted, so that all reflections from the ceiling area were routed back to the rear of the room through a series of angles. With a 100′ long room, you have time to let the reflection die on its own volition by simply running out of another surface to strike again. With their varied thicknesses, the ceiling panels had to be broadband absorbers.

The Sound

The sound from the piano that was playing was the only source that I used. I have yet to attend any concert or activity at the Mim, but I will that you can be sure of. In short, it was as natural as could be with no hint of room sound overall. The piano on stage and the sound that radiated from it stayed on stage with the piano. It was not thrown around the room to pick up additional room sound on its journey. Every note was separate and distinct, with excellent attack and decay without the hint of too much absorption or diffusion from the room treatments. I have never heard a room this size sound so good. I stayed and listened for at least an hour. It was so visceral; I did not want to leave.

SBIR – Speaker Boundary Interference Reflection

There was one issue that I did hear from my center seat. I am still the only one in the theater. People come and go, but they never do stay very long. There was a speaker boundary interference effect going on between the piano bed and the stage. This is what led me to believe that there was a speaker that was amplified under the piano pointing down. It is the same sound one gets when you place your speaker close to the wall in your listening room. It is a blurring and smearing of individual notes with improper time signatures on the attack and decay of chords. After listening for awhile, I realized that it covered all frequencies. A broadband absorber from 30 cycles to 6,500 cycles would do the trick.

Free Space Listening

MIM or Musical Instrument Museum is located on the corner of Tatum and Mayo Blvds. in North Scottsdale, AZ. One must make three trips. The first two trips are just to see the museum exhibits. There are two floors of exhibits. The third trip is to attend a concert in the 300 seat theater. This is where you were be transcended into hearing music as it should be heard. There has been so much care and concern put into the room acoustics that the room in effect has been made to acoustically vanish. It is the closest thing I have ever heard to free space listening, which is listening to music with no ambient noise around and no walls or ceiling either. I will report back after my first concert to let you know if the room translates as well with multiple instruments and vocals as it does with the piano. I sure hope so.

* * *

The Sound Of The Living Roof Project

Living Roof Project

The living roof project is the name we gave to a structure we built for a client in Arizona. The reason we called it the living roof project was because on the roof of the structure was 18″ of top soil that included its own irrigation system and solar panels to provide the power to run all the equipment. The project was centered around a 25′ x 50′ listening room that housed a two channel playback system. The project is finished and here are some highlights and disappointments we encountered from the process.

Many Unique Features

All structural issues for the building including the 20 ton support structures for the corners and the steel I beam construction went well and everything fell into place. Well, sometimes it dropped into place but that is another issue. The solar worked well and the irrigation system after some adjusting provided the proper amount of water to irrigate the structure. Standard carpentry issues arose and were resolved. Let's look at the listening room and see how that evolved.

Original Intent

The original intention of the listening room was to build a room that was acoustically correct including proper room volume and room surface treatment. With a space reserved for the listening room that was 25′W x 12′H x 50′L we had a great start. Granted the steel roof structure was not to our liking but proper room acoustic treatment could be applied to cure any reflection issues. Side wall surfaces would be handled through a combination of diffusion and absorption. However, it was not to be. We were struck by the WAF, the wife acceptance factor.

Listening / Living Room

Once the room tool shape and the equipment were beginning to be installed, the need to fill the room with stuff took over. The original intention and plan of just a listening room became a listening room and a living room. I hate when that happens. The listening chair and all the associated gear had to be placed and located so that one could also live in the room. Why does one need to live in the room? Isn't listening in the room living? It was not to be a dedicated listening room no more. It had to provide living room support. Yikes! There goes the room.

Murphy Bed

Our first issue arose when we looked at the right side wall for the right channel speaker. That wall was to be a combination of different acoustical treatments to minimize reflections from the 6′ tall electrostatic speakers. How does that saying go, even the best intentions… Our side wall now had to house a Murphy bed to satisfy our living room requirements. So much for side wall reflection control. No room acoustic treatment could be installed on a structure that opened up and then pulled down into a bed. Can you imagine a bed in front of your right channel speaker?

Ceiling Treatment No More

Our steel ceiling was necessary for the garden above but with proper acoustical treatment, we could have reduced all reflections from this surface area. We could have even alternated absorption and diffusion panels in a nice decorative array that would have complimented any decor. We lost our efforts to the unique color and texture of the metal ceiling which complimented the existing decor. I hate that word.

Left Side Door / Window

Our left side wall was a door that led outside to the back yard. It was not going to be an issue since proper acoustical treatment could be applied to the door and the glass inside of it. Alas, it was not to be. At the last minute a design change placed another door inside the opening. The door that was installed was a special door from an old building that had some type of nostalgic value and was not to be covered.

Rear Room “Treatments”

The rear part of the room was going to be reserved for possible another system set up at a later date. I mean, come on, we had a 50′ length to work with. How many times does one get that option? The future was not to be. The rear of the room provided a nice space for more living stuff. I will say that some of the living stuff did go with the rest of the room’s decor. Oh, there’s that word again.

Fun Project

All in all it was a fun project with many unique and different features to the design. The 8″ poured concrete walls, the 30 ton garden on the roof, the solar panels, so that this unit was off the grid, and the rain water capture system. Nice surface finishes were applied and the desert earth tones were nice in a listening environment. When asked what I thought of the sound, I had to bite my tongue and say fine. I hope the wink I received from the owner meant that we would work on that in the future. I went outside to pet Zap.

* * *

River Rock Barrier Build

High End Clients

We have the good fortune of working with very high end clients. These clients have the funds to see a project through from the design to completion without too much concern over costs. Even though money is no object, price is always a concern, but a few thousand here and there is not that big of a deal if the end result justifies the expense.

Barrier Technology

One of our clients, who we built a small project studio for, was tired of the traffic noise from the street they lived on. It was not that busy of a street but the client wanted to reduce the street noise in his outside yard area to as low as levels as possible. The outside patio and pool area were the primary social settings and less noise and more privacy were the objectives. Barrier technology needs to be employed.

STC – Sound Transmission Class

Sound transmission loss or STC rating is the number assigned to the structure we need to design and build for a building. This STC measurement really does not apply but we can use it as an example to illustrate what we are trying to achieve. Our measurements indicated that we needed to build a barrier that would have a STC rating of at least 65 to put the brakes on our 40 cycle sometimes energy from the garbage trucks and motorcycles. If we are trying to stop 100 SPL from the source, a barrier with a rating of 65 will reduce that pressure level down into the 30 – 40 dB range. This is acceptable for noises that appear infrequently. It is also very acceptable for noise levels that are consistent and steady.

OITC – Outdoor / Indoor Transmission Class

STC would be a good number if we are constructing a building, but this is an outside barrier configuration. For this measurement we need to use an OITC number. This is a number that measures the sound transmission between outdoor and indoor structures. OITC uses a noise source spectrum that takes into consideration frequencies below 80 Hz.

Full Frequency Range Design

Our goal for the structure was to be able to handle the full frequency range of sounds faced from the traffic on the street. Since it was a residential area, truck traffic was minimal but the garbage trucks in the area produced the lowest frequencies. You know the ones that set off all the car alarms as they go down the street. We had low measured frequencies in the forty cycle range and at 100 SPL at certain times of the day. If we could build a barrier for this frequency range, we were not that concerned about middle and high frequencies.

Big Brother

Obviously, we had to conform to existing city codes. Our goal was to build the barrier as high as possible. After checking with the city, we realized that building our fence/barrier could be no more than 8′ high. Height is critical with outside barriers to reflect as much sound back to its source as possible and out of our living area, but big brother would only permit us up to 8′.

Poured Concrete

Our design consisted of starting with a poured concrete barrier of 8″ thickness. Poured concrete is expensive, but it is the best barrier material we could use. We used the Fox Bloc molds for our initial design. With these molds, one can leave the mold on after the pour and wall is dry or you can remove the 2″ thick mold sides and attach anything else to the wall itself depending on your acoustical requirements.

Arizona River Rock

We were fortunate that the client had a large supply of what we call river rock in Arizona. River rock is a solid rock material with average rock size of between 6″ – 8″ and 2″- 3″ deep. They are dense rocks that have had their edges smoothed out from having water running over them for probably millions of years. The average size river rock weighs between 5 and 8 pounds.

River Rock Attachment

After our initial concrete poured barrier wall was in place, we began the process of attaching the river rock to the wall. We tried numerous adhesives, but we wanted one that would be able to handle the hot summer days in the desert and the colder winter nights of the Sonora Desert. Temperature extreme ranges can go from a low of 20 degrees in the winter to a high of 120 degrees in the summer. This is a 100 degree temperature swing range that must be accounted for. We do not want 8 pound rocks falling on anything or anyone. We chose to “wrap” the structure with steel rebarb that would rust naturally and lend its appearance to the natural rock structure.

Since it was an outside structure and in view of everyone, we had to make sure the river rocks were placed together in a pattern that lent itself to complimenting our 8″ thick poured concrete wall. This was the time consuming part of the project and accounted for most of the project’s cost. We wanted each rock to inlay with the one next to it, so there was no gaps showing that would show the solid concrete wall structure behind.

Live Room Wall

After the project was finished, I stepped back and looked at the structure. I could not help but think how great this build would be for a recording studio. Not only could the studio benefit from the barrier technology and its high STC rating, but I think it would be a unique design for the inside of a live room. The river rock and solid concrete wall would provide the necessary sound attenuation from both inside and outside sources but the river rock would provide a natural diffusion for middle and high frequencies. We would need to compliment the other live room surfaces with sound absorbing materials to keep the sonic balance of the room

Recording Studio Acoustic Treatment

Two Main Categories

Recording studio acoustic treatment falls into two major categories. We have sound absorption and sound diffusion technologies. Sound diffusion can be broken down into three sub categories: low, middle, and high frequency absorption. Sound diffusion is its own category but must not be confused with sound redirection. Lets exam low frequency absorption technology first.

Low Frequency Absorbers

Low frequency absorbers can be freestanding or built into a recording studio. If the studio is built new from the ground up, low frequency absorbers can be built into the structure in the places that they need to be placed to absorb unwanted low frequency energy. Two main types of absorbers used in this manner are slatted and membrane absorbers.

Slatted Absorbers

Slatted absorbers have slats or openings that allow the low frequency energy to enter and then be absorbed into the inside of the slatted chamber. Slatted absorbers are really another name for Helmholtz resonators. Air enters through the openings and resonates inside the slatted chamber which is designed with a certain depth and cabinet fill to absorb the problematic low frequencies the studio designer is working on. A coke bottle is a classic example of a Helmholtz resonator. It resonates around 185 Hz. Frequencies above 185 Hz. are absorbed.

Membrane Absorbers

Membrane absorbers or diaphragmatic absorbers are the second main category of low frequency absorbers. With a diaphragmatic absorber, we have a diaphragm or front wall that vibrates when low frequency energy strikes it. This vibrating front wall slows down the long, low frequency wave before it enters the inside cabinet dimensions. Inside the cabinet is sound absorbing material to assist in absorption of the low frequency energy entering it. Diaphragmatic absorbers can be designed to absorb a large amount of energy in a small amount of space.

Acoustic Foams

Middle and high frequency absorption is well known in the recording studio acoustic treatment genre. Acoustic foams receive the most attention. Acoustic foams, more specifically, open celled acoustic foams, absorb middle and high frequency energy by converting sound energy to heat. Sound energy enters each open cell of the foam and is converted to heat. This energy transformation process results in energy conversion from mechanical energy into heat and this energy conversion process creates sound absorption. Acoustic foams are popular because they are lightweight and relatively inexpensive to manufacture.

Mineral Wool / Fiberglass

Middle and high frequency absorption can also be accomplished using fiberglass or building insulation type materials. Mineral wools also fall into this category. These materials are inexpensive to manufacture and are readily available. However, they are difficult to work with and do present some environmental issues when handling. Fibers from the material can break off the insulation and be inhaled. Proper air filtration methods must be employed when handling this material type to avoid any chance of inhaling the fibers.

Sound Diffusion

Diffusion can take many forms within the genre of recording studio acoustic treatment. We must define sound diffusion vs. sound redirection, so we are all on the same page. Sound diffusion takes sound energy and spreads it out into both horizontal and vertical planes. Sound redirection is just what the name indicates. A sound redirection device takes sound energy that strikes it and sends that energy off in an opposite direction of the angle of strike. Sound redirection and sound diffusion are frequently used as synonyms but they describe different processes.

Quadratic Diffusion

The most popular sound diffusion in use today is termed quadratic diffusion. Quadratic diffusors are built using a series of wells or troughs that have a specific width and a specific depth. The number of wells are determined using a prime number sequence. A prime number of 7 would have 6 wells of different depths; A prime number of 23 would have 22 depths. Each well depth diffuses energy at a quarter wavelength and well width is based on half wavelength. A vertically positioned quadratic diffusor will spread sound out in the horizontal plane. A horizontally positioned diffusor will spread sound out in a fan like array in the vertical dimension.

Sound Redirection

Sound redirection devices are different than quadratic diffusors. A common sound redirection device looks like half a circle with a 180 degree arc to it. Sound energy strikes the hemisphere and depending on the strike angle, will be redirected into the opposite direction. The physical law of angle of incident equals angle of refraction applies here. There is no spreading out of the sound in a fan like array which is the hallmark trait of quadratic diffusion. Sound is simply redirected from one direction into another.

Sound Absorption / Diffusion

Recording studio acoustic treatment comes in two basic types. We have sound absorption and sound diffusion technologies. Sound absorption is broken down into three sub groups: low, middle, and high frequency absorption. Low frequency energy is absorbed using slatted and membrane or diaphragmatic absorbers. Middle and high frequency absorption can be achieved using open celled acoustic foams. Sound diffusion is not to be confused with sound redirection. Quadratic diffusion is a time tested and proven method of diffusing sound energy into the vertical and horizontal dimensions.

HVAC System Noise In Our Sound Sensitive Rooms

Barrier / Sound Absorption Technology

In our professional recording studio and listening rooms, we now know the two types of technology that we need to deal with the energy within our rooms and the energy that is generated from sources outside our rooms. We use barrier technology to reflect energy from outside sources back to the source and we use sound absorptive technologies to manage the sound energy we create within our rooms. We use a combination of both barrier and sound absorption technology when silencing our HVAC systems.

Air Movement

Air moves through our HVAC systems. This can be cool or warm air and all of this air movement against the duct work causes friction and with friction we have noise. We have this air movement through the duct work and we also have the noise from the machinery that produces this cool or warm air. The fan that moves the air and the grill work that the air flow exits through are all contributors to the background noise in our sound sensitive rooms.

ASHRAE Handbook

First, we must determine what noise levels we are willing to tolerate. The lower the noise level we require for our sound sensitive rooms, the more expense we must endure. Every dB of unwanted HVAC noise costs a certain amount of money. Finding the number that works within the intended use of the sound sensitive room is a balance between noise level and budget. If one has any doubts about how to establish the noise criteria, the best book to consult on the numbers is ASHRAE Handbook. It stands for The American Society Of Hearing, Refrigerating, and Air Conditioning Engineers.

Fan Noise

Fan noise is one of our unwanted contributors. There are two basic types of fans. There are pressure blowers and centrifugal fans. Pressure blowers are the nosiest of the two. The smaller the pressure blower the more noise created. It is the opposite with centrifugal fans which as their size increases, so does the amount of noise they create. We have the blades and the motor mechanism that drive the fans. Fans with less than 15 blades, produce relatively pure tones that are spread across the frequency spectrum. This is predictable noise. The air rushing through the duct work creates vortexes which are responsible for random noise.

Machinery Vibrations

All of this machinery noise is produced by numerous vibrations. These vibrations must be managed, so that they do not transmit into our sound sensitive rooms. Mounting the machinery on the roof is not to be considered. The equipment must be mounted and positioned on its own slab of concrete or other vibrational damping structure. The mounting slab must not contact the building in any form or manner. Keep the equipment as far away from the sound sensitive area as one can physically accommodate considering all connecting components. Vibrational mounts can be utilized as long as the vibrational energy spectrum of the equipment is dictated by the isolators.

Air Movement

As air moves from the machinery that creates it through the transport system or duct work, we have air flow. The speed or velocity of the air flow produces the noise levels. For every doubling of air speed, we have a 16 dB increase in noise. The quantity of air the room requires will determine how large the transport or duct work that will be needed. It is advisable to use larger duct work than is required by a normal room that is not devoted to sound. An air velocity of 500′ / min. is considered to be the maximum amount of air flow for rooms that must manage sound energy.

Air Flow

The air flow through our duct work must travel across a smooth and uniform surface. Any bumps or curves will increase friction and friction is the baby of noise. Air flow is similar to water flow. If you are moving water through a 2″ diameter pipe, then every 90 degree bend you make, the water traveling through and the additional friction created, will be the equivalent of adding an additional 10′ of pipe in the water's path way. The intensity of the noise will increase 5 – 6 times with the power of the moving water.

Duck Lining

To keep all of this noise under control, there are classes or types of sound attenuating devices. We can line our duct work with an absorptive lining that will be able to absorb energy. Open celled foam would be a good choice here. One must pick the lining material that will absorb at the wanted frequencies. Lower frequency absorption may be needed at one section and middle and high frequency absorption needed at another.

Blocked Line Of Site

Another way to minimize duct work noise levels is to vary the shape of an attenuator that is placed within the duct work. Duct lining allows for the absorbing material to be placed on the duct work inside walls. If one looks down the duct work they will have a clean line of site using a regular duct lining approach. If we place a foam wedge in the duct work, we can alter the air flows straight pathway. This process acts as a ” air flow re-director” by spreading or redirecting the air flow across different surfaces instead of a straight line.

Plenum Chamber

A plenum chamber is a chamber that is built into the duct work to redirect energy from a straight line shot to flowing into a plenum chamber. It is an expansive chamber or to use a car analogy, we would have a muffler inserted into the duct line. This muffler would cause pressure fluctuations which will act as a sound attenuating system at certain frequencies.

Compressors, Fans, Duct Work

Our HVAC systems move our warming and cooling air through our sound sensitive rooms. Care must be taken in locating the equipment that produces the temperature changes to the air. The cooling mechanism and the fans that move it are to be located away from our sound sensitive environments. Once we have the air source treated, we must then focus on the duct work where all the air will move through. Reducing the friction this air flow causes within the duct work is accomplished using numerous options.

* * *

Chapter 3: ROOM SET UP INTRODUCTION

There are many variables that must be addressed when we are setting up our professional recording studio, personal listening room, or home theater system. We must consider the room dimensions, speaker size, speaker distances to listening or monitoring position and many other variables that must be dealt with to insure that we arrive at the sound that will complement the existing room size. In this section, we examine all of these variables and show the why behind all the possibilities.

* * *

Control Room Design

Control Room Goals

The primary goal of control room design is to achieve a flat or smooth frequency response that would translate into a similar response time in domestic and consumer rooms. This room response was also to have a decay rate that was equally representative of end user listening rooms. Our acoustic goals for our control room on the professional side was a compatibility between control rooms so a mix in one control room would translate into another control room. Secondly, our control rooms must be designed to provide a comfortable working environment for the engineers who must spend hours working in the control room.

Standardization

In order to make sure that mixes that are made in one control room will translate into another control room we need a standard set of conditions present in one control room translates into another control room. The European Broadcasting Union tried this standardization many years ago but could not get anyone to agree. Control rooms are all different and dissimilar.

Monitor Location

The first and most important factor in any control room standardization process is the location of the monitors or loudspeakers. The location of the monitors is directly responsible for the frequency response in the control room. The position of the monitors is directly responsible for the cumulative response and blending of the direct and reflected sound which is critical to any uniformity or standardization of sound. Flush mounting of the monitor speakers in the front wall will go along way to achieving some sound standardization and cross studio translation. A control rooms goal is to add nothing to the mix sound.

Near Field Monitoring

Near field monitoring is a best effort to minimize room response issues. With near field monitoring, engineers can hear the sound of the monitors with minimum room sound entering in to the equation. With near field monitoring we are sitting within the critical distance. The critical distance is the area where the direct sound or straight line sound from the monitors predominates. With monitors positioned within the critical distance, the reflections from room boundary surfaces are minimized. Let’s push the critical distance to be “outside” the boundaries of our control room. Lets design rooms that have all reflected energy under control.

Near Field Pros and Cons

Near field listening has its benefits and disadvantages. If everyone near field listened, we would have a large number of engineers who at least knew of the sound of a group of monitors. This would be a benefit for all concerned. Work performed on near field monitors could be judged and compared with other control rooms. However, near field monitors lack good transient accuracy and cannot reproduce the lower critical bands of energy that provide the foundation of low frequency energy in our mixes.

Dynamic Range Limitations

Dynamic range of near field monitors is also limited. Without the ability to have dynamic range response in our monitors, we cannot assess the critical low level detail. This low level detail can only be realized if our loudspeaker has the necessary dynamic range to permit the distance between low and high energy passages to be heard. What we need to do is to extend the benefits of near field listening, namely staying within the critical distance parameters to the rest of the room.

Low Energy Management

We also need our rooms to provide the proper rates and levels of low frequency control and management, so that our critical distance is available throughout the room and low frequency pressure build ups will be evenly distributed within the room. We need low frequency absorption that can handle the lowest frequency issues our room dimensions dictate and also provide the proper amount of absorption to provide the necessary attack and decay so necessary with lower frequencies.

Golden Ratios

Proper room dimensions are critical if we are to have a running start to manage low frequency energy. It is always better to choose the correct room dimensions to minimize the impact of room dimensional resonances. Certain room heights, widths, and lengths are more favorable to producing less room resonances. We need to find those “golden ratios” and utilize them in our room size choice. We may even have to make the room smaller to allow for reduced modal resonances.

Reflection Control

Near field monitoring minimizes the impact of room boundary reflections. If we are to extend this concept to the whole room, we must use current absorption and diffusion technologies to bring the rate and level of these reflections down below the direct sound from our control room monitors. We must address the rear wall reflections that produce a time delayed signal of its own at the listening position. A balance of current absorption and diffusion technologies can accomplish this for us.

Ceiling And Side Walls

Ceiling and side wall reflections must be addressed in a similar fashion as our rear wall. We must use a balance of absorption and diffusion technologies to reduce the time signature on these surface reflections, so that it does not interfere with the direct sound from our monitors. Near Field monitoring is a direct response from engineers to minimize these surface reflections by sitting closely to the speakers. We need to extend this concept by treating the whole room so it does not produce the reflections that engineers are running away from by sitting near field.

Standardization Components

If we place our monitors in a surface mount position in the front wall and treat all room boundary surfaces with the proper amount of diffusion and absorption technologies, we can go a long way to achieving some type of standardization in the monitor or control rooms of our studios. Front wall flush mounting will standardize the frequency response in our rooms and the treatment of all room boundary surfaces will minimize the impact of these time delayed energy on our mixes. Proper room dimensions and boundary surface reflection control are a must if we are to begin to achieve the direct versus reflected energy ratio we must have for any control room standardization to occur.

* * *

Tom Hidley – Non Environment Rooms

More Than One Third Octave Needed

In an attempt to standardize all control rooms, so we can determine what good sound is we must look at room designer Tom Hidley. Tom Hidley came from the school of thought that looked at one-third octave room response and if balanced we were good to go. We now know today that this approach does not take into consideration phase and without phase considerations, we cannot have a proper transient response within the room. We need to look at wall surfaces and composition.

Stevie Wonder

During this time period rooms were viewed as over trapped. This term came about because individuals felt that the bass did not have the same balance as the middle and high frequencies. Individuals were not able to figure this issue out because the analyzers were all measuring flat. The room in question was booked for Stevie Wonder. During the session, Stevie Wonder kept referencing and pointing to the loudspeakers. However, The locations he was pointing to were not where the speakers were located. Localization of the speakers was difficult because there were too many reflections.

Japan Journey

His next journey took him to Japan where he was to build two rooms which were similar in design to rooms he had made in the past. The terms and conditions of this task were rather unique. He consented to building the rooms but he had certain requirements. He would build one room the way the client wanted it and the other room he would build the way he wanted it. Whatever room was the best liked by musicians and engineers, would be the room to stay built. The other room would have to be demolished and the favored room would be built into its place. The winning room was termed the Non-Environment design.

Non Environment Room

The new Non-Environmental design was different. It had low decay times, hard front walls, and of course flush mounted, front wall monitors. This was a radical departure from current “live end dead end” acoustical studio approaches that were currently being built in the USA. Chip Davis pioneered this technology which had the front of the room treated with absorption and the rear of the room left more lively through no treatment or the application of diffusion technologies. Vertically aligned monitors were introduced at this time into the Non Environment Room.

Vertically Aligned Monitors

With this new control room design, it was a relatively easy to fire the vertically aligned monitors into a highly absorbent rear wall. That issue was resolved. However, now Tom had to address the omni - directional low frequency energy within the room. Different sized rooms produce resonances at different frequencies because of the given room dimensions. He needed a universal type of low frequency absorber that could be applied to any room size, if we are going to standardize a room for the sound quality.

Membrane / Diaphragmatic Absorption

The solution to the low frequency absorption standardization technique came about with membrane absorbers in front of a panel or diaphragmatic absorption as we know it in North America. The membrane absorbers were good down to 100 cycles and then the panel or diaphragmatic absorbers would handle below 100 Hz. One could lower the resonant frequency of the diaphragmatic absorber by making the panel depth larger and also by lowering the Q value of the cabinet.

Modeling Not Easy

To make life easier, Tom tried to model this new room and come up with a standard that could be applied universally. He was designing rooms that had 10 Hz. cycles to design for, so a low frequency component that could be placed inside the rooms was paramount. He used a one tenth modeling of all absorptive systems, but this model did not seem to translate to real sound properties. Modeling of complex systems within a room is difficult.

Hard Front Walls

There was a general balancing of materials and construction methods that did appear on a consistent basis. The first was hard front walls. This was very different to what anyone was doing at the time. Absorptive front control room walls were the norm. Monitors built into the front wall were also new. This approach allows for the omni-directional energy that radiates from the speaker to be managed and it also allows for vibrational control of cabinet vibrations at higher sound pressure levels.

Hard Floors Everywhere

Hard floors were prescribed throughout the whole control room. The rear wall was to be highly absorbent along with the sides and ceiling. There was some degree of variability at these surfaces. If more absorption was deemed necessary by the end user on the rear wall then so be it. Ceiling and side wall reflections could also be managed in a similar fashion.

Non Environment Rooms / Playback

With the new Non Environment Rooms, one did not have to have a separate playback room to make sure our mix translated well. With the Non Environment Room, we had all the sounds present and accounted for in a nice and real balance. All low ends were tight and their place along with the middle and high frequency riding firmly on the bass notes. All images were focused and in place on the sound stage.

Balanced Standard

Tom Hidley's Non Environment Rooms were unique for their time and are still used today. The goal was to minimize all the contributing components of room sound so that the combined room sound variables all together did not add up to an issue. Reducing the room sound error rate with the room acoustical components down to their minimum influence levels, would produce a room with less errors and less room sound. Standardizing the room surface treatments for proper reflection control and a throughout the room low frequency control approach, provided the proper standardization for all of this room sound minimization to occur.

* * *

The Studio As A System

Basics First

Our main control room should possess some major components that all work well together to produce high resolution, low distortion audio that has full bandwidth delivery. We should be able to recreate high pressure levels along with lower levels and hear the same layering and separation of all instruments and vocals. Both small and large monitors are needed. The small monitors assure everything is in the mix. The large monitors give us more of that everything.

Components Of The System

All components of our studio must be taken into consideration. The most important component is the monitor. How is the monitor to be mounted? What type of amplification is required and what will be our speaker cable that we need to match the amplifier to the monitor. How does the monitor interact with the room? Our speakers are not independent components that can be moved into a control room and expected to sound well. They are one part of an acoustical delivery system.

Mixing Console

Our monitors are connected to our mixing console. Everything within the studio that has an electronic signature will pass through the level control of the console. The circuits that occupy this level control, the input level circuits, are really the front end of our monitor system. If we have a loudspeaker monitor that is active or has its own amplifier or power source, we will need to route this signal through cables and into the crossover. If the system is passive, the cables will run from the amplifiers to the speakers which will have their own internal crossovers.

Signal Chain

Now, we have our signal that must leave the electronic domain and convert to the analog domain so we can hear it. The signal leaves the output busses of our mixing console and then to our ears. When it strikes our ears it is also striking the room and with each reflected ray of energy we have a little bit of room sound adding itself to our sonic presentation.

Monitor Circuits

Mixing console manufacturers do not spend the money they need to raise the quality of the monitor circuits. These circuits are in the direct signal path and must be of highest quality. They are just as important as our mixing busses. They must have low noise and high quality audio presentation because the signal will always have to pass through our busses. If the monitor circuit is not of the highest quality then we will not really know what is really being recorded. This is a serious problem.

Price Point

The competition is fierce. Adding higher quality and thus higher costs can raise the final retail price into a price point category where the manufacturer may not be able to compete in. Even consoles that cost six figures are not removed from this cost cutting paradigm. Even a price increase for quality of a few dollars per channel can add two to three hundred to the retail price which could be a tipping point.

Poor Quality Equipment Level

This happens because there is not the concern for quality that there needs to be. It has migrated to non-professionalism that permeates through the recording world. Manufacturers have been able to pursue this cost/quality cutting course because studio owner’s equipment is not of high enough quality that they can hear a poorer sounding component that is part of the studio system.

Many Parts

The monitor system is composed of many different parts. Each one of these parts contributes to our overall system’s response. There are over 1,500 patents in our cell phones covering electronic processes that produce audio and video in our cell phones that interface with us as humans. The monitors in our control room must also interface with the cables. Careful attention needs to paid to the cabling that connects our interfaces.

Cables Are Important

These cables can be sources of interference and signal degradation between components. Professional gear is much more tolerant of changes produced by cabling because the signal outputs and inputs operate at higher levels than a similar situation in a personal listening hi-fi environment. Hi-fi equipment operates at lower levels so minute changes in cable response can be more readily noticed and detected.

Room Treatment Is Important

Just as the sound quality can be impacted by lower quality components in our signal chain, the room surface treatment must be given the same care and attention to detail as our cabling selection. Each room surface must be addressed to determine what the acoustic treatment of those room surfaces should be in order to achieve the sonic goals of the room in which we are in.

Different Quality Sounds

Monitor rooms can have as many sonic flavors as monitors have different sound. It is imperative to match the room surface acoustic treatment to what the room is required to sonically reproduce without distortion. Room sound is room distortion. If it is a monitor/control room we have detail and revelation of each sound recorded as our objective. If is a hi-f- playback scenario, then we need more room sound present in the music.

Everything Works Together

Our studios are systems within systems. Our monitors are connected to our consoles and the signal then goes into our studios where we get to hear the results of all our knob twisting and slider moving. Our monitor room is also part of this system. It is the room that we hear our sound in. It is the final frontier that we must manage correctly, so that the rest of our system sounds complete and accurate.

* * *

Voicing A Room

Acoustical Science

In the science of room acoustics, we have many variables that we can measure. We can measure resonances, reverberation, and frequency response not to mention a host of others. Each variable has an associated acoustic sound in our room. We measure these variables using science to assist us with certain starting points. That is all science can do for us is give us a starting point and for that we are thankful. The real “science” occurs when we take our personal perception of what good sound actually is to us and use this perception to voice the room.

Science and Art

Voicing a room is a blend of science and art. The science comes from measurements and numbers. The art comes from taking those numbers and fitting them or parts of them into our sonic perception of how much,for example, reverberation should we have? We know the numbers, but where on each side of those numbers does it lie for us. Which ones and how many of the resonances should we tame to allow us to be comfortable with the low end of our room? Is the attack and decay rate what we want? How much absorption do we use to minimize reflections? We must balance science and art.

Easy Science

It is easy to "get the numbers" to any variable. We can measure for it or look it up in a book. We can do this using very little time or energy. However, we must ask, "How does it sound to me"? Do I like it? Can I and do I become emotionally involved with the music. Does the room help me with my emotional connection with the music? What little things can I do to make it sound the way I want it to. This is the voicing part of the equation. This part takes much longer and is way more fun. It is a journey that must be taken slowly and done over longer periods of time.

Low Frequency Resonances

There are three parts to voicing a room. The first part is getting all resonances or most of them managed. Low frequency issues are present in almost any room. Room resonances at lower frequencies, especially those below 100 cycles, can ruin any quality sonic presentation. Low frequency resonances are like bulls in a china shop. They charge into everything and bump into everything else. They trample over our middle frequencies and can even have an impact on higher frequencies.

Attack And Decay

Low frequency resonances can impact attack and decay times with individual bass notes or chords. Excess resonant energy at lower frequencies can exaggerate some bass notes and completely eliminate others if our listening or monitoring position falls within a room mode. If we can't hear where one bass note begins and ends in its entirety, we are missing too much music. There is a lot of music below 60 cycles. Don't let the room get in the way of the music. Proper low frequency resonance control is a must have. There is no art needed on this one.

Middle Frequencies

Middle frequency ranges are plagued by reflections from our room boundary surfaces. All of these reflections add up to a certain reverberation time in our room. If we are listening to music and not recording instruments or vocals, we want a certain amount of reverberation in our room. Reverberation assists us in feeling the music all around us. It is different with a microphone. The microphone normally does not like reflections and will tell you so in the mix.

Vocals Are Emotion

Our vocals lie in this range of frequencies. Vocals are our primary source and link to the emotional content of the music. We must have a balance of the direct sound from our speakers and the reflected energy from our room. In a professional monitoring studio room, we want no reflections, so the engineer does not have to contend with room sound in the mix. In our listening or home theater rooms, we want the music to be part of the room and we want the room sound in our musical presentation for more emotional involvement and realism. We want to hear room sound and mix sound.

Time After Time

Achieving this balance between science and emotion takes time. It takes time because no one set of measurements will ever produce emotion or feelings. It is the sum of many variables with the personality and sonic preferences of the listener and room user thrown in. This emotional drive can be taken every time in a room where one has spent a great deal of time listening to music from many different genres.

Thunder And Lightening

We want the thunder from a bass kettle drum in our classical music. We want the attack and decay of every note to be heard and felt in our room. Only numerous playing and listening sessions will reveal the true color of the room. Once we have found out over time and patience what we like about the room and what we don't, we can try and voice for the likes and try to eliminate or manage the dislikes.

Resonant Hunting

With low frequency resonances, we must find their locations within the room and place large low frequency sponges in those locations. Please, no foam. Low frequency resonances must be identified and the proper low frequency absorption technology applied. Please, once again, no foam. If you are serious and you must be when dealing with low frequency resonances, you must employ diaphragmatic absorption or a Helmholtz resonator that is frequency tuned. Resonances don't play around. There only mission is destruction.

Check The Corners

Start in the corners first, going floor to ceiling. Next, look at all room boundary intersections. Treat the ceiling to wall intersection and the floor to side wall intersection. These are the areas of greatest pressure within our rooms. Do not forget the area behind the speakers; the area between the front wall and speaker back. This is a high pressure area where resonances like to get together and party. Please, no foam.

No Foam

Alright, I will stop saying, no foam. We have to get away from the myth that foam can absorb low frequency energy. It cannot. I do not know how this myth officially got started but I have a good idea. For years, acoustic products companies have been distorting the term low frequency absorber. Some companies even call them "bass traps". Most "bass traps" do nothing to absorb any energy below 100 cycles. They definitely do not "trap" any bass.

Definition Alert

Acoustic products companies have been raising the sound absorption bar when it comes to promoting their "low frequency" absorbers. If you examine some company's definition of bass absorber, you will see that it will not be low enough in frequency to absorb below 100 cycles.

One company claims that 400 Hz. is even a low frequency. Let's stop this nonsense. Make sure you obtain the performance numbers on any bass absorber first and foremost from a manufacturer prior to purchase, if you can find them.

Reflection Control

One can control reflections through absorption. Once we have our primary and secondary side wall reflections managed correctly, so our sound stage has width, depth, and height, we are free to add or subtract absorption technology over time and many different listening sessions. We can add or subtract materials from different places in the room to find that correct balance between direct and reflected or room sound that brings us closer to the music. It takes time and many efforts, but the destination is worth the journey.

Voicing our rooms is an art form that we personally get to exert upon our room. We get to add or subtract different acoustical technologies over time to help us better emotionally connect to the music by emotionally connecting to our rooms. We develop this working relationship with our rooms by first knowing how the room sounds with all types of music and then listening to the changes our voicing makes in the existing room sound. This knowing our room and what we need to do to help it help us emotionally better connect to our music is what voicing is all about. I am connected to my room but my connection to my room transcends even feelings.

* * *

Bright Rooms

This Room Sounds Too Bright

What is a bright room? We have all heard the expression, this room is too bright. What constitutes a bright room? To determine what causes a "bright room", we have to look at the surface material of the room. What materials comprise the walls and in particular the walls that surround us on a horizontal plane at our listening position. We also need to examine reflections from these same surfaces.

Parallel Walls

Parallel, flat, room surfaces create numerous acoustical issues that must be dealt with in a bright room. The parallel surfaces create flutter echo which is a baby echo. It has all the makings of what we would consider to be a full echo but not in the required amount and duration because of the room boundary dimensions. These are termed specular reflections and add to the final sum when it comes to room brightness. We want to produce fewer specular reflections to minimize brightness in our flat surface rooms.

Different Surfaces

We must create surfaces that when the sound energy strikes it, it is not returned in a patterned and somewhat predictable way. We want the surface to reflect or better yet diffuse the incoming energy into it out into the room in a somewhat unpredictable fashion. The irregular shape of our room surfaces can have a large impact on the redistribution of unwanted reflections.

Small Rooms

If one compares two rooms that are the same in surface material, the smaller room will have the lower reverberation time because there will be more sound energy to surface contacts occurring in the room with the smaller size. These surface contacts will also be increased when one measures a particular time interval which will show a higher density of reflections within that particular time span.

* * *

Special Needs of Small Rooms

Small Rooms Defined

Small rooms that have a volume of less than 100 cu.ft. are rooms in transition. They have all the acoustical issues of larger rooms, with a greater emphasize on low and middle frequencies. In these sized rooms, people become part of the room acoustic. Each human has the absorption coefficient of around 10 sq. ft. of carpeting. That amount has an impact on small room sound.

Make a Big Deal Out Of Everything

Everything is exaggerated within a small room. Even the surface material of the room boundary surfaces can have an impact. One must make sure all the individuals that will be involved in the recording process within the room must be calculated in during the sound check phase prior to recording anything. A single person’s room position change in a small room can be noticed in the recording.

Variable Acoustics/Low Frequencies

The only way to achieve some sonic sense to a small room is to have moveable panels. Small rooms have no space for low frequencies to go. They must be made smaller to sound larger. Low frequency management must be attempted to be dealt with. Only a diaphragmatic absorber can provide the necessary rate and level of absorption for a small room. It must also be mobile, so it can adapt to different sound recording requirements. Resonances will move around more easily within a smaller room depending on the pressure created by the source instrument.

Variable Acoustics/Reflections

Movable panels or variable acoustics help change the direct to reflected energy stream or direction. If our small room has close in proximity room boundary surfaces then we need to be able to redirect the reflections along different energy pathways. Close, parallel surfaces, give rise to flutter echo which is never wanted in any size room. Anything that has the word echo in its name cannot be good.

Mids and Highs

Middle and high frequencies can be managed using absorption and maybe diffusion depending on the room's use. Diffusion requires certain distances in order for the diffused waveform to expand fully, so a small room may lack the space requirements for diffusion. Sound absorption technologies can be readily employed. Care must be taken not to over absorb at all frequencies.

Reflections

Reflections within our small room takes on a new meaning. How do we separate the direct sound from the reflected sound within our small room? We need to hear the direct sound first, but with close room boundaries we are always competing to find the direct sound. Trying to find that balance between direct and reflected energy at the microphone position is critical in a small room. The musicians must also be able to hear each other or all is lost.

Room Sound

Small room coloration can be used to one's benefit especially with today's modern music. Everyone is always looking for a different sound to record with this instrument or that vocal. A small room can add numerous effects if you will to your sound. Care must be taken not to be taken with new and seemingly unique sounds for they can tire quickly if overused.

Their Own Sound

All small rooms have a characteristic sound to them. In fact, if one goes in enough of them, one can tell which sound absorbent technology is being employed. One can even tell who the manufacturer is. Small rooms receive large amounts of absorbent technologies because reflections are competing with direct sound from sources.

Time Domain, Not Frequency

This unique sound we hear in small rooms is attributed to time not frequency response. The frequency response does fill the room with sound, but it is the push and pull of the pressure areas of room modes and the abundant reflections from the close in proximity room boundary surfaces. EQ cannot even compensate for these deficiencies.

Source Correctness

Care must always be taken from the very beginning of the recording process. It must be monitored closely and the purest waveform recorded. It cannot be fixed later in the mix. All of this is hypercritical when it comes to small rooms because the reflections and room modes will leak into everything and do it quickly. Do not assume mic position # 1 will work with all instrument and vocal amplitudes.

Restrict Uses

Small rooms should have small uses. By that we mean that one should find the two uses for the room that sound the best and stay with those uses. Small rooms cannot and should not do everything. They can do some things well, things that have less energy associated with them. Small rooms are energy sensitive at all room locations.

Special Needs

Small rooms have special acoustical needs. Their use needs to be limited to the uses that produce the best sound. Resonances and reflections abound, so care must be taken to try and address these issues along with finding the proper microphone position for optimal sound recording. Variable acoustics will help us but there is still no substitute for cubic volume.

* * *

Critical Loudspeaker / Listener Distance

Reverberant Fields

When we look at the sound in a room and in particular the reverberation times and reverberation fields in a room, we seek to find true reverberation. true reverberation exists only in a diffuse sound field. All reverberation must be spread everywhere equally for true reverberation to take place. It must be equal energy and equal volume. It must also be 100 % diffuse. This is not an easy scenario to find.

Many Issues To Consider

There are many issues that prevent us from having a true reverberate field in our rooms. Room modal resonances can impact our reverberation uniformity requirement. Resonances are pockets of energy that lie in particular room locations. These positions are determined by the room dimensions and associated volumes.

Resonances

Resonances radiate energy in certain directions and at certain frequencies which interfere with reflections which must develop into a true reverberate sound field. As resonance energy radiates from its center point it can add large pressure gains at their respective room locations. A microphone placed into a room mode, may “hear” some frequencies, but may miss others.

Furniture

The furniture within our room minimizes our efforts to achieve a true diffuse reverberant filed. A console or back wall couch can add impediments towards our reflections equally spread out. The absorption coefficient of the piece of furniture coupled with its size, all add negative variables to our equation. Reflections from the furniture surface materials can also add to the positioning of reflections in areas not necessary towards our true reverberant field goal.

Direct vs. Reflected

Our room is a combination of direct and reflected sound. Direct sound is the sound energy that travels in a straight line from the source, say a loudspeaker, to your ears. Reflected sound is everything else you hear. Reflected sound comes from the room boundaries to your ears. The direct sound emits from the source or loudspeaker and travels directly in a straight line to your ears.

Power Loss

We know from basic physics that sound energy loses power as it travels farther from its source. Physics tells us that our direct energy will reduce by a factor of 6dB for every doubling of the traveled distance from its source. The reverberate field created by all room boundary surface reflections will still be spread out and evenly distributed within the room.

Low Frequencies

Low frequencies within our room are a different animal. Low frequencies radiate 360 degrees from any source producing low frequencies. We mean frequencies below 100 cycles. No matter what the low frequency producing source this radiation pattern exists. With this 360 degree radiation pattern, we have the low frequency waves striking multiple wall or boundary surfaces. All of this energy will impact itself upon our reverberate sound field.

Critical Distance

Critical distance is finding that balance between the direct sound from our sources and the reflections from our room boundary surfaces. Where a person sits or stands within the room can make a large difference. There are paces within the room where the room sound or reverberate field would be 20dB or greater above the threshold of the direct sound. The area within the room where the two sound fields are equal is termed the critical distance.

Formula For Everything

To find this number we turn to physics and the associated mathematics. We look at two variables that impact themselves on our formula room constant number. They are the room constant or absorption coefficient and the directionality of the loudspeaker. We can even find the distance for our critical distance with both low and high frequencies.

Critical Distance Meaning

What does this critical distance mean in our listening or monitoring rooms. If we run the numbers and we get back say six feet for high frequencies and maybe 3 feet for low frequencies, we need to seriously address both low frequency control and reflection management from our room boundary surfaces.

Rule Of Thirds

Another good start, would be to divide the room into thirds. The middle of the room would be the middle third. The remaining thirds would be the front and rear portions of our room. Start with your listening distance in the rear third of the room and move towards room center. You will immediately begin to hear the differences. You will also see the need for proper room boundary reflection management either through absorption or diffusion technologies.

Different Uses

We do not want the room sound to predominate at ant position within the room. We also do not want the direct sound to dominate. We do not want direct sound to dominate in our listening rooms. We do not want room sound to dominate at our monitoring or mix position. There needs to be a balance of direct and reflected energy for both room type applications.

We Have The Technology

One can treat the room with acoustic treatments to bring our critical distance more in focus with our acoustical needs. Low frequency management can be installed at room boundary intersections. Middle and high frequency absorption and diffusion technologies can be implemented upon individual room boundary surfaces. Today, we have the technology to maximize the critical distance formula and make it usable for the intended acoustic purpose.

* * *

Room Tuning A Piano

Full Range Instrument

When we have a piano in the room, we have an instrument that is capable of producing all frequencies that the human ear can assimilate. We can go down to 20 Hz. and upwards past 10,000 cycles which gives us a representation of all of our hearing critical bands. It is a powerful source and must be granted the utmost acoustic consideration and respect.

Stay Away From Walls

Since it is a physically large instrument, it must not be placed next to a wall. This is just an absolute no when it comes to acoustics. There are many no’s but this one is high upon the list. The first energy boundary reflection point cannot be a wall that is one foot away. Don’t do that to the room and please do not do that to the piano. Put the piano in the center of the room.

Room Center Placement

By placing the piano in room center, we fit the piano into the room acoustically. Since our sound energy from the piano is radiating at many 360 degree radius, we allow that direct sound source energy to radiate from the piano into the room. If all room surface are away from our piano source, we are staying acoustically true to the instrument itself. The room will add its own stink to our sound but by placing the piano in room center at least we have a chance of minimizing or maximizing that room sound.

Elevate Don’t Deviate

Our next surface issue is the floor. The floor is the closest surface next to our piano unless we shove the piano against the wall which we have agreed never to do. We must raise the piano off of the floor. It must be elevated from the floor as much as our room height will allow for. If we have 30′ ceilings, raise it 5′ in the air. If we have 12′ ceilings raise it 2′. This will improve instrument and room response.

Vibrations

Vibrational energy from the piano to the elevated platform, needs to be managed. Vibrational isolators must be chosen to compliment the vibrational energy ranges exhibited by the piano to surface area. These isolation devices can also be used to produce different piano sounds especially when it comes to attack and decay rates.

Absorption And Diffusion

Room treatment in our room, should be a combination of absorption and diffusion for all room boundary surfaces except the floor. Diffusion can add to the spaciousness of the already spacious piano sound especially at the microphone position. Reflections can be minimized through diffusion and can be spread out away from the direct sound of the piano. Absorption can be distributed to absorb any excess energy that would contribute to unwanted room decay times.

Variable Acoustics

If possible, a variable acoustic room treatment program would be desirable. The ability to alternate between different acoustic technologies at will and on all surfaces would be a valuable tool. In a rectangular room it would be desirable to have the flexibility of changing the acoustical treatment on the short side or rear walls versus the others. Having a variable acoustic ceiling in a piano room would be highly welcome especially by the microphones themselves.

Platform Acoustics

Since our piano is elevated on a platform, we now have space for acoustic treatment. We must now address the lower frequencies that can get trapped between the platform and the piano. We raised the piano off of the existing floor to improve room frequency response, now we must deal with resonances that will exist between the piano and its new platform.

Comb Filtering

These are resonances that occur from two physical objects in close proximity to one another, one of which is a sound producing instrument. We will have mostly mid frequency and low frequency resonances to content with. They will be over a limited frequency range, but they are there. We need to absorb them because they can blur or smear those instruments that generate sound within those frequencies.

Reduce Carefully

We also need to absorb these resonances at an even rate no matter what level of frequency absorption we design for. Our absorption goal will be to reduce all troubling frequencies at just enough in level to reduce their sonic impact. We do not want to take a 100 % of everything. We want to reduce the amplitude of the existing resonance so that it does not interfere with the piano player or the recording engineer.

Broadband Absorber

A broadband, low frequency absorber is necessary that extends from 30 Hz. – 200 Hz. would be a good start. If we can reduce overall amplitudes or resonances of these resonances that fall within this range, by a factor of 20 – 30%, we will have gone a long way to minimizing all associated sonic issues. No foam technology need apply for this job. A more powerful absorber technology is needed.

Diaphragmatic Absorption

Diaphragmatic absorption can provide the necessary rates and levels of absorption to handle this issue. It is also a dense technology that will lend itself well to installation in our piano platform. It can be designed and inserted into the platform directly below the piano bed. It will be close to the area of maximum pressure created by the piano, so it will perform at its best.

Microphone Positions First

All that is left to do is find your mic positions for recording both the direct sound from the piano and the room sound. This will take some practice. Don't forget about the variable acoustics on each surface area. Get as close as you can to the sound you want by moving the microphones and then fine tune it by moving the acoustics around.

Watch Out For Room Pressure Zones

Pressure Zones

The pressure zone of a room is defined as that pressure area that exists below the frequency of the lowest room mode. This pressure zone is dependent upon the room's dimensions. The room's dimensions will tell us what our lowest resonant frequency is going to be. Anything below that frequency we are entering the pressure zone.

Pressure Zone Pressure

The move into the pressure zone is a gradual slope within the frequency response of the room. The rate of this transition depends on the strength of the resonance. Inside our room's pressure zones, waves of energy do not exist. They energy in the room is raised or lowered through the diaphragmatic action of the speaker driver. There are points of pressure maximum and pressure minimums within these pressure zones.

Look Below 100 Cycles

If the room is considered acoustically a small room, then we need to look at 100 cycles as the frequency where our pressure zones can be considered acoustically useful. The longest dimension in our control rooms should be at a half wavelength of the designed for lowest frequency we need to hear clearly without room resonance distortion. If we use 20 cycles as our designed for lowest frequency, then half a wavelength would be 28′. With this dimension, we would have no speaker response within the pressure zone.

Room Modal Response

Modal room responses are the track that the room's frequency response "rides" upon. Under every trough in our frequency response curve lies a room mode. Each room mode has an amplitude and width, starting at one frequency and ending at another. This is the domain of the mode with the modal response frequency at the center point in the mode.

Q Value

Modes can have a high Q value which would be a squashed bell shaped curve and a low Q value which will result in a more peaked and narrow bell shaped curve. It is desirable to have each of these modes underlying the room's frequency response to be at least 10 Hz. apart in order to not increase our pressure issues in different room locations.

Locate Room Modes

Looking at the frequency response of the room we now need to place that energy picture with all the underlining modes within the physical room. Let's go room mode hunting. Lets first start in the room's corners. Next, all floor and wall boundary intersections. Third, the walls and ceiling join points and the floor to ceiling area. The strongest axial mode will between the two farthest apart room surfaces.

High And Low Pressure Areas

Between each room modal pressure area, there are areas of high and low pressure. Depending on the frequency of resonance, there will be areas of high pressure at the mode frequency and then radiating out from that high pressure area in a series of lower pressure rings as we get away from the modal frequency. This radiating effect is similar to throwing a stone in calm water. Higher pressure waves begin at the stone/water entry point and radiate out from this center point losing intensity as it moves away from the source.

Anti-Node

A loudspeaker placed into a pressure anti-mode would fill that anti-mode with pressure as sound waves generated from the loudspeaker. If we place a listener in this anti-node position, they would also hear an amplified sound. This frequency of resonance would produce no sound for a listener in an anti-node. Having all these modes in certain room positions, makes finding the correct location for both listener and loudspeaker spatially dependent.

Reflections

Reflections from room boundary surfaces can also factor to our response graph effect frequency response. If we look at the floor bounce, we see a dip in the frequency response curve of a typical room. This usually occurs around 200 cycles. The ceiling adds another bounce at 200 – 300 Hz. Increasing the same frequencies that the ceiling bounce caused. The back wall increases the hatching of our frequency response curve. Adding in the side walls, we have an all boundary response curve with many more jagged edges especially above 100 cycles.

No Cube Shaped Room

It goes without saying that we do not want two identical dimensions within our room. If we take a cube room, we have all axial modes at full strength. They will superimpose themselves upon each other and this will produce strong resonances. There will be greater spaces between modal frequencies because there will be less frequency distribution than would be the case if the height, width, and depth would be different dimensions.

Non – Parallel Walls

Non parallel wall surfaces will reduce reflections and smooth out our room frequency response. This approach will not make the number of room resonances smaller. Only room dimensions can have that impact. One can reduce some impact of resonance modes to a certain degree with non parallel surfaces. However, no standard formula exists to determine what impact and where non parallel walls will have that impact. Only the experience of the room designer can help here.

* * *

Small And Large Room Acoustics

Small Rooms vs Large Rooms

Small rooms have certain acoustical issues that are different from large room acoustics. Large rooms have certain acoustical issues that are not found in small rooms. Assuming we use the same full range sound source in each room size, small rooms are about sound pressure raising havoc between the room boundary surfaces. Large rooms are all about reflections off of surfaces that contribute to higher reverberation times.

Small Rooms

The size of our small room environment has a major impact on the acoustical issues of the room, especially at low frequencies. Certain ratios of room height, width, and length contribute to low frequency pressure build up areas in our small rooms. These higher pressure areas are termed room modes and can cause acoustical distortions at our listening or monitoring position.

Room Modes

Room modes can blur and smother certain frequency ranges that we must use to listen to vocals or music. They can over exaggerate some frequencies within the mode or can completely smother others. They are areas of pressure created by the frequency that is bouncing or running against a certain room dimension that does not correspond to a ratio of wavelength to wall to wall length. Large rooms have more space.

No Modes

Large rooms do not suffer from room modal issues. They have larger distances between their room boundary surfaces and longer wavelengths get a chance to spread out or run their full wavelengths. They can run free without striking a room boundary surface. I was in a church today that has walls that were 185′ apart. If we take a 20 cycle wave which the organ can produce and measure it, we would find it to be about 56′ long. With 185′ long distances to travel, the wave will fully form before striking any surface.

Small Room Reflections

Small rooms must deal with reflections from room boundary surfaces. All of these reflections get interlaced with the direct energy from our speakers and confuse the wanted direct energy. The direct energy is the energy that travels in a straight line from the speaker to the listener. This is the actual sound. When reflections from room walls mix with the direct energy, they superimpose themselves upon the direct sound from the speakers. This delayed signal reduces source clarity and staging. There is a much smaller time window to deal with in small room acoustics than with large room.

Large Room Reflections

Reflections from large room walls and ceilings, all add up to increased reverberation times. The reflections in large rooms increases the reverberation times, which plays havoc with everything. It mainly impacts the frequency range from 500 – 2,000 Hz., which is the range where vocals lie. This is termed the speech intelligibility range. If reverberation times exceed 1 second, then speech begins to become unintelligible very quickly.

Exceed One Second

If we exceed 1 second reverberation times for speech, the reflections in our large room become superimposed over the direct sound we need to hear. The direct sound is the sound that leaves from a source such as our loudspeaker and travels directly to the receiver’s ear. It is the straight line sound that does not have any room reflections interlaced with it to confuse and muddle the direct sound.

Reverberation Everywhere

No matter where one sits, the reverberation times blur and confuse the signal. This produces room acoustic distortions and the direct sound becomes unintelligible. Churches built 50 years ago are a good example of large room acoustics and usually high reverberation times. It is difficult to hear the pastor when he gives the sermon. When the choir starts to sing there may be spiritual salvation but acoustically, all is lost.

Stereo Signal In Small Rooms

Most sound systems that are placed in small rooms are stereo or multiple channel systems such as home theater or simply two channel stereo. A stereo signal is composed of a signal that is designed to produce depth and direction perception. A properly set up two channel system will produce a sound image that can extend wider than the physical position of the left and right channel speakers. This is what audiophiles refer to as the sound stage.

Sound Stage Impact

Reflections off of the side walls in small room acoustical set ups have a direct impact on the sound stage. If the side wall reflections are not delayed enough in time below the 20 ms. mark, then sound stage image will suffer. We will also receive an image shifting if there is unequal distances between the side walls. The sound stage image will be pulled towards the shorter side wall distance dimension.

No Sound Stage

Side wall reflections, in larger room acoustical situations, add to the room’s overall reverberation times. There is no sound stage created between the speakers in a large room environment. The signal is mono and is not designed to create depth and direction. The mono signal is intended to project the sound out in a straight line array that matches the use and need of the building. Many speakers may be needed to allow for adequate sound coverage in the given large room size.

Multiple Mono Sources

In some large room acoustical situations, the area to be covered with sound is large and the rooms reverberation times are too high. One method for dealing with this is to use multiple speakers with tighter dispersion patterns across the sound surface area, say of a congregation. The smaller radiation area pattern produced by multiple speakers positioned in specific areas for coverage, produce direct sound in shorter patterns but one still has the high reverberation times within the room to deal with.

Different Level

Small rooms have similar acoustical issues as large rooms just on a different scale and level. Small room surface boundary reflections, especially from side walls, can play havoc with our sound stage presentation in a two channel system. We can have image shifting and image size reduction. Large room reflection issues contribute to the overall reverberation levels and confuse the direct sound from our mono source. Low frequency issues are predominant in small rooms, where larger rooms have the physical space for lower frequency wavelengths to extend themselves.

* * *

Location, Location, Pressure, Pressure

Low Frequency Waves

Low frequency energy fills our rooms with waves of energy. These are long waves of energy. They can be as long as 56′ They are omnidirectional and radiate in a 360 degree pattern from the low frequency source in our rooms. Whether it is a kick drum in a recording studio or a sub woofer in our home stereo system, this low frequency energy wave is like an ocean wave rising up and down and splashing against the boundary surfaces of our room.

Sound Waves / Ocean Waves

As these low frequency energy waves move up and down, they have different distances between the peak of the wave and the trough or bottom of the wave. These waves are moving from the front of our rooms to the rear of the room. They are also moving from the ceiling to the floor and diagonally across all six surfaces of the room. The amount of time they bump into each other is determined by the room dimensions.

Total Room Response

The total room response we receive is a combination of all room modal responses. We have waves traveling from floor to ceiling, back to front, and along all six surfaces of our room all in virtually the same time. All of this wave movement creates pressure within our room. These energy waves are trying to get back to the ocean but they are contained, well some of them, in a box. Some are happy within the confines of the box or room, most are not.

Pressure Piles

Where are the pressure piles in our room located? For sake of discussion, we will use a rectangular room. A rectangular room has parallel sides with consistent and uninterrupted surfaces. This structural consistency lends itself to predictable and consistent measurements and consistent wave behavior. Seal your lips and puff out your checks. Your mouth is the room and your cheeks are your room walls. Collapse your checks and then expand them. That is what your room walls are doing in response to the energy waves. If your room walls move past certain vibrational thresholds, they begin to sing and add their own sound into the room.

Location

The pressure in our rectangular rooms accumulates in certain parts of our rooms. Sound pressure begins to pile up at the places where all of this energy bangs into each other and at what places in the room it does. The room dimensions determine how much and where these waves will collide with themselves within the room.

Corners

Waves of energy pile up in the corners of a rectangular room. In fact, the first cousin of the wave, the ray, which represents higher frequencies than the wave energy, resides in the corners with the waves. We have waves and rays living together in the corners of our rooms. This is why you have heard people say that all room modes lie in the corners of our rooms.

Room Middle

When you see energy piled up in the room corners, the next place you see it is in the room middle section. All room modes may end in our room corners, but they also leave energy piles in the middle of our rectangular room. The amplitude or strength of these two pile locations does vary with room dimension. The strength of the room middle energy pile is always less than the corners, but it must be taken seriously because the room middle is where we sit and listen at.

Sound Pressure Minimum

If you think of a sound pressure wave like a ocean wave, you see the top or peak of the wave. This is the part that surfers like to ride on or just underneath the top curl. This would be our sound pressure maximum area of the wave. The valley or trough is the part that helps create the crest of the wave. This is sound pressure minimum area.

Sound Pressure Maximum

If we map the pressure areas we have just discussed in terms of pressure, and we assign them numbers, we can get a handle on how this pressure is distributed. The number 1 will represent the highest pressure reading. When we examine the corners of our rooms, we will see the number 1 in the very corner, at the wall/floor/ceiling joint. It will radiate out from this corner.

Pressure Plot Mapping

On top of this most powerful zone, will be an area of decreased pressure that will be reduced by approximately 20%. On top of that area, radiating out into the room, we have another pressure reduction occurring that is 20% less than the one underneath it. One more on top of that at a 20% reduction and finally the last one at another 20% reduction and the energy pile ends up with zero pressure about the locations of the room where our speakers in a two channel system would be positioned. This is why one never puts their speakers close to the corners of a room.

Room Modes

These pressure piles produce room modes. Room modes occur at frequencies and positions in the room that are dependent and dictated by the dimensions or space within our rooms. Waves that are certain dimensional ratios to the length, width, or height of a room do not like the rooms size. When they don't get along with their surroundings because they are too long to fit into our box and keep hitting their heads on the ceiling, they produce distortion. This distortion can be heard by our ears and microphones.

Three Modes

These distortions are termed room modes. Axial modes occur between two parallel surfaces and are our strongest. Tangential modes occur between four parallel surfaces and are 50% weaker in strength than axial modes. Oblique modes occur between the six parallel surfaces of our room and are 50% weaker than a tangential mode.

Studio Design

Our goal in studio design is to see what modes we are dealing with, what frequency they are at, and what position in the room they are. We want to identify, measure them, and then treat them according to their strength. If the modes are spaced together in frequency, we have more energy issues to deal with. If our modes are at least 20 Hz. apart in the axial dimension and at least 5 Hz. apart in tangential, we will have a manageable situation to begin with.

Sound Effects

Room modes add distortion to our music because these areas of high and low pressure can mask certain frequencies and over exaggerate others. If we place a microphone in a room mode, we may hear too much of some frequencies and maybe none of others. If we are sitting in a room mode, the mode may allow us to hear some things in our recording but miss others completely. Staying away from any room modes is the goal of any microphone or monitoring position.

Pressure Wave Colors

Pressure waves fill our rooms whenever sound energy is placed or generated within it. Our rooms try and contain the waves but they want to be set free. Some make it to freedom and are able to leave their captor and go into the next room and create havoc in that room. Most are trapped by the dimensions of the room. The waves that are trapped within the room as a result of bouncing into each other and the room, locate themselves within certain physical positions within the room. These pressure piles occur at certain frequencies and are termed room modes. Room modes vary in strength and must be treated to avoid sound colors.

* * *

Ten Guidelines For Room Acoustic Treatment

Many Variables

There are many variables to room acoustic treatment. There can be even more variables to the application of the technology associated with room acoustic treatment. A step by step check list is needed. Just as a pilot goes through a pre-flight check list, we need an acoustical flight checklist before we can musically “fly”.

First Guideline

Choose the correct room size. Find the balance between height, width, and depth that minimizes all resonances that occur below 200 cycles. Remember, our room is a huge box of sound pressure. We need to have room size that has all room resonances spread out through the room. If you need to take an existing room and make it smaller to fit a golden ratio of room dimensions that spread resonances out, do it.

Second Guideline

Treat all low frequency issues now. Run a room modal calculation and find out where these rascals lie within the room. One has to take a measurement, move the measuring mic. and then take another measurement. Repeat this process every three feet around the room. One can actually map the resonance’s location and its amplitude. It takes awhile and a couple people to help do it, but it will be worth it. If building new, use a resonant cavity to control low frequency energy. If using an existing room, use a resonating panel type of absorber. A diaphragmatic absorber is a good example of a resonating panel.

Third Guideline

Isolate the room from outside noise. Insulate and isolate the rest of the world from the sound produced inside the room. Do not increase the ambient noise level of the universe. Keep all sound produced in the room where it belongs, in the room. Keep all outside noises from getting into our mixes or playback musical presentations. Use barrier technologies to achieve sound transmission loss within or on existing structures.

Forth Guideline

Choose room building materials that will naturally produce a better room sound. Room energy that strikes a surface within our rooms takes on the sound of that surface. Sound strikes glass, one gets glass sound. You know that sound. That is the sound of your car stereo. Sound strikes wood, one gets wood sound which is smooth and warmer sounding. Some rooms are harder than others. A concrete room will have more reflectivity due to the harder surface of the concrete. A gypsum wall surface will flex slightly when compared to a concrete wall that will move much less and cause less reflectivity.

Fifth Guideline

Decide on the room purpose and use. A monitoring room has different acoustical goals than a playback or listening room. In a monitoring room, we need to keep the room sound out of the mix. We need to hear only the music, not the music and the room. In a playback room, we want to hear the room sound and the music. Our goal is to reproduce the original recording with all its accuracies and sometimes flaws. We want to manage the amount that we hear, but we want some room sound.

Sixth Guideline

Find the proper location within the room for your speakers. The distortion that occurs from the speaker/boundary is a source of acoustical distortion. Improper speaker positioning can boost some frequencies and bury others. Find the location that produces the smoothest frequency response curve. This position will be a certain distance from the front and side wall boundary surfaces.

Seventh Guideline

Reflection control must compliment room usage. If one is using the room for professional monitoring of recorded signals, then we must use a near field monitoring position to minimize side wall reflections. We also must absorption technologies for side wall reflections, so they do not interfere with the direct music sound from our monitors. Our monitors must be frequency response flat. If we are using the room for playback, we want a blend of absorption and diffusion on the side walls, rear, and front walls.

Eighth Guideline

The rear wall of any monitoring or listening room must have two dimensions of diffusion. This is a minimum requirement. A two dimensional diffusor can be installed or one can use quadratic diffusion. The frequency range of the diffusor must be specifically designed for. Once that is determined, one must position both vertical and horizontal quadratic diffusors to achieve a two dimensional reflection free sound field at the listening or monitoring position.

Ninth Guideline

Use absorption as the ceiling treatment in a professional project studio that has lower ceiling heights. Our goal with our professional mixing environment is to keep as much as the room sound out of our mixes as we can. Ceiling reflection absorption technology employed on the ceiling will keep ceiling room sound as a minimum. Listening rooms need two dimensions of diffusion or a blend of absorption and diffusion.

Tenth Guideline

There are only three things that happen with the sound energy within our rooms. Sound energy is either absorbed, diffused, or reflected. To control and manage these three energies we use sound absorption and diffusion technologies to deal with reflections within our rooms. We use absorption technologies for lower frequency control and management. Lower frequency energy is not diffused only absorbed. We do not want to encourage it by using huge diffusors.

* * *

Listening And Monitoring Rooms 101

First Things, First

There are basic acoustic rules that must be followed when one is dealing with setting up speakers for two channel listening or monitoring. Sound energy from our speakers must be dealt with in many ways that are the same regardless of the end use of the room. In a listening room we have rules and with a monitoring room we have similar acoustical principle that must be followed.

Room Size

The first acoustic rule is to choose a room size that has the proper ratio of width, height, and length. This is a priority because if one chooses the correct ratio of these three variables from the beginning we can minimize the number and amplitude of these pesky resonances. I know it is not possible to find larger rooms because larger rooms have less low frequency issues. Most of us have to make do with an existing room. However, we may be able to make the room smaller to sound better.

Golden Ratios

There are published ratios of room width, length, and height that lend themselves to a better acoustical environment. All of these “golden ratios” have one goal in common. They all use dimensions that when you run a frequency response measurement in that room with the proper dimensions, the lower frequency modal resonances are more evenly distributed throughout the room. This separation of room modes is acceptable if they are at least 10 Hz. apart in frequency.

Make Room Smaller

If you have a room that does not fit a golden ratio, then look to the next size room dimensions that will fit inside your existing room. A smaller room size can have a smoother frequency response. Find those smaller room dimensions that will fit into your existing room and change the room size to fit those smaller size. If you are moving only one wall to more conform to a golden ratio, make sure you use new construction materials with the same densities that the other walls are constructed with. Consistency in room surface densities is important when dealing with small room acoustic issues.

Sound Speed

Sound is an energy wave that is generated by an electromechanical device, a speaker. The sound waves and rays produced by our speakers travel at a given speed. It is this speed that we deal with when we are trying to find that balance between direct and reflected energy off of our side walls. The direct sound from our speakers is the sound that travels in a straight line from the speakers to our ears. The reflected sound is the sound that leaves our speakers and strikes the side wall closest to that speaker. Our goal is to balance those two energies together into a direct/reflected ratio that works for the room's intended use.

Control Room

If we are tuning a control room, we know our objective at the mixing position is to have less room sound and more speaker sound. We want our reflections from the side walls, which represent the room sound, to be less than the amount of direct energy from the speakers. In fact, in most control rooms, we want only direct sound from our loudspeakers at our monitoring chair. No room sound in our mixes.

Listening Room

In hi-fi rooms where our acoustic goal is to recreate the original sound in the recording that the recording engineer put so much time into achieving, we want more of the room sound so that it more closely resembles the sound found as if live musicians are playing in your room. We need more of the room sound in our system presentations. Since we need more room sound for more realism, we will want more side wall reflections in our sonic signal at the listening position.

All Side Walls Are Equal

The only way to be able to effectively adjust this direct/reflected ratio of energy is to have side walls that are of equal distance from the left and right channels. Since sound travels at a given speed, we need surfaces that are of equal distance from the speaker, so that the speed of each reflection at the listening position is arriving at the same speed. This speed consistency from both side walls is much easier to manage than if one side wall is two feet farther away.

Low Frequency Resonances

Low frequency resonances in our rooms must be dealt with. All small room acoustical environments have some type of low frequency resonance that must be dealt with. Low frequency resonances smother and blur our instruments and vocals. Low frequency resonances can have amplitudes that are +20dB-30dB in strength. This is a huge unwanted guest in our rooms. It must be treated as a guest and asked to leave immediately. One must hunt each resonance down and treat the location within the room in which it occurs.

Resonance Interference

If our monitoring position or listening position is in one of these resonances, we will have to move. If we cannot treat it by reducing its amplitude to a level that does not interfere with the task we are seeking at our monitoring or listening position. If we sit in a resonance or room mode, we can have certain frequency ranges smothered to the point we cannot hear them. We can also have situations where the resonance exaggerates certain frequencies and makes them more predominant. A lower frequency resonance also has its first and second cousins in the form of fundamentals that we must also treat. The whole family of resonances must move out, so we do not have to.

Objectives

Our first objective with any room that we are going to use for some sonic purpose is to choose a room size that has the proper ratios of room width, height, and length that will give us the smoothest, frequency response. We want to choose a room size that minimizes room resonances. We can even make our room smaller if those dimensions produce a smoother, frequency response and more evenly distributed room modes. Side wall to speaker distances must be equal. We must have consistency in distances to keep our reflections speeds the same at our listening or monitoring position. Low frequency resonances will only get worse as we interject sound energy into the room. We must treat them in the beginning with powerful low frequency absorption technology.

* * *

Listening And Monitoring Rooms – 102

Listening And Monitoring Rooms – 101

In our last narration, we discussed three major acoustical benchmarks that must be used in any listening or monitoring room environment. We discussed proper room sizes, side wall reflections, and low frequency resonances. In this discussion, we will focus on our reflection free/reflection minimized zone, comb filtering effects, and front and rear wall impacts on our listening or monitoring position.

Reflection Free Zone

Our monitors must be set up in a way that creates a reflection free zone at the monitoring position. We must position our monitor speakers and monitoring listening position as the points of our reflection free triangle. The two left and right channel speakers form the two base points of our triangle and the listening position forms the point. Our acoustic goal is to slow all reflections down to a point where they do not have any sonic signature on the pure, direct sound from our monitors. This is what acoustic people call a reflection free zone.

Direct Sound

The direct sound from our monitors is the purest sound we can get at the monitoring/listening position. All of the music is in the direct sound without the room sound. The direct sound is the sound that comes straight at you from the speakers. The shortest distance between two points is a straight line and the direct sound travels on this straight line.

Listening Rooms

In our listening room environments, we want more of the room sound in our presentations. Our goal with our two channel playback systems is to try and recreate the original recording and its environment that it was recorded in. If it is a live recording in a small room, we want more room sound because that is what the music sounded like when it was recorded. In order to achieve this room sound, we allow more reflections in our presentations. We also may move the listening position back farther out of the reflection free zone triangle.

Wall Reflections

When wall surface reflections enter into and interlace with our pure direct sound, we get a different sound. The reflections represent the room and they interject their energy into the direct sound. We not only have reflections from the side walls which are the most noticeable. We also have reflections from the ceiling and front and rear walls. I guess we could even say that reflections from our console are part of room sound.

Comb Filter

Reflections from our console and any other physical object with the reflection free zone of our listening or monitoring position can create a comb filter. The best way to explain a comb filter response is to think about sound energy striking an object and then hitting another object. The reflections bound back and forth between these objects and create their own "sound" or rather cover or smother some of our sound energy. This phenomenon is especially harmful to our middle and high frequencies.

Signal Coloration

Comb filters can mask certain frequencies partly or completely. They can interfere with an accurate mix and result in a coloration to the mix on play back. We have to be careful with the console and any reflections that may bounce off of it into our ears. These reflections produce distortions that we hear and the less room sound in our mix the better.

Listening Rooms Comb Filters

In our listening rooms we have to be careful with equipment positioning and set up. I see a lot of equipment set up between the left and right channels. This produces a comb filtering effect when sound energy bounces off the equipment rack and back into the listening position. There is also a comb filter effect from equipment and the front wall. Energy can get trapped in this small space and produce unwanted coloration.

Cumulative Effect

One may not hear this isolated situation immediately but a series of these situations can add up to a noticeable sound difference in our presentations. If we have an equipment rack, comb filter going on and then another one with say a coffee table in front of our listening chair, the cumulative effect of both of these can produce audible distortions at our listening positions. One small one by itself may not be audible, but they do add up and are especially troublesome with our middle and high frequencies.

Control Room Front Walls

Our front walls in our control rooms are a source of reflected energy. The front wall will produce reflections from energy that is generated from our monitors. Remember, energy is generated from a 360 degree pattern around our monitors. Those front wall reflections bounce back to our monitoring position and mix with the direct sound from our monitors. Our goal at the monitoring position is to minimize these reflections because they contain room sound.

Front Wall Absorption Technology

Front wall acoustic treatment is absorption technology in our control rooms. We do not want any front wall artifacts interlaced with the direct sound from our monitors. Sound absorption technology is the preferred method to minimize front wall reflections in our control rooms. Don't forget about low frequency issues in the front of our rooms. This is where our speakers are located, so we must deal with the speaker/room boundary issues that their energy produces.

Rear Wall Time Delayed Signal

The rear wall produces a time delayed reflection as it strikes the rear wall and then comes back to the monitoring position. This unwanted time signature from this rear wall reflection interlaces with our wanted, direct sound from our monitors. This rear wall reflection is full of room sound because depending on its distance from the monitoring position, it will also have a delay effect added into it.

Rear Wall, Control Room Treatment

Rear wall reflections in our control rooms can be dealt with using sound absorption or sound diffusion technology. Sound diffusion technology will take the rear wall energy and break it down into a series of smaller energies if you will which will not be so predominant at the monitoring position.

Diffusion is the preferred method for rear wall acoustic treatment because using more absorption may deaden the room too much.

Listening Rooms Diffusion

In our listening rooms, we want more room sound. We therefore treat the front and rear wall with sound diffusion technology. Quadratic diffusion can be used on both the front and rear walls to achieve a more realistic sonic playback presentation. We can position quadratic diffusors in vertical and horizontal positions that can generate a two dimensional sound field at our listening position.

Different Objectives

Our control and listening rooms each have different acoustical objectives. In our control rooms, we minimize reflections at our mixing or monitoring position, so we can remove as much of the room from our recordings as we can. In our listening rooms, we want more room sound to add to the realism of our musical presentation. Each approach requires that the room be treated differently and that each room surface has a particular sonic impact on our final sound we hear in the room.

* * *

Smaller Rooms / Larger Absorbers

Smaller Rooms / Low Frequency

In a lecture at Drexel University on acoustics, John Storyk of WSDG, the premier recording studio designer with offices across the globe, stated that the trend towards the future in the recording studio market is smaller rooms with creative low frequency management technologies to manage the room resonances that go with smaller room volumes. Low frequency management can take two basic forms. It can be active or passive. Active low frequency management is electronically based and passive technology involves the use of smaller, but more powerful traditional absorption which can be built into walls or freestanding.

Active Low Frequency Management

Active low frequency technology involves the use of noise cancellation technologies. Noise cancellation takes two signals that have equal amplitude and frequency and then focuses on their opposite polarity. When all of these variables are in line, we will have a complete cancellation of the chosen signal. This phenomenon is used when it comes to large amounts of industrial noise. Building barrier technology to isolate workers from this noise is expensive. Instead of shielding through barrier technology, we go the other way and amplify the signal. The problematic noise is then amplified and reproduced by speakers with inverted phase from the frequencies we wish to cancel. The result is greatly reduced sound pressure levels at the chosen low frequencies and the noise levels are reduced drastically without using cumbersome isolation technologies.

Passive Low Frequency Absorbers

Passive low frequency technologies can take two basic forms. One can use resonators or membrane absorbers. Resonating absorbers, such as the famed Helmholtz resonators, uses chambers of certain depths with slots cut into the top of the chamber to let the air in. It is the air inside the chamber that resonates at a certain frequency depending on the chamber's designed volume and area of the opening. All frequencies above the chamber's resonate frequency are absorbed. Frequencies below the chamber's resonating frequency are not.

Membrane Absorbers

Membrane absorbers have a membrane or wall that vibrates when sound pressure energy strikes it. The front wall membrane is surrounded by a cabinet that is rigid and has a certain type of cabinet fill to absorb internal cabinet resonances. The vibrating membrane slows the sound energy down and then it enters the inside cabinet fill material and is reduced in intensity. Some of the energy is absorbed, some is sent back through the front wall membrane, and some leaves through the rear of the cabinet. The sum of all of these variables determines the cabinet's total absorption performance.

Diaphragmatic Absorbers

Membrane absorbers are also termed diaphragmatic absorbers. The front wall or membrane acts like a piston and vibrates in sympathy to the sound pressure exerted upon it. This front wall movement is said to be diaphragmatic because of this movement. The diaphragm movement is not visible movement like a speaker. It is microscopic movement that the sound pressure exerted upon it produces. This moving of the diaphragm, slows the sound energy down before it enters the inside of the cabinet.

Diaphragmatic Absorber Improvements

To maximize this movement/absorption process in a diaphragmatic absorber, we can do three major improvements to this time tested and proven technology in order to improve its overall performance. We can add an additional front wall or diaphragm, use a more sound absorbing internal cabinet fill, and make the cabinet more rigid to force the dual front wall diaphragms to move more to increase rate of absorption.

Two Front Walls

When we add an additional front wall, our design goal is to get both walls working together to maximize efficiency in slowing down the energy that strikes them before it enters the inside of our absorber. This sympathetic movement is based on the density of each wall which must be different and the distance between each wall. Vibrational analysis of each wall will assist one in determining the appropriate wall density to be used and the air space required between them to produce maximum efficiency.

Internal Cabinet Fill

The internal cabinet fill with our new, dual wall, diaphragmatic absorber has traditionally been a type of building insulation. Fiberglass and mineral types have been commonly used. In fact, the interior walls of most rooms can be considered a diaphragmatic absorber but with limited low frequency attenuation. The cabinet is the drywall on each side of the wall and the insulation between the studs is the internal cabinet fill. To absorb more energy, the internal cabinet fill can be activated carbon or charcoal. Charcoal has numerous pores that absorb sound energy and each charcoal pellet has thousands of pores. Sound energy enters each pore and is absorbed. This large amount of pore absorption, lowers the cabinet’s internal Q value to a level never before achieved in the scientific literature.

Multiple Layered Cabinet

The cabinet construction must work together with the dual front wall construction. We want to encourage the dual front walls to move without the cabinet moving. The cabinet must be designed to be as inert as possible, similar to a speaker cabinet. One can achieve this cabinet rigidity by using multiple layers of materials that have different densities with each layer separated with vibrational damping compound. The key to the process of making the cabinet as inert as possible is to choose cabinet layers that have the correct densities that when married together, the vibrational energy transmission is reduced from layer to layer throughout the cabinet.

Smaller Rooms Require More Creative Approaches

Smaller room volumes in today’s recording studios produce larger low frequency resonances. This requires the need for either active or more powerful passive absorption technologies. Active noise cancellation technologies require an electronic approach where a signal is interjected into the room through a speaker. The energy interjected into the room is out of phase with the frequency that is chosen to be absorbed and this active process results in frequency cancellation and reduced sound pressure levels. Existing passive, low frequency, technologies can be improved upon by fortifying existing design criteria.

* * *

Tuning A Listening Room

Professional Vs. Consumer

We work both in the professional and consumer markets. They are the same in some respects but radically different in others. Both seek “good” sound quality, but go about it in different ways. The professionals use their room and the sound in it to make a living through the recording process. The consumer is all about playback and taking the recorded sound and actively listening to it in their rooms. The rooms they use to accomplish both their purposes are radically different.

Different Functions

Professionals want to hear everything that is going on in the mix. Their rooms are set up and treated to avoid most of the issues that small rooms have on sound quality. Most professionals want less room sound and more of just the instrument or vocal. If the room is a vocal room, it is set up to minimize reflections at the microphone position, so there is less room sound. Consumers rooms are usually rooms that have multiple functions attached to them. They are usually living rooms where many individuals socialize and listening to music is a secondary function.

Different Room Surfaces

With a living room, we have numerous types of room surfaces that must be dealt with. We have drapes, fireplaces, and the dreaded windows which can run across a whole wall. Recently, we were asked to tune a room for a client that had one whole wall as a glass window, a large video screen on the front wall, and a alcove full of albums for the front wall. With our right channel speaker next to a large window of glass and our left channel speaker positioned next to an alcove full of albums, one can immediately see the acoustical issues that must be dealt with. Don’t forget about the large screen glass video display unit on the front wall.

Low Frequency Management

When tuning any room, one should start with managing the low frequency energy first. Without proper low frequency management, there is nothing for the middle and high frequencies to sit upon without getting smothered or blurred in an acoustical “mud”. Most listening rooms are not optimized in size to reduce the resonances created by low frequency issues, so one must use large amounts of low frequency absorption to assist with resonance control. with our room tuning project consisting of a 15′ width, low frequency resonances must be addressed.

Portable Acoustic Technology

In this client’s room, we needed to manage everything. The room was 15′ wide with a full length glass window as one wall. The left channel had to fire its reflected energy into a alcove that was full of albums. At least the albums provided some mass to work with compared to the full length window on the right channel side. Our solution was to make a mobile “wall” that could be moved into place when listening and then moved away for living. Living and listening are two different room functions.

Dual Acoustic Purpose

Since our first goal with our 15′ wide room is resonance control with frequencies from 30 Hz. – 80 Hz., we must have a low frequency absorber that is capable of handling this energy. We also need to handle the reflections from our speakers off of the glass. To accomplish both of these objectives, we built larger sizes of our ACDA-10 and ACDA-12 series diaphragmatic absorbers that would cover a larger surface area. They were 30″ wide and 60″ tall on casters since they had to be mobile. They also weighed in at 250 pounds each. You must have mass when dealing with low frequency energy. There is simply no substitute for mass.

Middle And High Frequencies

To deal with the middle and high frequency issues within the room, we attached our 2″ foam to the face of each unit, directly behind the fabric. The foam technology begins its absorption at 125 cycles and goes through 7,500. The ACDA-10 unit starts its absorption process at 30 Hz. and goes through 200 Hz. With the addition of our foam technology, we now have a unit that can absorb energy beginning at 30 cycles and advancing through 7,500 cycles.

Front Wall

Our next step is to work on the front wall where the center image of our sound stage resides. It resides there because we have used the proper amount of absorption for the side ‘walls” to lower the time of the primary reflection from the side walls. We must lower the time signature of both the side wall reflections so they arrive at the listening position after the wanted, direct, sound from our speakers.

Absorption Technology

Since we have a video screen that is mounted on the front wall and the glass surface of it must be covered, we can install a portable panel that can be hung over the video display screen when playing music and then removed for video viewing. This panel will contain the same sound absorption technology as the side walls. It must be light in weight so as to not add too much additional weight to the video screen mount system.

Listening / Living Rooms

Listening rooms must serve multiple functions in most consumer environments. Unfortunately, this does not allow for the proper room acoustic treatment to be installed in the correct locations to compliment our stereo presentation. Any acoustical technologies used must be mobile and removable. All frequencies must be addressed from low frequency room resonances to middle and high frequency reflections from side walls. Room treatment technologies can be developed that can be positioned in place when playing music and removed or repositioned when other room functions are desired

* * *

Trouble Shooting Signal Chain Distortions

Signal Chain

Our signal chain is composed of many different components. We have instruments, vocals, microphones, cables, mixers and so on. All of these devices carry electrical energy that must be able to travel freely from the beginning of the signal chain to the speaker. Sometimes all of this equipment with each component speaking its own language causes something to occur that we do not want. Signal chain distortions take many forms.

Hum

Hum is an issue that will appear regardless of how many components are in the signal chain. What is hum? Hum is a continuous signal. In the United States we are operating at 60 Hz. In Europe, we are operating at 50 cycles. Our power supplies are the first place we want to look at. Once that is ruled out, we next need to look at our transformers. If our transformers are too close to an amplifier, the amplifier will do what it does best and amplify sound energy even if it is a hum. Amplifiers are equal sound employers.

Cables Everywhere

Microphone lines next to power lines are something to be avoided. Video signals must also be isolated from power and audio cables whether signal or power in function. Keep all three of these lines separated and if they have to cross which should be avoided, make sure they cross at a right angle. The most common cause of hum in almost all situations is the dreaded ground loop. To begin our quest, we must decide if the hum is continuous or affected by gain controls.

Continuous Or Intermittent

If our hum is continuous or unaffected by gain controls, then the ground loop is probably in one of the components that connects to the device in question. If the hum increases in amplitude when increased gain is applied to the signal, we need to look at the components that are ahead of the mixer or gain producing device. With our mixing consoles, we can suspect our microphone pre-amps and the slider. Op amps will affect the hum level also.

Buzz Is Hum’s Cousin

Buzz is another signal chain distortion. Buzz and hum are siblings. Buzz is the sound produced when the hum becomes distorted. Dimmer noise can be buzz. Dimmer noise is still a 60 cycle issue but sounds like a buzz because of its wave shape. Dimmer buzz can also enter our microphone lines. When we have buzz that occurs when we connect two pieces of equipment together, we can be fairly sure that there is some type of electrostatic coupling.

Electrostatic Coupling

Electrostatic coupling can occur even with transformer less inputs and outputs. Transformers that have electrostatic shields sometimes referred to as Faraday shields, will usually solve the problem. However, these devices need to be grounded like all others, so the potential for a ground loop is increased. The only fix for this scenario is to reconfigure the total electronic signal chain.

Oscillation

Oscillation is defined when the output of a device is electrically joined to the input of the same unit or another component in the signal chain. It appears in many different forms. The distortions produced by oscillations may sound blurry or fuzzy. The sound produced can begin as a steady sound. If you hear this sound, get out an oscilloscope. It will show immediately on an oscilloscope. If the sound appears at higher gain levels, one needs to look at cables and inductive couplings.

Static

We have all had static and pops to deal with in our electronic equipment chains. Static and pops are usually the result of a poorly designed ground system or no ground system at all. Sometimes a floating ground or a more correct term is floating the system above the ground is used. Not only is this process very poor engineering, it can result in a deadly shock. Never float grounds. You are only substituting one minor problem with another that can be life threatening.

RF Interference

If the static occurs with short sustained pops, one can look at radio frequency interference which has entered the system through some open portal. A poorly shielded cable or a cable connector that has worked its way loose must first be examined. With no ground or a poor ground, the cable shield can not do what they were designed to do by shielding against radio frequency interference.

Signal Chain Distortions

Distortions in our signal chain have many causes. We can have annoying hum, buzz, oscillations, and static. Hum and buzz are closely related. Buzz is simply a hum that has been distorted by a waveform created by an electronic component. Oscillations and static can be corrected by a properly grounded system. Floating the ground above the system itself maybe a quick fix but it will be dangerous to use and is not worth the cost of electrocution.

* * *

Loudspeaker Cables

Resistance

All speaker cables exhibit three main electrical properties: resistance, inductance, and capacitance. These three elements are mixed into the cables performance in different amounts. Resistance by definition is not welcome and should be kept at minimum levels. Resistance can reduce amplifier power and cause overheating. It also affects the damping capacity of the amplifier which controls the low frequency cone movement. It impacts amplifier output impedance along with loudspeaker input impedance. Both of these issues will impact upon timbre if there are issues with impedance and frequency.

Induction

Induction is not a good thing although not as bad as resistance. It will act as a low pass filter and influence the high frequencies in our signal. Inductance can also allow for penetration of radio signals into our amplifiers and thus our signal chain. There is a grating to sounds all through the frequency range with induction issues.

Capacitance

Capacitance is a type of enigma. If capacitance is large it has been known to cause amplifiers to become unstable. One may or may not be able to figure out that this maybe more of a function of the amplifier than the cable itself. One amplifier may be able to handle capacitance better than another amplifier. When designing a speaker cable, we definitely want the lowest capacitance we can achieve.

Shorter Is Better

When dealing with speaker cables, we all have heard that shorter is better. Speaker cables of long lengths create large issues. Let's take the example of an amplifier placed far away from the speaker. Our speakers have passive crossovers and are full range. This would be our worst case scenario. If our speaker cable is 30′ long, we will have signal loss and contamination.

Power Closer To Crossover

If we move the amplifier closer to the speaker's crossover, we can help with this signal degradation. We can improve things further by running separate cables from the crossover to the low frequency and higher frequency drive units. This separate cable process handles full bandwidth and can be restricted to shorter cable lengths. Moving the crossover from the speaker is always a good thing. Speakers have magnets that do not play well with electric currents in our cables.

Low Frequency Energy

Low frequency energy within our cables is caused and created by larger amounts of current than our middle and high frequencies. This larger current requirement has its own artifacts and must be kept separate so that it does not impose any dielectric charge onto the middle and higher frequency lower current cable. Low frequency energy needs its own cable.

Bi-Wired Cables

Bi-wired speakers cables that are connected to our passive crossover inside the speaker are another way to go if the inputs to the high and low frequency energy are separated. We then run separate cables from the high and low frequency inputs back to the amplifier. This separation is necessary to minimize the larger current requirements and their impact on cables.

Cable Composition

The material to conduct our current whether for low frequency or high frequency has been a source of debate for years. Current cable technology even employs silver and aluminum. Silver has a smoothing quality to today's high frequency digital information that can be bright and harsh sounding. Oxygen free copper appears to have sonic benefits over copper that is not so oxygen free. However, if cable lengths are kept at shorter distances, these differences are not so prominent.

Cable Thickness

The literature tells us that for 8 ohm loudspeakers we should keep our speaker thicknesses to 2.5 sq. mm or greater. This applies to middle and higher frequency energy carriers. Low frequency cables should be at least 4 sq. mm. At 4 ohm on the resistance of our loudspeakers, a 6 sq. mm thick cable would be required. If we increase the cable thickness and length, our cable will still keep the same resistance. However, our inductance will increase proportionately to the cable length.

No Fuses Allowed

We never want to place a fuse inside of a loudspeaker circuit. They do not possess constant resistance and can increase with temperature. In this scenario, the fuse acts as a limiter, increasing the series resistance as the drive current increases from the amplifier. The fuse also has a built in time clock if you will. The temperature changes in the fuse will always be lower than the current. Once the fuse blows, we have signal distortion.

Let Amplifier Protect

A carefully designed protection circuit inside the amplifier is the answer. Relays are not to be used because over time, they can have the resistance at the contact points diminish and change over time and use. If the contacts on the relays get contaminated, they can introduce a distortion into the signal path that is far removed from linear.

Synergy Of All Components

Resistance, capacitance, and resistance are the three main electrical properties exhibited by our speaker cables no matter consumer or professional. Make sure you are watching all of these variables when choosing a cable that is electronically compatible. Choose the correct cable thickness for the application of the cable. Make sure the electronic crossover is closer to the amplifier and keep the crossover out of the speaker cabinet. This critical feature has been overlooked in both today's consumer and professional markets.

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Chapter 4: HOW TO INTRODUCTION

The internet is full of room acoustic projects that individuals have built in garages or shops. Unfortunately, most are just the same project done over and over with a different twist thrown in here and there. The How To section in this book is different. First, we examine the scientific bases for room acoustic products and why they are needed. We also examine current projects and examine whether they meet the scientific criteria necessary to solve the acoustical issues that they claim to solve.

* * *

How To Soundproof A Rehearsal Room

What Are We Rehearsing?

If we are going to answer the question on how to soundproof a rehearsal room, we must first define what we are rehearsing. Is it vocals or instruments? Is it one vocal or many? Is it a single instrument or a small band? We need to know the amount of energy that will be created within the rehearsal room to plan accordingly for the correct soundproof method to employ both to the inside and outside of our rehearsal room.

Energy Assumptions

Let's first make some assumptions. Let's take a small choir, say 10 vocals and an 8 piece band. Let's use these two as our sound generating sources. These two sources will become the benchmark, so we can illustrate how to soundproof a rehearsal room. They both produce energy in similar but different parts of the frequency spectrum.

Concrete Shell

Once we know how much energy we are going to produce in the room, we can design the shell or barrier that will keep the sound generated from within our room, inside where it belongs and the noise generated from outside our rooms, outside where it belongs. A good start is concrete which will provide the barrier protection we need. We should make ours walls 8″ thick and poured concrete into molds is preferable to block. Block is a good second choice if poured concrete is not an option.

STC – Sound Transmission Loss

Sound transmission loss is the ability of a structure to reduce sound transmission from one side of the wall to the other A 8″ poured concrete wall will provide a sound class rating of 56. This means that if we have a sound source on one side of the wall that measures 90 dB, it will be 34 dB on the other side because the concrete barrier will reduce the sound pressure level by its sound transmission rating.

Dual Wood Framed Walls

if block or poured concrete is not an option, one can use a wood frame structure or rather two wood framed structures. We construct a 2″ x 4″ wall and then another 2″ x 4″ wall. We leave an air space of 4″ – 6″ whatever our physical location will permit. We isolate each wall from each other with the air space and we mechanically decouple each wall from the existing structure. This dual wall structure will afford almost the same STC value as a poured concrete wall. The poured concrete wall has a STC rating of and the dual wall has a STC rating of.

Room Size Critical

Once we have chosen our barrier configuration, we must focus on the inside of our room. If our room has been "acoustically sized" then we can begin right away with the acoustical treatment. If no thought or consideration has been given to the rehearsal room's size then we must address that issue before we go any further. If we are rehearsing a small band then we need the correct room volume to accommodate the band's frequency range which is a larger requirement than a vocal rehearsal room.

Room Modes

Room modes or resonances build up inside a room that is not large enough to accommodate the complete frequency range that is produced by the rehearsing source. Resonances, especially those created by lower frequencies, have no place within our rehearsal room. A microphone or band member placed in one of these modes, may not be able to hear themselves and the microphone will not be able to record the correct information because the sound needed to be recorded will be smothered by the resonances. For a small band rehearsal room make sure you have at least 30′ in one direction of the room. For a vocal room, make sure you have at least 15′ in one direction. Always choose higher ceilings for both rehearsal room sources.

Sound Absorption

Acoustical room treatment for your rehearsal room can be absorption. Low frequency absorption must be used to manage low frequency modes. It cannot be foam or panels filled with building insulation. One must use tuned low frequency absorbers that can handle the low frequency energy created within room locations. Middle and high frequency absorption can be used to tame rehearsal room reflections to manage reverberation times. Make sure you choose the correct rate and level of absorption that compliments your use.

Sound Diffusion

Diffusion can be an important tool in dealing with room boundary reflections. Diffusion can take the reflected energy from the wall surfaces and spread that energy out in a fan like array in two dimensions. This spreading out of energy allows for a smoother presentation of energy at the microphone position. Two dimensions of diffusion can be achieved within your rehearsal room by using quadratic diffusion.

Variable Acoustics

Variable acoustics have gained popularity. One can have absorption panels that can be absorption on one side and diffusion on the other. An engineer can alternate between absorption and diffusion to suit the recording engineer's acoustical palette. Portable low frequency absorbers can be rolled in to handle room resonances at certain places within the rehearsal room.

Follow Steps

When you are planning on how to soundproof a rehearsal room, you must first define what sound producing sources are going to be using the room. Once determined, you can assign the correct barrier technology to manage the sound pressure levels generated from the rehearsing source and keep wanted sound within the room and unwanted sound outside. The rehearsal room must have the correct volume to accommodate each source whether from a single vocal, a choir, or a small band. Proper room volume minimizes room resonances. A combination of absorption and diffusion technologies can be used inside the room.

* * *

How To Build A Dedicated Listening Room.

PART ONE

Dedicated Listening Room

A dedicated listening room is just what the name implies. It is a room dedicated to listening to music in. It is usually a two channel system with left and right channel along with the listening chair. The dedicated listening room is not for any other use. It is not for playing pool or ping pong. It is not a home theater room with multiple mono sources. It is a room dedicated to the playback and enjoyment of only two channel audio in all its splendor. Don't have one but want one? Let's set one up.

Ideal Room Size

Our first step is to choose the correct room size. We determine this by the music type we will be listening to. If we will be classical music focused then we need to plan for frequencies that are starting at 20 Hz. and moving up from there. If our music choice is Jazz then our room should handle low frequencies down around 30 cycles. With rock music, 40 Hz. is a good beginning point. For this exercise let's assume a classical taste and with that in mind plan for a room that can handle sound energy down into the 20 cycle region. With that parameter, we will be fine for all other music sources.

Air In The Room Vibrates

Our room dimensions determine how much sound energy that particular room can handle. Think of our room as a large container that we are going to “pour” sound energy into. The size of our container determines how much energy the room will “hold” without splitting apart at the seams. It is the air that vibrates between our room walls that causes resonances.

Room Dimensions Critical

Our dedicated listening room must be designed with the proper dimensions and thus room volume to minimize resonances. Resonances are sound energies way of telling us that they do not like the fit of the room. It is like buying a medium shirt when you need a large. For women, it is like squeezing into a size 6 dress when you are really a size 10, eventually something must give. The clothes will tear. The room will create resonances that can smother or blur and even exaggerate certain frequency ranges associated with our music choices.

Ideal Room Dimensions

To minimize resonances, we need to look at our chosen 20 cycle wave as our low frequency goal and allow for that size wavelength to run free. Our 20 cycle wavelength is roughly 56′ long. To calculate exactly, simply divide the speed of sound, 1130 by the frequency 20. For our room purposes, we need to have the space for one half of this wavelength, say 28′, to run uninhibited without slamming into a wall or structure. Therefore, we need at least one room dimension to be larger than 28′. Let’s call it 30′ for discussion purposes.

A No Compromise Dimension

The wavelength travels down our 30′ length and then strikes the wall and begins its journey back to its source which is the opposite wall. It will fall short of the other wall because our 20 cycle wave is 56′ long and it is traveling 60′ total. It only strikes the one wall and not the other. This minimizes resonances. To complete this resonance free scenario, we need a room that is 30′ in all three dimensions. This is ideal acoustically with no compromises. Unfortunately, the real world and existing room sizes are much smaller and are nothing but a compromise that must be dealt with to minimize resonances.

Room Ratios

There are a set of ratios that various individuals have proposed that do their best to minimize resonances but remember these are all compromises from an ideal room size and volume. What compromises one is able to live with usually depends on budget and room location. Room size and the ratios of height, width, and length must be taken into consideration. We have seen from our example of a 20 Hz. wave that we need 30′ in an ideal situation to ensure that the air inside our rooms does not begin to vibrate and produce resonances because the air within the room is squeezed into a room dimension it does not like.

Follow This Ratio

The literature is full of numerous room ratios of height, width, and length that will minimize those dreaded axial modes, resonances between two parallel surfaces. To simplify these ratios, one can use the ratio of 1:1.14:1.39. If we take these numbers in order of appearance, we have the ceiling height as our first number, the room length as the second and the room width as the third. If we put 10′ in for the room height in the first position, we come up with a room length of 13.9′. Next, we keep our 10′ room height constant and calculate the room width to be 11.4′. Proper room dimensions will go a long way down the road in minimizing the type of low frequency absorption we need to use.

In part two of How To Build A Dedicated Listening Room, we will discuss proper speaker and listening positions and low frequency management along with reverberation times.

How To Build A Dedicated Listening Room

Part Two

Part One

In part one of this series, we focused strictly on room size and volume. It is the most single important variable when it comes to realizing the full potential of our music systems. Without the room to run free, low frequency energy builds up within our rooms and excites the air inside our room turning it into a resonate cavity. Resonances must then be managed through proper room absorption technology and dealing with resonances below 80 cycles takes special sound absorption technology. If we get the dimensions correct from the beginning, we will hear more music from our systems.

Speaker Set Up

Once we have determined the correct room size for our playback system by following the suggested height, width, and length ratios, we are ready to set our two channel system up. Finding the correct location for our speakers and listening position is our task and we must locate these three positions at proper distances to obtain the smoothest frequency response we can achieve within the room. There is a position that will give us the smoothest response where all frequencies are evenly represented and resonances are minimized.

How To Begin

To start, lets divide our rectangular room into thirds. A rectangular room configuration is essential because it offers us predictability. With a rectangular room’s parallel surfaces, we have energy that is moving and striking surfaces that are predictable distances from each other. Yes, parallel surfaces are not wanted when we are dealing with middle and high frequencies, but this can be better managed in a rectangular room. It is also easier to deal with low frequency issues within a rectangular room due to the room’s shape consistency.

Measure, Measure, Measure

After we have divided the rectangular room into thirds, we need to position our speakers along the first third division line we have set up within our room. Position the speakers at least 4′ from the side walls. Make sure both side wall/speaker distances are equal. Now, take a frequency response measurement at the listening position. There are numerous software programs that will assist you with this measurement. Look at the curve and notice any peaks or dips in it. Divide the response curve up into two sections. Look at the response curve above 100 cycles and then look at it below 100 cycles. Move your speakers 6″ forward from your start position and take another measurement. Repeat the same procedure by moving the speakers 6″ back from the start position and measure again.

Look For Patterns

Now, let’s examine the three response curves we have taken. We should begin to see some patterns developing. Let’s look at the response curve below 100 Hz. What does the curve look like at the original start position? How about the one with speakers forward? Is it smoother or more exaggerated? Is the response curve below 100 Hz. better when the speakers are more forward into the room. It probably will be. Now, let’s move the speakers another 6″ forward and take another measurement. Repeat this procedure focusing on all energy below 100 cycles. One will start to see a pattern developing and the smoothest curve will eventually show itself.

Listening Position

We want our new speaker locations to be in synch with the listening position. If our speakers end up being 8′ apart, then we should start with our listening position at 8′ so that the speakers and the listening position form the angles of an equilateral triangle. If more sound stage width is desired the listening position can be moved backwards. Move at small increments. Don’t forget about listening position height. One may find that elevating the listening position up a few inches may take the listening position out of the direct beaming of the tweeter and balance the tweeter and mid range out more evenly. Remember, it is the off axis energy that includes the room sound and moving listening position up may benefit.

Sub Woofer Position

Are we adding a sub woofer? If so, we need to treat that low frequency device as its own system and find the correct position for it. Do not and I repeat do not put it into a corner. The corner of our rooms is where all room modes end and accumulate. We do not want to place a low frequency energy device in the corner and excite all of these room modal issues. Let’s leave sleeping modes lie. Place the sub woofer along the longest wall about 1/3 of the way down the wall. Measure the room response. Raise the sub woofer up 12″ in the same position and measure again. Change to the shortest wall width and repeat the procedure. You will quickly see that maybe two sub woofers and possibly three would be even better to equalize the pressure within the room.

Move And Measure

Speaker and listening position have to be located within the smoothest measured room frequency response curve location which is determined by moving speakers and then measuring. All of this moving and measuring must have an eye towards the best response curve. It will appear, just keep moving in small increments and then measuring. Once found, align the listening position from the speakers. Don’t forget to move up at the listening position a few inches to add more room sound. Off axis sound is different from on axis frequency response. Treat the sub woofer as its own speaker. Start 1/3 of the way down the long wall and measure. Raise the sub off the floor and measure. This upfront time will be well spent, you will see in part three of this series on “How To Build A Dedicated Listening Room”.

How To Build A Dedicated Listening Room

Part 3.

Part 1 – Part 2

In part one of this series on How To Build A Dedicated Listening Room, we focused on room size. Starting with the correct room size is critical and sets the stage for the type of acoustical issues you must deal with down the road. Part two focused on positioning of your speakers and listening position. With a two channel system, there is a position for your speakers that will compliment the room's size and volume. In part three, we will focus on low, middle, and high frequency room acoustical treatment to minimize reflections at the listening position and to manage low frequency resonances.

Low Frequency Issues

Low frequency issues should have been minimized if we followed the steps listed in part one. However, real estate is expensive and we must sometimes compromise on the dimensions that we really need. To really go after low frequency issues and the resonances that low frequencies produce, we need to make the room larger. We need a larger width, length, and height. Since that is not usually an option, we must go the other way and make the room smaller. We must make it smaller by installing low frequency pressure producing technologies.

Axial Modes

Low frequency energy issues are found mainly in the axial modes. An axial mode is the energy that occurs between two parallel surfaces. It is the energy that resides between the floor and ceiling, the two side walls, and the two rear walls. It is the most powerful of all the modal resonances. This is where our low frequency absorption technology must be positioned. We must have it in every corner and along the two shortest wall dimensions that we have. If the room is 15′ wide and 19′ long, we must have the low frequency absorption placed along those two short walls. We cannot use foam or tubes filled with building insulation. We must use diaphragmatic absorption.

Diaphragmatic Absorption

Diaphragmatic absorption is pound for pound, the most powerful and absorptive low frequency technology one can use. It can be made to absorb across a broadband of frequencies or it can be made to absorb at certain frequencies. A diaphragmatic absorber has a front wall or two front walls that slow the low frequency energy wave down. Once it is slowed down, it can enter the inside of the cabinet and be absorbed depending on the internal cabinet fill material. Mineral wool, building insulation, and fiberglass are traditional fills but activated carbon or charcoal gives you the best performance to size of cabinet ratio.

Quantity Vs. Quality

How much low frequency absorption do we need? This depends on room size and volume. The smaller the room, the more one needs. Only by taking frequency response measurements within the room after the low frequency diaphragmatic absorbers are in place with tell the story. To impact the frequency response curve of the room, will require at least both sides of our 15′ width to be treated with absorbers. From that start point, one can add or subtract units based on the room’s attack and decay times in frequencies below 100 cycles.

Room Surface Reflections

Reflections from our room wall surfaces intermix with the direct sound from our loudspeakers. The direct sound is the sound that travels in a straight line from our speakers to our ears. This wanted direct sound is the purest sound quality our system can produce. Once the room wall reflections enters the direct sound, we now have direct and reflected energy mixed together. This is not a bad thing. We want both direct and if you will indirect sound for more realism and lifelike presentation. The sonic goal is to find the correct balance between room sound and direct sound.

Reflections Produce Spaciousness

Our reflected energy from our side walls is critical for the impression of spaciousness in our sound stage presentation. We do not want the reflections from our side walls arriving at our listening position “ahead” of the direct sound. We want to delay the reflections from our side walls, so that they arrive after the direct sound by a time frame of 15 milliseconds. This small time delay will add spaciousness and assist us in creating our sound stage.

Sound Absorption Technologies

To achieve this small time delay, we can use absorption or diffusion technologies. For the sake of this discussion, we will use absorption. The market is full of sound absorbing panels and choosing the correct one should not just be a matter of price and convenience. One must choose a panel that has the proper rate and level of absorption that will treat all the important frequencies with equal respect. We need absorption technology that does not over absorb or under absorb at any frequency below 500 cycles. Why 500 Hz. or lower? Because this is the region where all our vocals occur and our vocals are what provides the emotional connection we all seek from our music and sound stage presentation.

Acoustic Foams

Acoustic foams are popular treatment options and most work well above 500 Hz. The real test of an acoustic foam is how well it works below 500 cycles. Most acoustic foams absorb very little at 125 Hz. and absorb a little more at 250 Hz. This frequency region is the true test of a foam. Do your research and find a foam that has a smooth response curve below 500 Hz. with a gradual but smooth absorption rate and level.

Part 4: Diffusion And Electronics

In part 4, of How To Build A Dedicated Listening Room, we will discuss the other room surfaces such as ceiling and front and rear wall of our listening room and their overall impact on our sound stage. We will also discuss the electrical requirements for our system so that we are not introducing more “noise” into the room. That we don’t need. We have enough “noise” just dealing with the room boundary surfaces with reflections and low frequency resonances.

How To Build A Dedicated Listening Room

Part 4

Parts 1 – 3

In part one of this series, we discussed how important it was to choose the correct room size. In part two, we discussed speaker and listening position and its importance to room frequency response. Part three discussed low, middle, and high frequency room treatment. In this part four, we will focus on low frequency resonances and the importance of low frequency management through appropriate absorption technologies.

Low Frequency Definition

There is so much misunderstanding when it comes to low frequency energy in small room environments. There is also a large misunderstanding of what constitutes low frequency. Low frequency is any frequency below 100 Hz. Human hearing is broken up into five critical bands in our audio world. Low frequency is any frequency below 100 Hz. Let's keep this round number of 100 cycles in mind as we proceed forward with our discussion.

Low Frequency Pressure Plots

Low frequency energy into our rooms does not fit because of its long wavelengths. Since it doesn't fit, it builds up and creates pressure areas within the room. These pressure areas occur at room boundary intersection such as the intersection of floor to side walls and side walls to ceilings. The corners of our room are also areas of higher pressure for low frequencies. The corners of our room are also havens for other room modes that represent higher frequencies. We must pay attention to these low pressure areas if we are to have any chance of an equal representation of all frequencies at our listening position which is our goal.

Low Frequency Management

There are three main ways to manage low frequency energy within our rooms. First, we can choose a room size that can handle the pressure that long low frequency energy creates. This is the best option, although the one not usually chosen. It is better to choose a room that has the proper ratio of width, height, and length to be able to handle low frequencies. There are ratios that work well with lower frequencies. One can spend the money up front and choose a room that has the proper size and volume or one can add sound absorption technology to existing rooms and spend more money. It is a case of pay me now or pay me later.

Tuned Absorbers

Tuned absorbers called Helmholtz resonators are another option. These are technologies that are cabinets with certain depths or lengths and have a tuned port or slat that air enters through. The air vibrates inside the chamber and is reduced in intensity. They can be built into walls within the room or be freestanding units located in areas of highest pressure. A glass coke bottle is an example of a Helmholtz resonator, with a resonant frequency of around 185 Hz. Frequencies above 185 Hz. are absorbed. The resonant frequency of the unit defines the lowest limit of the unit’s absorption.

Diaphragmatic Absorbers

Diaphragmatic absorbers are another option that is used extensively in the professional market but not readily known in the consumer market even though the interior walls of their listening room are probably a diaphragmatic absorber. A diaphragmatic absorber is a cabinet with a certain depth and a certain density. Both depth and density are critical components. One needs cabinet depth to absorb lower frequencies along with the cabinet density. Foam, tubes, and boxes filled with building insulation will not absorb frequencies below 100 cycles. They will above 100 Hz., but not below.

Resonance Locations

Low frequency resonances must be defined and located within the room. Once defined and located, one can design the particular low frequency technology that will absorb at the necessary rate and level to minimize the amplitude of the resonances within our rooms. We may need to design absorbers that can handle low frequency issues that go from say 30 Hz. – 50 Hz. These frequency specific absorbers must be designed with care and attention to cabinet size, depth, and density. Broadband absorbers covering a wider frequency range can also be designed. One must define the low frequency issues and then design the proper type of absorber and place it in the correct location.

Low Frequency Management

Managing low frequency energy within our smaller rooms is always an exercise in compromise. Without the correct ratio of width, height, and length, we are always climbing up hill. We will never be able to achieve a perfect absorption curve, but we can minimize resonances so that they do not pervade our sound stage presentation all the time. We can forget about achieving a flat response down to 20 cycles and use 30 cycles as our low end goal. Thirty cycles represents the lowest string on a five string bass and will also cover any low frequencies generated by a bass drum.

No More Mud

Without proper low frequency energy management, our sound stage presentation will be plagued with low frequency mud. We have all heard this. It is the blurring and smearing of everything we value, especially in the mid range area where our emotional connection to the music lies. Resonances can be at 30 cycles and all of its fundamentals. A microphone placed in a room mode will not hear certain frequencies and may hear too much of others. Resonances and their reduction through proper low frequency management technologies should be the first goal of any listening room build.

* * *

How To Soundproof A Recording Studio

Recording / Monitoring

How to soundproof a recording studio can be broken down into two main parts. First, we have the recording environment. Is it for recording vocals, drums, choir, band? What will the sound producing sources be that will be recorded? The second part is the monitoring or playback environment. Is it the mixing, control, or editing room for film? What are we monitoring? Both of these areas have different soundproofing requirements.

Live Room

The "live" room or room in which instruments will be recorded in needs to be able to perform two very different acoustical functions. First, it must minimize the sound transmission from the live space to the rest of the facility. It must also employ sound absorbing and sound diffusion technologies to manage all of that "live" energy.

Barrier Technology

In order to keep the sound energy within our room and to also keep sound energy out of our room, we need to construct a barrier between us and or our microphones and the outside room noise. This barrier does two things. It must reflect sound energy that occurs outside of our rooms, back towards the outside source and it must also reflect sound energy created within the room, back into the room itself. Yes, a barrier keeps sound out but also reflects sound back into it. The barrier works both ways and we must be aware and plan for this.

Poured Concrete

A good barrier is poured concrete. One can use molds and build a wall by pouring concrete in the molds and letting it dry solid. The outside foam of the mold also helps a little with some sound isolation. A solid concrete room also has vibrational reducing qualities over a room built of wood. A wood framed room is another option. One should use two 2′ x 4′ walls that are at least 6″ apart. Both walls must be mechanically decoupled from each other and the existing room ceiling and floor.

Cinder Block

Another good barrier technology is block. One can add different materials to the block center to lower the sound transmission rating even more. Block is economical and can even be purchased with a quadratic diffusor built into the actual block itself. Sand can be added to the block center to minimize sound transmission through the cinder block sides. Barriers are necessary for our "live" rooms and our monitoring or control rooms.

Low Frequency Management

Inside our "live" rooms, we need to manage both low, middle, and high frequencies. Our goal acoustically is to make the room as balanced as possible with a smooth frequency response curve. We must address any room modal resonances with powerful low frequency absorption. Only a tuned absorbing technology will work for low frequencies at the SPL levels generated within a "live" room. Foam and boxes filled with building insulation will not work.

Middle And High Frequencies

We must always manage middle and high frequencies throughout the room. This management of middle and high frequencies can be accomplished through the use of absorption and diffusion technologies. In our live rooms we use absorption to lower reverberation times by minimizing the strength of reflections from the room’s surfaces. We do not want to overload our microphones with too many reflections. We need to know what the room sound is at our microphone positions and manage it accordingly. I like live rooms that have variable acoustic technologies. They can move a panel in with middle and high frequency absorption and produce a whole new room sound.

Low Frequency Absorbers

In a live room, portable low frequency absorbers can be placed in the room where resonances will be lurking. One can also keep the low frequency absorption next to the source of the energy such as a bass drum or tom and absorb excess energy closest to the source that is producing it. Absorb the low frequency waveform as soon as it leaves the source, so that it is reduced in strength immediately. Control how fast the low frequency energy “grows” in the room. This process takes a special absorption technology termed diaphragmatic absorption.

Diaphragmatic Absorption

Diaphragmatic absorption consists of a diaphragm that low frequency energy moves through. The diaphragm actually moves in response to the low frequency waveform. Two front walls moving in sympathy are even better. Once the waveform is slowed by the two moving diaphragms, it then enters the cabinet. Inside is a powerful sound absorbing material. Mineral wool is a possible cabinet fill material because of its higher density when compared with normal building insulation. Activated carbon or charcoal exceeds both of these materials by a factor of 10.

Monitor Room Barriers

The monitor room of our studio needs the same barrier technology as just described for the “live” room with the addition of a sound lock. A sound lock is two doors separated by a small hallway. This provides a triple barrier approach; the two doors one to the outside world and one to the control room and the air space between them in the form of a hallway, which is also acoustically treated.

Windows Are Barriers

Windows also come into play in the control room. They are another barrier technology that must be addressed in any how to soundproof a recording studio tutorial. They must be seen through but must stop sound. Make sure the wall in which the window is installed is equal in acoustic strength to the window. If you are using two 1/2″ glass plates separated by air, then you have a very powerful barrier. Make sure the window’s wall that is supporting it is equal in sound transmission loss strength.

Rear Wall Diffusion

The rear wall of our monitoring room or control room should always be diffusion. The type of diffusion can be debated, but not the need for diffusion. The time delayed bounce off the rear wall at the monitoring position cannot be. It is difficult enough to get a balanced mix with control room sound added in. We definitely do not want a large reflection that is severely time delayed interfering with the direct sound from our monitors.

Common Needs

Live rooms and control rooms require the same barrier technology. We want to keep energy out and energy in. Low, middle, and high frequency absorption technologies must be used in both. Diffusion can be optional in a live room of adequate size. It is mandatory in our control room. Quadratic diffusion can provide two dimensions of sound diffusion for our control room rear wall.

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How To Soundproof For Drums

Energy Management

How to sound proof a room for drums is all about energy management. Drums produce a lot of energy at many different frequencies. Bass drums can produce energy at 30 Hz. Toms can produce energy starting at 80 cycles and snares fall in between. So, we have an energy producing device that is capable of large pressure levels (over 100 SPL) covering all frequencies and we are going to take this instrument and place it in a small room and expect the adjective soundproof to apply. Let’s think through this step by step, starting with the largest offender first.

Low Frequencies First

Let’s start with the lowest frequency producing instrument in our trio, the bass drum. The lowest note produced is 30 cycles. A 30 cycle wavelength is about 40′ long. We want this wave to behave itself in a room that has its largest dimension at say 12′. Well, it is not going to behave itself. It is going to want to escape from that room into the next rooms. The energy that does stay will create pressure nodes within the room and excite all resonances that are fundamentals of the 30 cycle wave and the room dimensions.

Tom And Snare

A tom will produce energy at 80 cycles. An 80 Hz. wave is 15′ long. In a 10′ wide room, the wave will travel 10′, strike a wall and the remaining 5′ will rebound back into the room and play havoc with mid room modal resonances. The middle of the room is not where you want resonances to occur, especially resonances introduced and magnified by a drum which can easily push pressure levels over 100 SPL. How do we manage all of this energy that is squeezed into a tiny box.

Pressure Levels

With a drum room, our first objective is to choose a room that has the necessary volume to support all wavelengths and the pressure levels they will be produced at. A room whose resonance signature can be manged with sound absorbing technology. We need a room that is at least half wavelength length or width of the lowest frequency that our bass drum is capable of producing. That would be at least 20′ in width and ideally 20′ in length. We know we are going to have resonances because we are in a box, but let's choose our battles wisely and choose a room dimension that can handle the pressure levels produced by drums and produce resonances that we can manage properly. If we choose a room to small, we are continually running uphill in our bass management.

Barrier Technology

Barrier technology must be employed to minimize the drum energy from leaking into other rooms or structures. A double wall approach is best here because of the higher pressure levels, we need to provide a high level of sound transmission loss. A double wall constructed so that each wall is mechanically isolated from the other would be an ideal situation. An air space of at least 4″ between the two structures would be welcome. We must construct a barrier or shell to keep outside energy out of our drum room but more importantly keep the drum sound in the room.

Resonant Management

Inside our drum room is all about resonant management. The smaller the room, the more high power absorption is needed. We must find the locations within the room where resonances occur. Once found, we must treat with the proper type and amount of absorption. We must also try and keep microphones from being placed within these resonance pressure nodes. A microphone placed within a room node may receive an exaggerated amount of energy or none at all. We want to try and achieve a room with a flat frequency response below 400 cycles.

Middle And High Frequencies

Middle and high frequency issues within our drum room can be managed using sound absorption or sound diffusion. Sound absorption should be used to control drum room reverberation times. There is much debate on what is a good reverberation time for a drum room. Find a live room that you like the sound of and measure the reverberation time of that room. This procedure will give you a good start point for your room. Another approach is to over absorb and take away absorption technology until you find the right number for you.

Quadratic Diffusion

Diffusion can be used to manage wall reflections within your drum room. Diffusion technology will spread the sound energy out in a fan like array across two dimensions of sound. Make sure and use quadratic diffusion to aid you in your efforts. Adjust the prime number that works best for your budget and room. A general rule of thumb is to use the highest prime number one has room for on the drum room's surfaces.

* * *

How To Soundproof A Bedroom

Not An Easy Question To Answer

How do we soundproof a bedroom? That's not an easy question. A bedroom is surrounded by other rooms in most cases. All that separates a bedroom from the other rooms is an interior wall that is usually made from 2″ x 4″ or 2″ x 6″ wood frame interior walls. Wood framed, interior walls that are and were never designed for any type of real noise control. It is usually easy to hear through a bedroom wall.

Must Address Usage

What will we be doing in our bedroom that we need to isolate sound from getting in or out of? Are we going to convert it into a project studio to do what? Are we going to record vocals, maybe instruments? Where is the bedroom located within the house. Is it located next to other bedrooms or areas of necessary quiet or is it located next to a higher noise producing area. All of these questions will have to be answered. Let's start with least noise producing first.

Small Project Studio

If the bedroom is located away from the rest of the house or apartment and there will be no noise producing sources in joining rooms, we can focus on the main use of the bedroom conversion. If we are playing back and monitoring a recording through monitors, then we need to begin by addressing the noise source within the bedroom itself. We do not want to disturb other members of the household.

Must Deal With Low Frequency

Let's start by treating the room with the necessary low frequency control technologies to minimize the impact of our lower frequencies from the monitors. This will require additional low frequency absorbers that are tuned specifically to the low frequencies generated by the monitors in our small bedroom. We will need floor to ceiling absorbers in every corner and along all four room sides. We actually could not have too much low energy absorption in a small room. The smaller our room, the more low frequency issues we have and the need to make it smaller by adding low frequency absorption.

Reflections Must Be Minimized

Room wall and ceiling reflections in small rooms destroy our stereo image and mess with the wanted direct sound from our monitors. Acoustic foam will work well on the side and front walls directly behind our monitors. Make sure you choose an acoustic foam that has the necessary rates and levels of absorption to handle the vocal and mid range presentation in your bedroom. Not all acoustic foams are created equal and one needs to be aware of their sonic impact especially in small room environments.

Pay Strict Attention To Rear Wall

The rear wall is of special concern. A small room has many acoustical issues because of its size and one must address these issues at the start. The reflection from the rear wall at the monitoring position is a time delayed one and can really have an impact on your mix. It must be dealt with by using diffusion. In particular quadratic diffusion which will reduce the reflection from the rear wall and spread it out in a series of smaller “reflections”.

Use Both Vertical And Horizontal Diffusors

Try to use the highest prime number for your sequence as you have room for and make sure to position your diffusors both vertically and horizontally to afford two dimensions of sound diffusion. Small bedrooms need all the diffusion they can get especially from the rear wall at the mix position. Position vertical diffusors across the total width of the rear wall and then place horizontal diffusors across the top of the vertical ones you just positioned.

Still Not Enough ?

If we perform all of these treatments and sound energy is still migrating to other areas of the house, then we need to get out our tools and build some barrier technology. This may or may not be feasible in a bedroom situation. What we will need to do is build a barrier within our bedroom that keeps the energy we produce within the room, inside the room itself. To accomplish this, we must place a barrier between the sound or energy source and the rest of the building. This is the room within a room concept.

Build Your Footprint

We start by laying a 2″ x 4″ across the floor bordering all around the room. Make sure our border is 6″ away from the existing wall. This is the new footprint of your room. Complete the floor assembly with 16″ on center studs. Fill the interior space between the studs with mineral wool insulation. Do not use fiberglass. Mineral wool is denser and will assist us in our sound isolation efforts better.

Isolate Floor Assembly

Raise the fl0or assembly up and place it on rubber isolators. Many companies make these and follow their recommendations for how far apart on center they should be placed. Now, our floor is isolated mechanically from the rest of our bedroom. Build the walls with 16″ on center studs upon our isolated floor assembly. Fill with mineral wool as the floor assembly. To cover the studs on the floor, one must use floor covering materials. Consult your local building codes one can use drywall for the walls or a commercial grade multiple density fiberboard which will give you more density and a much smoother surface free from drywall flakes and chips.

Ceiling Assembly More Difficult

The ceiling assembly will be more difficult and depending upon the width and length of your bedroom, may need a rafter type assembly approach. If you do not have the skill set for this, hire a professional. You don’t want the ceiling to come crashing down on your board or monitors, not to mention your head.

Must Have Game Plan

How to soundproof a bedroom is not an easy question to answer. The answer depends on what usage, the location of the bedroom to the rest of the house or apartment and what recording or playback processes are involved. Start by treating the inside of the room with low, middle, and high frequency absorption technologies. If that is not enough, you must go to building barrier technologies to isolate the sound energy produced in the bedroom from the rest of the house. If barrier technology does not work, you must move.

* * *

How To Soundproof A Floor

How To Soundproof A Floor

If one was going to write a book on how to soundproof a floor, the first thing that comes to mind is floating. Our floor however, we construct it, must “float” or be mechanically decoupled from the existing structure. There must be an air space between our new floor and the existing floor.

Assess Noise Issue

First, before we begin any construction project, we must assess our noise problem. Why are we building a new floor? The answer is usually to isolate ourselves or others from noise. We must then ask ourselves, how much noise do we need to isolate from. Are we isolating a drum room? Is it a vocal room? Each will have its own set of noise issues that must be dealt with. Let’s put a number to the noise.

Measure Noise

Take out that Radio Shack dB meter and measure the amount of sound pressure within your room during the times when the most energy is produced. Assign a number to this noise. Is it 85 dB, 90 dB, or maybe a 100 dB. Now, take your dB meter into the room where you want the sound to stay out of and measure what the levels are in that room when you are producing the most energy. Are they 75 dB, 80 dB, or 90 dB? The difference between these two sets of numbers is what we need to address.

How Much Bleeding?

If the room directly below our floor is a regular type of living space, then we want ambient noise levels around 60 dB. If we are producing 85 dB of noise and that is raising the ambient noise level in our normal living space to 80 dB, then we need to isolate at least 20 dB of sound pressure from leaking or bleeding into our normal living space. Each dB of isolation costs money and takes special planning to achieve.

Who Is At The Party?

We now have a measurement of the overall noise levels. Now, we must focus on what frequencies are involved in this noise party. Are most of the frequencies in the middle to high range? Are there low frequency issues that we must deal with? The frequencies that cause the noise level we are planning to reduce must be addressed in the structure of our new floor. Take a frequency response reading of all noise and look at what frequencies are contributing the most to the noise levels.

Below 100 Cycles, Best To Move

If we are faced with noise that is mostly below 100 Hz., we should consider moving to another location. Stopping or minimizing low frequency energy is no easy task. it is also not very cost effective. Constructing a floor to stop drum bass noise is completely different than building a floor to stop office noise from bleeding from one office to the next. It is usually desirable to find another location when low frequency energy is an issue. This is why musicians practice in rooms that are removed from other structures.

Above 100 Hz. Good To Go.

If our noise levels are caused by energy above 100 cycles then we can build and design a floor system that will provide proper noise management for the structure below. Our numbers tell us that we need to stop around 30 dB of energy. What type of structure to we use that will reduce our sound pressure levels by 30 dB? We need to look at another number called STC or sound transmission class. This is a number that will tell us what structure types will hold back what amount of unwanted energy.

Exceed Goal By 50%.

Our goal is to hold back at least 25 – 30 dB of sound energy. If we build a single, 2″ x 4″ “wall” for our floor and fill the interior of the wall with building insulation, we can achieve a STC rating of 40. This is a good start, but we should try and overshoot our goal by 50 % to ensure that we meet all the requirements for our space. Let’s add another few layers of thick carpeting and a thick padding to add an additional layer of protection.

Installation

Installing our new floor system is critical. We must mechanically decouple the floor from the existing structure. We do this by floating the floor on rubber isolators that are placed at supporting intervals throughout the floor layout. We also need to leave at least a 1″ air space between our new floor bottom and the existing structure. Make sure the existing structure can handle the additional weight requirements you are imposing upon it. It will not matter how well you did with your new floor, if it comes crashing down into the room below.

Professional Advice

Sound isolation involves both air borne and structural noise. Both types must be dealt with and measured for any project. Once you have determined the actual problem through measurement, you can decide on the appropriate structure that will meet the sound transmission loss objectives. Building and installing the correct structure is not an easy task. If you do not mechanically decouple the new floor from the existing floor, you could negate performance and isolation qualities. If you have any doubt about how to proceed seek additional knowledge or hire a consultant to guide you through the process.

* * *

How To Soundproof A Basement

Ceiling First

How to sound proof a basement must be approached from the top down. Our ceiling to our basement is really the floor of the next level above us. The walls are usually block or poured concrete which provides another barrier layer. To our sides, behind the side walls, we have lots of earth. Earth is an excellent barrier material, especially for lower frequencies.

What Is Our Basement's Use?

We must first decide what our intended use of the basement is going to be. For the sake of discussion, let's make our basement usage a small project studio. No musical instrument or vocal playing, just monitoring through playback monitors. Let's make our top playback level around 85 SPL or so. Let's focus on our ceiling which is the floor for the room above which is the room we want to keep energy from transferring out of our basement into the floor above.

Barrier Technology

We will have to keep as much energy within the basement as we can. To do this, we must employ barrier technology for the ceiling. The best way to make a barrier is to laminate different layers of different density materials. One can use plywood, MDF, or other composites. Arrange the materials in a manner that starts with say a 1/2″ solid piece as the center and build a multi-layered sandwich of materials out from that core piece.

Barrier Sandwich

Take a 3/8″ of plywood and stack it on top of the 1/2″ solid MDF core. MDF stands for multiple density fiberboard. We need the commercial variety for this project. Before we attach them together, let's separate them by placing a layer of vibrational damping compound between the 1/2″ MDF core and the 3/8″ plywood. Next, let's use another piece of MDF at a 1/4″ thickness and place it on top of another layer of vibration damping compound. Each layer of different densities is damped by compound. Our goal is to end up with our "barrier sandwich" at 6″ thick.

Vibration Reduction

As vibrations move through each layer of material they must go through different thicknesses and also must go through the vibration damping compound layers. We want to make the vibrational journey as difficult as possible. Vibrations equal noise upstairs. This is the reason for alternating different materials with different densities. We want to reduce the vibrations that strike one side of the barrier from reaching the other side.

Barrier Installation

Once we have our barrier built, we must install it. It will not be easy because we will have to lift it into place and secure it. It also must be damped or decoupled from the existing basement ceiling, so that once again we minimize vibrations. This should be left to a professional who has the tools and equipment to do that. A 4′ x 8′ barrier sandwich could easily weigh a 1,000 lbs. Don't ask your buddies for help on this project.

Double Wall Approach

Another way we can achieve sound transmission loss is by building two walls, if you will, that do not come into contact with each other. We will be building two 2′ x 4′ walls with an air space between them of at least 4″. These two walls will be standard interior walls with 2″x 4″ lumber covered in drywall. It is an easier build and install but care must be taken that each wall built is mechanically isolated from the other. Once again, we want to throw as many barriers as we can against air borne energy and the air space between each wall is another barrier.

Inside Basement

The inside of our room or basement already has walls that are concrete reinforced with earth surrounding them. We are not going to improve upon the density or sound isolation characteristics of this system. We will need to focus on the dimensions inside those walls to discover any low frequency issues that will be produced by the basement's dimensions. Once you have determined what the dimensions are that you will be using, we will then go to work on taming the low frequency resonances first and then dealing with middle and high frequency reflections off of the wall surfaces.

Low Frequency Sponges

Once you have determined what low frequencies are going to cause you problems, one can design and build low frequency diaphragmatic absorbers that will absorb at the lower frequencies one needs to deal with. If you are fortunate and do not have specific low frequency resonances to contend with and you would indeed be fortunate, you can build a broadband diaphragmatic absorber that will absorb energy over a broader frequency range.

Concrete Wall Reflections

Side wall reflections off of the basement walls may be wanted but most will not. Sound "borrows" from the surface that it strikes some of that surface sound. If sound strikes glass, one gets glass sound. We all know this sound. This is the sound we hear in our vehicles. If sound strikes concrete, we get concrete sound. It can be harsh and brittle and increase the reverberation times in our room.

Acoustic Foams

Side wall reflections can best be dealt with by reducing their strength through the use of acoustic foams. They are lightweight and relatively inexpensive. Make sure you use a foam that has a smooth absorption curve below 500 Hz. This is the frequency range for most vocals and you want absorption in that range to be as smooth as possible. Most foams currently in the marketplace show poor performance below 500 Hz.

Sound Compromise

Keeping sound from entering and leaving our rooms is not an easy task. The best we can usually hope for is a compromise. We reduce the energy within our room using absorption so that our neighbors do not hear too mush of it. If the noise is coming from the outside, we build barriers to try and stop most of it but we cannot usually get it all. Our basements have walls that have good isolation but we need to address the ceiling which is the floor of the rooms above us.

* * *

How To Soundproof An Apartment

How To Not Soundproof An Apartment

How to soundproof an apartment sounds like a daunting task. It is not easy. With paper thin interior walls and noise generating people living above, below and to the sides of you, it is not easy. Our soundproofing must also be portable and mobile, so after we get kicked out, we can take our stuff with us. Let’s back track a bit and see if we can figure out how to soundproof an apartment without getting evicted for excessive noise.

Identify And Measure

Fist, we must decide who or what is making the noise and how much of it we have to soundproof for. Is it our neighbor to the east that is playing his stereo at certain times of the day. Is it the family below with the home theater system that has more sub woofers than acoustic sense? Is it your electric guitar playing or better yet, how about drums? We need to identify what source and level we are dealing with no matter if it comes from inside our apartment or outside.

Putting A Number To The Noise

After identification we now need to determine what our sound pressure issues are. Place a Db meter within your room at the quietest part of the day. Do the same for the loudest part of the day. Record this information. Measure outside your room to find the level of the noise outside our room. Pick the loudest part of the day and what you think is the quietest part of the day or night. You will have to set your alarm clock for this test. Once we have both numbers or sets of numbers, we can decide what method in our bag of tools on how to soundproof an apartment.

What Do The Numbers Mean?

What is the difference in the two sets of numbers? Let’s look at the outside low to high representing the nosiest and quietest times we measured. Was the pressure reading at 85 SPL during the loudest outside? Was it, say 60, during the quietest? Was the inside measurement, say 50, at the quietest which was probably 2-3 in the morning and maybe 80 at the loudest when you were playing guitar. If we want the quietest within our room, we must stop 35 decibels of sound energy from the outside during the loudest part of the day for the quietest part of the day inside our room. Each dB of energy costs money.

We Are The Noise

For illustration purposes, let’s take the path of least resistance and the path that we have the most control of. Let’s say we are making noise from whatever the source and we want to protect our neighbors from it, so we do not get thrown out. The very first thing we must do is turn down, talk lower, and play more softly.

Room Within A Room

Don't like any of these options? That's all good. You want to play louder passages and sing rock and roll. No worries. We will just build a new room within your apartment, just kidding. It is an ideal approach but it would have to be designed so that it was self sealing, think of sound like water, and it would have to be assembled and then dis-assembled when you moved. Don't forget about the additional weight upon the apartment exterior and interior structure. A room within a room is ideal acoustically but not practical in our discussion of how to soundproof an apartment. If we turn down in all areas, we can focus on the inside surfaces of our room as a start.

Sound Absorption

Excess energy from within our room can be dealt with using sound absorption technologies. If we have a low end or low frequency generating device in our room, we can use low frequency sound absorbing devices. The smaller our apartment, the more we need to make it smaller by adding low frequency sound absorbers. With the wall surfaces of our apartments we could use acoustic foams to absorb excessive middle and high frequencies.

Furniture And Drapes

Reflections from our room wall surfaces can be treated with sound absorbing materials to reduce the strength of the reflection and help us to lower the overall room reverb times, so our vocals and instruments can be heard clearly without trying to pull them out of some sonic soup. Draperies can be used or open celled foam acoustic panels can be color coordinated into the decor of the room. Furniture can be placed at least the large cushion sixes for lower frequency control above 100 cycles.

Drums And Bass Must Move

If you are going to play sound sources with bass drums and guitars, you need to move. There is simply no way to treat your room to manage the noise to your neighbors without building another room which is mechanically decoupled from your apartment at every mechanical connection. The floor must also be separated from your existing apartment. It is best with these instruments to get a free standing structure away from other people.

All In Control

We can control the noise levels within our rooms and certain instruments are just not practical for apartments because so much new construction is needed. Work within yourself and the surfaces of your room to control reflections and either add lots of thick soft furniture or build low frequency absorbers that can be tuned to your room for maximum performance.

* * *

How To Sound Proof A Window

Window Is A Wall

What is a window? It is a wall that you must see through for various reasons to perform certain tasks necessary in your control rooms, project studios, or listening rooms. In order to sound proof it, you must treat it as any other structure within our room in terms of acoustical issues. You must address isolation issues especially with low frequencies and reflection issues with middle and high frequencies.

Step 1: Sound Measurement

The sound isolation of a window is necessary to keep unwanted sound energy from outside sources out. If a band is playing outside your control room, you definitely want to keep that energy out. You need to first decide how much energy we need to isolate, let's say, a control room environment from. Measure the energy within the band room with a simple SPL meter. Take measurements from the band using a ballad and then a full blown rocking out song. Measure the frequency response of all that pressure and you will see most of the problem causing energy is low frequency.

Step 2: Window Size

Once you have assigned a number to all noise and sound issues, you can begin to design your window. Line of site is critical and you must decide how large of a window you really require to achieve all of your visual objectives. Determine this by blocking the existing area for the window and reducing its size down to the minimum window size required to accomplish all of your objectives. The smaller the better.

Step 3: Window Wall-Weakest Link

A wall that is used for sound isolation is only as good as the weakest acoustical link in the wall system. The isolation of the window can not be greater than the sound isolation provided by the wall in which the window is installed. If you have designed a window with 60 dB of isolation and your wall you will install it in is only 40 dB, you are wasting your money and time. Noise or sound energy will flow like water through the weakest link in the acoustical chain. Make sure your wall is equal in isolation to your window.

Cost No Object

Isolation is difficult for most individuals to grasp. Sound isolation numbers are hard numbers and it does not matter to the wall or window, what device or devices you use to create that energy. I have heard people say that they only want to practice their drum kit, not play on a full set, so therefore they do not need to spend very much on noise isolation. There is no relationship to the cost of isolation and the devices that will be used to create the energy. Sound energy is sound energy and is measured by a number. It does not matter what produces it or how much that device costs that does.

Step 4: Window Plates

Once you have determined your minimum window size, you next need to determine what thickness and type of glass you need. If your low frequency issues are large, the thicker the window the better. Obviously a 1″ thick piece of glass will be more powerful in reflecting low frequency energy from its surface without moving and creating vibrations which will create sound. We do not need a single pane of glass that is very thick. We can use two thinner pieces. Laminated glass is preferable over regular plate because it has a thin sheet of plastic between glass sheets that will minimize our vibrations. Laminated glass is also called safety glass because if it breaks it will not splinter because of the layer of plastic between the glass sections. So if a angry guitarists throws his guitar against the control room window, all is good.

Step 5: Window Plate Separation

We know that air space can be another layer of material that we can use to isolate sound energy with. Finding the correct distance is the more difficult decision. As a general rule, the more the better but we must work within existing construction materials and techniques. If we use a plate glass that is 4mm thick and use two plates close together, we are worse off than using a single 4mm plate especially between 200 Hz. – 700 Hz. With thin glass plates and larger spacing we are much better off. A good start point is to increase glass plate thickness to 12 mm which is about 1/2″ and to make your air space a minimum of 4″. If you have the space, a 6″ air gap is best.

Step 6 : Reflection Control

Reflections off of our control room window are always unwanted. I cannot think of a single situation in which they are desired. In order to minimize the amount of reflections at the monitor position, we need to angle or splay the window surface so that the reflected energy moves away into another room surface. We accomplish this by angling or splaying the window at a minimum of 15 degrees from center. Find the area most impacted by the window surface reflections and splay or angle the window away from that area.

Step 7: Sealing And Foam Lining

When we install our glass wall, we are creating a miniature room between our two glass plates. In that room, with its walls, floor, and ceiling, we have a small box that can resonate with energy at the dimensions of the “room”. We need to line the window inside edges with acoustic foam that is designed to handle the resonances that can be created inside our “window room”. Placing the acoustic foam around the window edges with a minimum thickness of 2″ will handle most resonances within our 4″-6″ window depth. Larger window depths will require larger thicknesses of foam. Plan for this early in the window design.

Follow The Steps

Fitting a window into an existing wall requires several calculations before one starts. You must first determine what noise levels you are trying to isolate from. Next, you need to determine glass plate thickness and the distance between the two plates that will be needed to isolate from all invading frequencies. Angle the window away from the listening or monitoring position. Seal each plate to the existing structure against dirt and insect penetration and don’t forget the foam window lining.

* * *

How To Soundproof A Room

What Is Soundproofing?

Soundproofing a room means that people want to either keep sound energy from entering a room or keep the sound made in the room, inside the room where it belongs. Most of the time both are desired. Each approach requires different science to solve and before you start any project you have to keep these two sciences in mind. So first let's define each area of barrier and sound absorption technology before explaining how to approach the solution.

Barrier Technology

To keep outside sound energy or any sound that is generated from outside your room, outside where it belongs, you need to use barrier technology. You need to create a barrier between the sound on the outside and your room. Barrier technology is designed to reflect sound energy back to the source or the direction in which it came by creating a barrier or sound blocking structure between you or the room and the outside sound source.

Sound Absorption Technology

To manage sound that occurs within our rooms, you need to use sound absorption technologies. You must absorb the excess energy within your room, so that it does not create issues within the room. You must manage the excess energy through sound absorption, so that the sound energy does not "bleed" into the rooms that adjoin our sound room. Everyone has had this issue.

Step # 1 Define The Noise Issue

You must first define what noise issues that you need your barrier technology to stop. What is the noise level you need to address that comes from sources outside your room? Is it traffic noise, people talking, manufacturing sounds? One must put a number to this noise. One can use a Radio Shack SPL meter (60 USD) or as they call it decibel meter. Go out in the morning, afternoon, and evening and take some readings over a 15 minute time span. Takes highs and lows and average, say 10 or so readings. Measure it over a one week time frame. Include hours of most noise and then measure the quietest times. Now, you must define what you have measured.

Step # 2 Measure The Noise Issues

What kind of noise is it? What part of the frequency spectrum does the most noise occur at? What part of the frequency spectrum does the smallest sound pressure level occur at? Is it low frequency, middle frequency, or high frequency noise we are dealing with? This is a little more difficult than using a SPL meter. One will need to take frequency response readings to match the pressure readings. This is best left to the professionals unless one is familiar with the process. All of this information is required in order to build the proper barrier technology to minimize your noise issues. If you have low frequency issues from garbage trucks going by, one must build a different barrier than if you are trying to keep the phone voice from the next office from disturbing your lunch.

Step # 3 Define Your Room’s Purpose

Defining what your room will be used for is critical. If you are recording within this room, we need a certain sound pressure level of quiet. Are we recording vocals or bands? Each has different “quiet” requirements. If you are using your room as an office, you need to be concerned with middle and higher frequencies from entering, so that vocal mid range frequencies will not be impacted. Intended use is critical for defining how much we have to spend with barrier technology to protect your room’s sound environment and lower the noise floor to acceptable minimums for the room’s use.

Step # 4 Barrier Build Materials

Once you have all your data about the outside created noise and have defined your intended room usage, you can choose the materials and wall construction method to address the level of frequencies of the noise issues we have coming in from the outside. If they are low frequency issues, it would be advisable to find a new location. It is usually more cost effective to find a new location than trying to stop low frequency energy.

Low frequency energy take thick barriers to isolate you from the long low frequency wavelengths. The more mass we use and use it we must, for low frequency energy isolation, the more our costs go up. Considering the cost of isolation from these long and powerful wavelengths, it is very difficult to build the proper wall to keep this energy at bay. Every low frequency Db costs lots of mass and money to isolate oneself from. It would be better cost wise to consider another location if you have to deal with too much low frequency energy in your room.

Step # 5 Inside Our Room

If you are in an office environment and need to absorb excess voice and office equipment noise, you can use standard sound absorptive technologies. Sound absorbing foam can be used along with sound absorbing ceiling tiles. Drapes can cover office windows and special builds can be created to control and mange equipment noise. Even a couch can be an absorber.

Recording Studio

If you are recording a band within your room, you will need to manage and control the full frequency range of sounds. Drums produce low frequency energy and that energy must be managed, so that the microphone picks up and thus records the drum sound the engineer wants. Absorbing excess drum sound means less room sound or more depending on what the producer thinks the drum part calls for. Excess low frequency energy within a recording studio is usually unwanted and specially designed and positioned low frequency absorbers must be used.

Vocal Rooms

Our vocal rooms are usually located within our studio walls. There is a reason for this. Vocal rooms are a room within a room. This is an ideal method for achieving sound isolation. They are full of sound absorption and diffusion technologies to manage the sound energy within the vocal room itself. The studio provides the barrier or shell to keep outside noise outside. Usually a balance of sound absorption and diffusion technologies are used inside a vocal room.

Must Follow Steps

How to sound proof a room must be approached in a series of steps that you must follow in the order listed above if success is to be achieved both inside and outside the room. You must employ barrier technology to keep unwanted noise out of your room and then you must use sound absorption technology to soak up excess sound energy that is generated within your rooms from sound sources such as instruments and vocals. One must measure how large of a noise problem, both inside and outside your room, and construct the proper barrier to mange this unwanted energy effectively. Once you have your numbers, you can design and build the proper structure that will accomplish your acoustical objectives without draining your financial objects.

* * *

Ways To Increase Existing Wall Sound Insulation

Barrier Technology

When we look at our existing walls in our sound rooms, whatever the type of room we are in, we need to keep in mind that we are dealing with two very different processes. We have to keep the sound that is coming from sources outside our room, outside where it belongs. We also need to keep the energy created within our room, inside our room where it belongs. We use barrier technology to keep energy out of our room. We use sound absorptive technology to manage the excess sound energy within our room.

Reflection Vs Absorption

Only three things can happen to sound. It can be absorbed, reflected, or diffused. It is sound reflection that we are concerned about with any barrier technology which is the term for the technology to keep sound out of our rooms. Mass in our structure reflects sound energy back to the source it came from with our barrier technology. Mass through weight increase will help us to produce a surface that will reflect sound back to its source, so that it will not enter our room where we only want to deal with the energy we produce within the room.

Mass Is Friendly

Mass is our best friend when it comes to barrier technology. Mass can take many forms. It can be drywall, plywood, concrete, or even lead. Density or the weight of any material per square foot is the number we need to look at. The higher the number or the greater the density will give us isolation properties against sound energy of all frequencies. The lower the frequency, the greater the mass we will need to stop it from entering our room. If your studio is next to a highway, drywall will not stop the traffic energy from entering your room.

Air Is Good Barrier

Air is also a good barrier element. If we take two walls of a certain density and add an air space between the two walls, we can keep more energy out. A 4″ air space is the minimum. A six inch air space between two walls is a better starting point. We also need to make the mass of each one of our two walls different in order to alter the vibrational signature of each wall to keep the vibration transmission of sound energy “confused”. Placing insulation type material in the air space between the walls will also increase the sound transmission loss by reducing internal wall resonances.

Staggered Studs

If we use staggered studs to support our walls, we can gain another advantage. Staggering the studs breaks up the vibrational paths that the energy can take. If sound energy from the outside of our room strikes our barrier, it is changed from acoustic energy to mechanical vibrational energy. By staggering the studs, we keep the vibrational path ways uneven in position and placement and this unevenness will disrupt the vibrational energy flow’s pathways.

Resilient Strips

Resilient strips follow this similar thinking. A resilient strip is another way to alter the vibrational pathways and create a new barrier asset. If we use another layer of drywall to attach to an existing layer, we can use a resilient strip to place between each layer of drywall. A resilient strip will attach itself to one wall and then the other. The strip will also add a small layer of air between each layer of drywall. The combination of the resilient strip and the additional air space will establish another multiple layer of defense from vibrational assault.

Wall Cavity

Inside our dual wall cavity there will be an air space separating each wall. Each air space has a length, width, and height. It is a small room by itself. It will produce the same sonic issues as a regular size room only on a smaller proportion. We will have to deal with those issues accordingly. If we fill the space with sound absorbing technology, we can control those issues. Our goal is to create a wall that keeps unwanted sound energy out. Our goal is not to produce another sound generating source, especially one the size of a wall.

Acoustical Sealant

Sound can leak through any opening in our structure. Sound energy is like water. It will find the smallest opening to enter and come through. All edges of our material that touch another surface must be caulked or sealed. The proper sealant must be used. It must dry when applied but not dry completely, it must be pliable so that expansion and contraction of our wall surfaces can be allowed to occur without breaking the seal surface to surface contact. There are many quality acoustical sealants available for this important task.

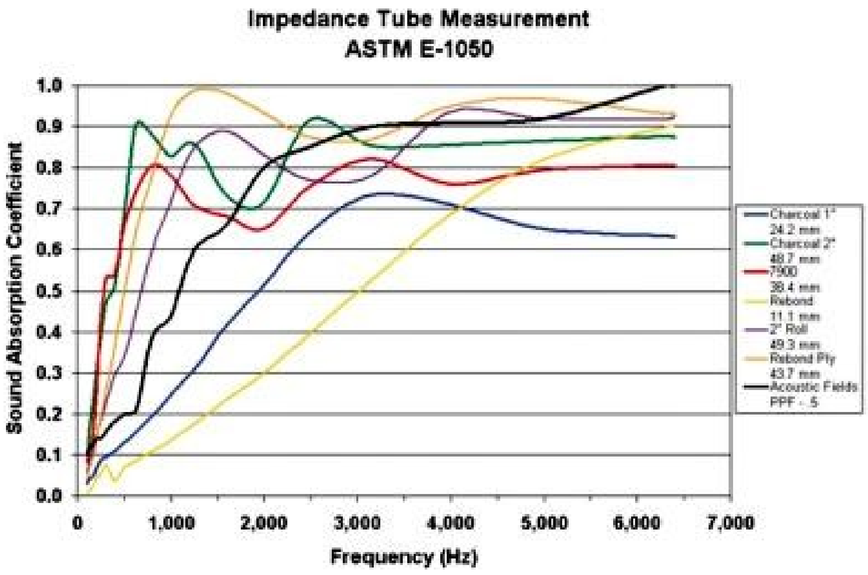
Doors And Windows

Doors and windows must be given the same care and attention as our walls. Just as we used double walls with airspace between them to increase our STC or sound transmission loss number, we must use double and triple pane windows to isolate our sound energy. Laminated layers of glass will go a long way to reduce the vibrational energy that sound energy generates. Laminated glass is the same glass we have in our windshields. Each layer of glass is separated by a layer of plastic. Our doors must be solid and be sealed correctly, so that no sound energy can leak in or out of our room.

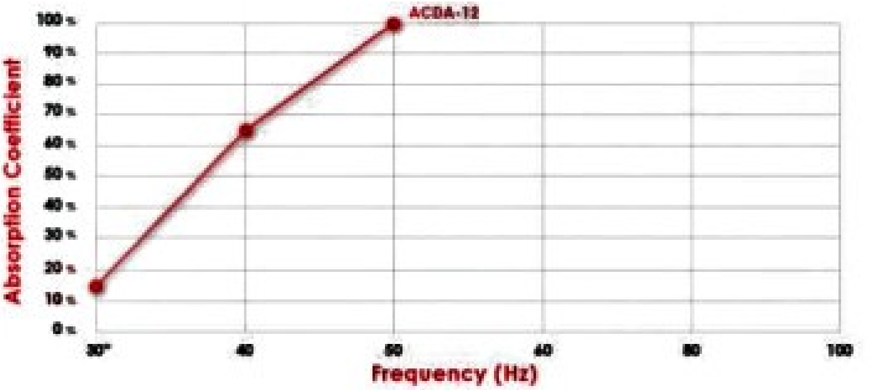
Barrier / Sound Absorbing Technology

Mass and air space can assist us in our sound isolation efforts. It is the two working together that creates a good barrier combination. In order to determine how much density and what type materials we need to use, we need to know how much noise we are dealing with from the outside and how much energy we will produce on the room inside. We need to also keep in mind that any energy generated within the room that leaves the room will be reflected back into the room by our barrier technology. Care must be taken inside the room with sound absorbing technologies to minimize any energy leaving the room and striking our barrier shell.

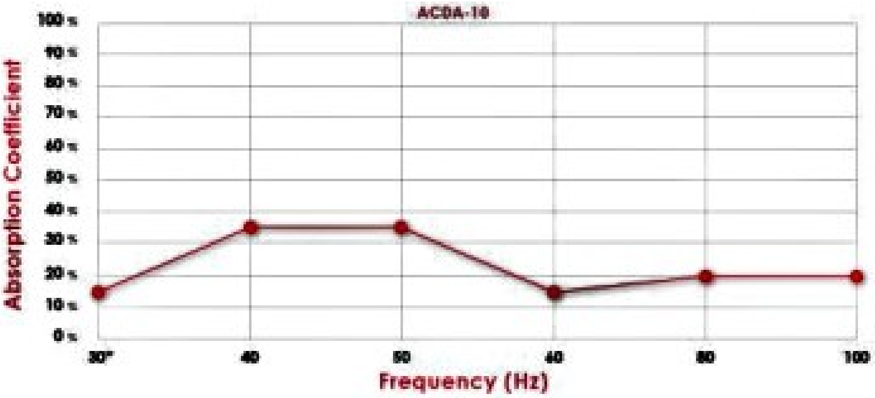
Acoustic Fields' Foam



ACDA – 12 Activated Carbon Riverbank Labs Test Results



ACDA-10 Activated Carbon Riverbank Test Results



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