Sound Waves Vs. Sound Rays And How They Apply To Room Acoustics
Listen To Your Music...Without Hearing Your 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:

www.acousticfields.com

or through select, online book retailers.

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Advance Praise for Sound Waves And Sound Rays

Listen To Your Music...Without Hearing Your 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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The Acoustic Fields activated carbon diaphragmatic absorbers are generous in bass, but also tight and they've softened the mids and the high's in a way that I can only say was just kind of amazing, magical really.

I don't really understand how you achieved it but I do know that you achieved it and I think the part of the signature sound of this technology that you've created, is the decay of the low end is smooth but its generous.

It's been an absolute total success here and everybody who comes in to hear the room, especially the heavy hitters, they're blown away, they're blown away and like I said it's not just the mix position but the client couch is very tight and accurate.

Dennis you know I can't thank you enough for inventing this technology and believing in it and propagating it and helping Joe all the way across country get it together in this room. And all I can say is the proof really is in the amazing response in this room and this response I'm getting to the room which is just across the board, people are just blown away.

So just wanna thank you and hopefully this will serve a little bit as a testament to those who are either building new rooms or have been sitting in a room with low-frequency problems and knowing what they're missing but not knowing what they're missing because this technology was very clear and straight forward to set up and it worked instantly.

Testimonial from Daniel Wyatt, Multi-platinum, Grammy and Emmy-nominated producer/engineer and senior instructor at Dubspot www.dubspot.com New York City.

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Foreword

My name is Dennis Foley and I'm the owner of Acoustic Fields. We are a specialist small room acoustics company. I’ve been an Acoustic Engineer for over thirty years. I’ve had products in Electric Ladyland Studios, Sony Music in New York, Mark Levinson at Cello Music and films, Saltmine Studios here in Mesa. We’ve done a lot of testing over the years and we've refined our technology to the point where we’re pretty comfortable in our small room acoustic domain. Low frequency absorption is our main game, that’s what we’re all about. We also have a smooth absorption curve with our proprietary acoustic foam so that’s another thing we can discuss later on.

Our Acoustic Foam in action at Javier Weyler’s Beat Factory studio in London

You’re probably reading this today because you don’t have a solution to the room acoustic problems you're facing. You probably have something in your room that’s really bothering you and it’s probably low frequency pressure because that’s mainly the issues we have in small rooms. Trying to fit long wave lengths into our little boxes, as our rooms get smaller and smaller because prices keep going up.

So, we need to pay close attention and here’s what we’re going to cover in this paper:

1. We’re going to cover the current technologies that are in the marketplace.

2. We’re also going to cover how to apply those technologies to solve your room acoustic problems as some work and some don’t.

3. We’ll try to clarify a few of those things for you and there’s a process that you must go through in order to treat your room modes. These are the pressure areas, the low frequency pressure areas that are giving everybody all these issues and problems. There’s a process for locating them, there’s a process of hunting them down if you will and I’ve made a video to show you how to do that (more on that later).

4. If you really want to push the envelope and go a little further, I’ll even show you how to build a solution into your room.

People generally don't invest enough in room acoustics

As a general rule, people don’t have a lot of money for acoustics. They spend their money on gear and I get that, you know, I like gear too. We've got to have speakers, we've got to have amplifiers, we've got to have converters, microphones, etc. So I understand that, but it’s also true that you need to address your room acoustic issues because they account for more than fifty percent of what you’re hearing in your room (speakers and amps can take the rest). Think about that for a second. Room acoustics make up more than fifty percent of what you hear in your room and yet most people never treat the problem. That's like buying a Ferrari with no wheels! It's crazy.

Even more worrying is how even the people who do make a decision to buy acoustic treatment get it wrong and this is for two reasons:

1. A lack of understanding, and

2. The way certain manufacturers take advantage of this lack of understanding to sell products that won't fix the problem...This is the one that makes me incredibly angry! And hopefully, by the end of this paper, you'll be on the road to understanding enough about the physics involved in room acoustics to make informed decisions.

Budget Is Not An Issue

Even on a small budget we can find solutions if you build the right technology for the right problem. You have to match the technology to the problem, that's what we're going to try to do a little bit of in this paper so that once you're done reading it, you're going to be able to explore different solutions to resolve your particular problems but in order to do that, I want you to think seriously about three things:

1. You must be actually willing to solve your acoustical problems and not live with them. So many rooms I go into, people are just constantly working around the problems and you really don't have to do that. You really can solve them. It's not trial and error if you apply the right technology to the right problem.

2. You need to push through your comfort zone a little bit and learn enough about room acoustics to really tackle the problems you face. To that end I have made a tonne of instructional videos for you to watch on our YouTube channel at www.youtube.com/acousticfields to help you with this. We have instructional videos on everything that you need to do. Also if you go to www.acousticfields.com/free-ebook you will free have access to my step by step instructional

videos so you can hunt room modes. What are room modes? Read on and all will become clear. So make sure to go there and subscribe right now so you can immerse yourself in those videos.

3. Don’t let self-doubt get in your way. These are problems you can solve so long as you do your own thinking and don't buy into some of the myths certain manufacturers perpetuate in order to sell products. No square peg in round hole solutions my friend. Get wise to the problem and then find a solution that actually solves that problem.

So let's get you started.

How did I get to where I am today?

I was fortunate to become a partner in a real estate development firm that was concerned with building high-end office buildings. Now, when I say high-end, I mean really, really high end. We had to have very quiet rooms. Some of the walls were twelve to fourteen inches thick. Doctors, lawyers, things like that, they wanted me to design rooms that made them stand out, so that when people walked into the rooms, they would immediately be taken by the acoustics of the room and as that would obviously be a big selling point to impress potential clients.

We tried a lot of things that were in the marketplace but I could never find anything that was really acceptable especially in the low frequency absorption end. If we were using our room for music, we needed low frequency control. Obviously if it was just a conference room we were using it for voice and so we needed middle and high frequency control.

So I was given a team of eight guys, a bunch of money and eight years for me to figure all the solutions out. I bought three homes with the money. The middle home was the home that we used as our testing facility and we would build rooms, measure them and then tear them apart on an almost daily basis. We built different sized rooms that would resemble the rooms that we were going to be building in the office complexes. In all we built around four thousand offices over a ten year period. So from that we amassed a huge database of over a hundred different rooms of different sizes that were actually physically built and acoustically measured.

So, without being too boastful here, I could probably say that we have a room that's really close to the room that you're in and I can pull it up on the screen and know exactly what kind of issues you're faced with because I've built that room, stood in that room and treated the issues that you are facing. There is no substitute for practical, in the field experience, over textbook learning.

The Magic of Activated Carbon

Our big success came when we stumbled upon using activated carbon for low frequency absorption. It's kind of a fun story. You see the frustration with small rooms is the low frequency pressure problems they create. People have put up with the problem for far too long. I've talked to a lot of audio engineers over the years who just simply accept it. They just accept that you can't control bass in your rooms because the rooms are too small. Well, yes the rooms are too small but there are ways to deal with the problem.

You can't work around them all the time and you can't ignore them for there's really no reason to do that. If you've purchased products from other manufacturers and installed them and been unhappy, I can understand why. I did the same thing when I built the office buildings! I bought current technology and installed it and was unhappy. So, believe me, I can understand you're frustration.

What is the problem in small rooms? It's that muddy, bloated and blurred bass, we've all heard it. Some people call it bass boom. There are all kinds of names for it. It's quite honestly disgusting and it's just not acceptable because it has so much energy and it covers such a wide range of frequencies from 20 Hz. - 100 Hz. that you will never be able to hear clearly if you do not manage your room's low end. There's a lot of music in that particular frequency range.

Well, if your room is not set up to handle those low frequencies or treated accordingly to handle them, they'll blur your middle and high frequencies and you know that you just can't have that because that's where your emotional connection to music is and hopefully you're trying to emotionally connect to your music. So if you're not experiencing enough hairs on the back of the neck moments for your liking, this could be partly why.

It's that musical connection we all want in life and that really only comes about when all the acoustical issues of our room are in balance. Namely, our listening position is at the right distance, our speakers are at the right distance and our acoustical issues are all addressed with correct room dimensions and treatment. If you're going to achieve an emotional connection to your music then those three issues need to be resolved.

The above image shows us installing the carbon into the stud spaces of a recording studio wall.

So I took the technology that I put in the office buildings and I said "look let’s build a bass absorbing unit that people can put in their room". So I worked for a couple years on taking the rigidity that we had developed in the new construction situation and measured that for vibrational analysis and then came up with a cabinet that basically duplicated it within about ninety percent of the vibrational characteristics I had in a permanent building.

We can’t all build walls in our rooms so we have to have a unit that’s free standing and easily positioned to do that, so that’s what we’ve done with our ACDA units. They have seven layers of materials in them and they have different damping materials between each layer. So it’s a serious cabinet. I mean it literally does not move, it does not vibrate. It forces all the vibrational energy to the front two walls of the cabinet.

The way I found the activated carbon which gives use units their low frequency absorption horsepower is a bit of a funny story. I was in the office one day and I saw the light flashing on the filter on the faucet. I guessed it was time to change the filter, I tried to unscrew it, I couldn’t get it unscrewed so I shook it and I could hear something on the inside. Since I couldn’t get it open, and I needed to figure out what was going on, I hit it with a hammer and out came all of these little pellets and I started looking at them and they looked like little meteors.

So I started doing some research on activated carbon and I discovered that people were using it to filter water and they were using it to filter air. Well sound is found in both mediums, air and water, right? Then I started looking at the surface area of this stuff and, I know this will look like a misprint but it’s true, there are two thousand square meters of surface area per gram of this material! So what did I do? I put sixty five pounds of it in each of our units. So that will kind of give you a feel, a kind of ratio, of how powerful these low frequency units are. They’re without a doubt, the most powerful absorbers in the world.

I will tell you this, they’re without a doubt the heaviest in the world too! An average two foot by four foot unit is two hundred pounds. So this is a real serious technology. No papering over the cracks.

What's the end result of all this?

Your middles and highs just literally jump out. There is a definition and a separation when you get the low frequency issues, found throughout your room, under control. They can even be close to the center of the room. Obviously they're more prominent towards the room boundaries but they are everywhere in your room and not just the corners. I know the literature is full of all kinds of references to put your low-frequency absorption in the corners and I would say that's a good start but that location is not the only place.

There's a feeling of intimacy that you get when you get all of these issues coming into place. When you get the low frequency energy in a room under control so that the middle and high frequencies can ride smoothly on that low-frequency energy, so to speak, there's a nice balance to your presentation so you can hear everything. And my favorite moments are always when I am able to sit with an audio engineer at the conclusion of a project, hit the play button and watch their response. It's like a fog is lifted from their presentation and a real nice "ah ha" moment occurs... I can always tell by the insanely large grin! That is what happens when you take the room out of the way so you finally hear what your monitors and speakers are producing but which you couldn't hear before.

OK so anyway enough about me. Let's get you started understanding how you hear what you hear, how the room affects that process and how you can get the room out of the way. There's going to be a little physics involved but before your eyes glaze and you turn your Kindle off, I promise to make it real easy going and not get too involved. I try to explain concepts using simple analogies so you don't have to put on a lab coat and glasses to understand. It's all nice and simple stuff to ensure you are armed with knowledge and wisdom to finally experience all the beauty in your music which your room messing it up!

Let's go.

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CHAPTER 1

Understanding Waves & Rays

Sounds are made of waves and rays. Those are the two basic kinds of energy we're dealing with. Long waves, short rays and we need to really understand those two types of energies before we go any further with acoustics.

Nikola Tesla was a great physicist. He thought about things in terms of waves and energy. He said that if you want to find the secrets of the universe you should think in terms of energy, frequency and vibration. Well this certainly applies to the way you should think about room acoustics.

Waves are anything below one hundred cycles (Hertz/Hz.). Now you'll see different break points in the literature but for purposes of this discussion and applying acoustical treatment to the issues you will find, we're going to stay with a hundred and below because we can solve frequency issues at a hundred and above relatively easily.

So 100 Hz. and below are real long waves. Think of them in terms of ocean waves, a big swell starting far out in the ocean. A thirty cycle wave is thirty seven foot long. They're the most problematic of all because they don't want to fit in small rooms and, let's face it, thirty seven feet...none of us have rooms that big. What happens when things don't fit in confined spaces? They create pressure (think trying to fit into the clothes you used to wear as child... not a pretty sight!). In room acoustics, that pressure is called modal pressure or room modes.

Now rays, on the other hand, are much shorter wavelengths. They're greater than a hundred Hertz. So think of a 1,100 Hz. wave as being about a foot long. As a result, these guys contribute to different room acoustic problems, namely reflections, comb filtering, speaker boundary interference effect (SBIE) and poor diffusion. We'll look at all of these terms, what they mean and how they affect you when mixing or listening to music in the coming discussion.

Sound pressure

I did a wavelength calculation, which you can see in the below graphic, and that will give you some idea of the length of some of your low frequency waves. If you don’t have a room that’s at least as long as the 40 Hz. wave requires, you’re going to have issues. And who does have a twenty-seven foot room? I would love to have a 36 foot room even a 55 foot room but most of us can’t afford that kind of real estate.

WAVE CALCULATIONS

20 Hz. : 1,100 / 20 = 55.00'
30 Hz. : 1,100 / 30 = 36.67'
40 Hz. : 1,100 / 40 = 27.50'
50 Hz. : 1,100 / 50 = 22.00'
60 Hz. : 1,100 / 60 = 18.33'
70 Hz. : 1,100 / 70 = 15.71'
80 Hz. : 1,100 / 80 = 13.75'
100 Hz. : 1,100 /100 =11.00'

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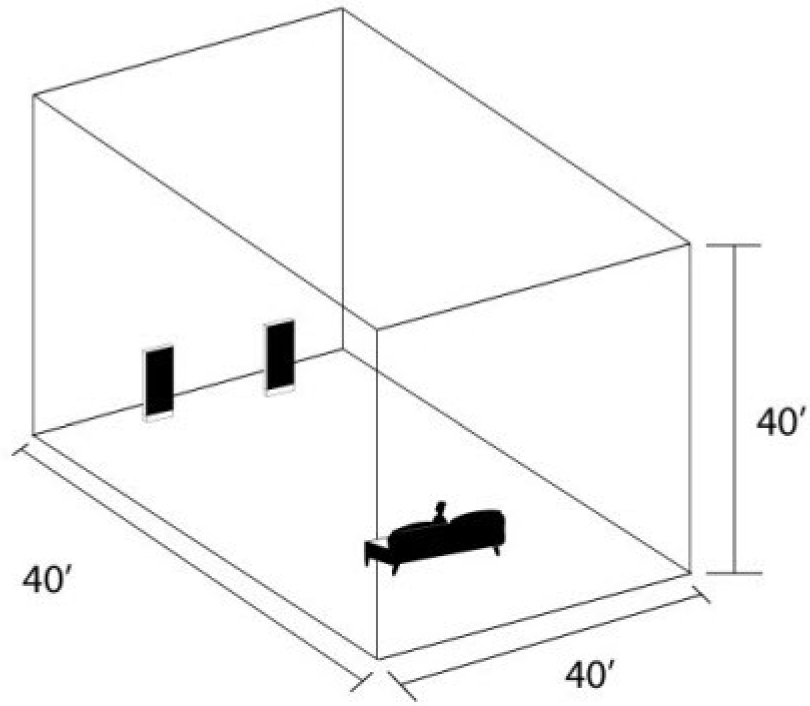
An ideal room, if we were going to have thirty cycles, would be 40 foot in every dimension as shown in the below graphic. That’s really ideal.



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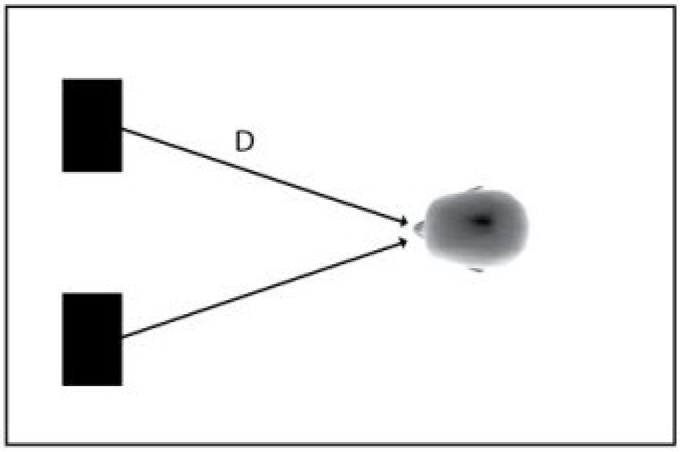
Now with the rays, the three reflection points for middle and high frequency absorption treatments, you have to look at those reflection points because those contain a lot of information.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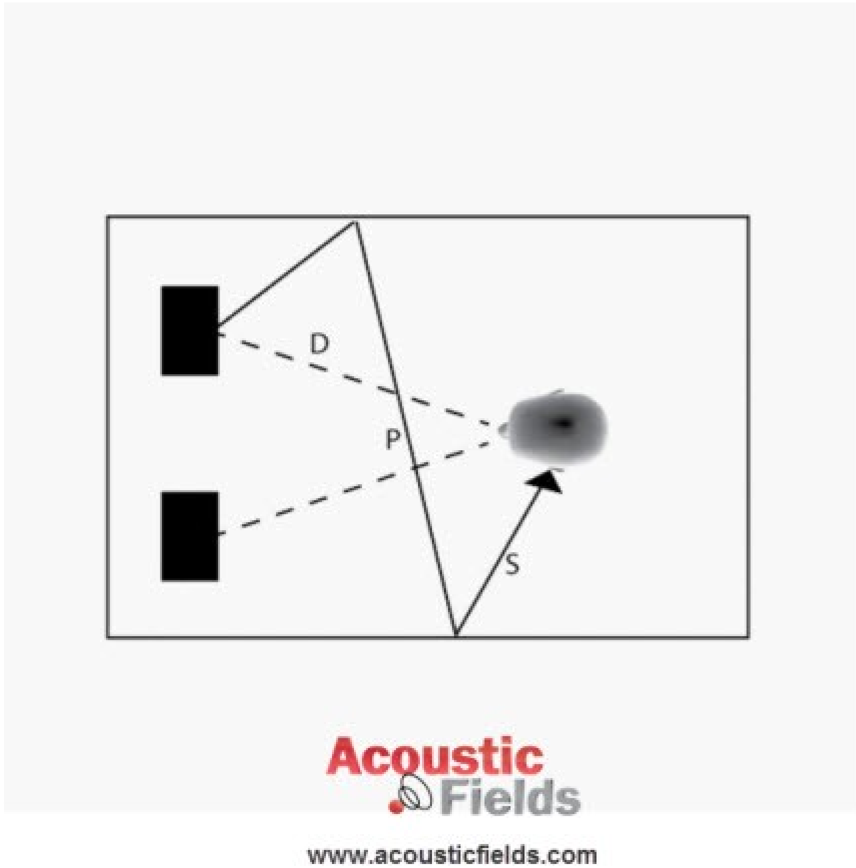
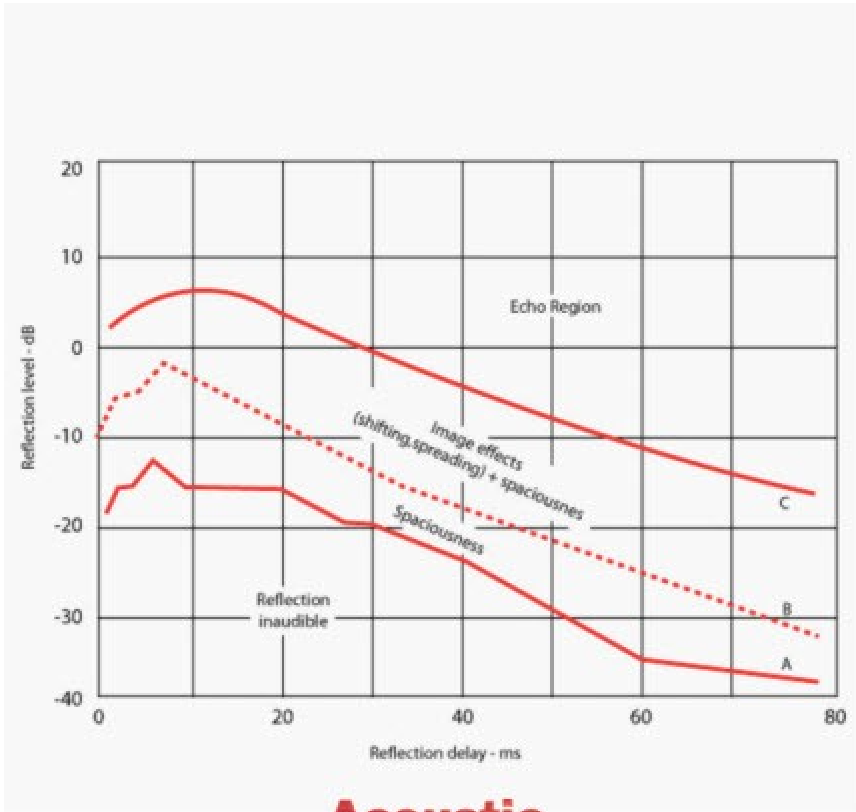


There is a shifting, there's imaging, there's spreading, there's spaciousness all in that time delay from the reflection point to the listening position. That all needs to be addressed and has to be done at the right rate and level too, so reflections are critical.



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Room Distortions

There are four major room distortions that we need to talk about. There's:

1. Room Modes: These are powerful pockets of energy that cannot get comfortable within the chosen dimensions of the room they are placed in. Low frequency energy has long wavelengths that can reach 37' for a 30 Hz. wave. How is that long wave going to fit into a room that has as its longest dimension, 12'? It will not and when it does not, the part of it that does not fit will express its discontent by creating areas of high and low pressure. These varying pressure areas are located throughout the room and must be located and treated before any speaker has a fighting chance at any type of response.

2. SBIE or Speaker Boundary Interference Effect: can occur when a speaker is placed too close to a room boundary surface. The speakers send out energy and it strikes the nearest wall surface exaggerating some frequencies it produces and completely smothering others. This improper location can exaggerate the low frequency response curve of any speaker and cause 1 – 3 dB increase in certain low frequencies no matter how smooth the speakers response curves are.

Finding the correct distance from the speaker to the walls is always a time consuming task but must be calculated correctly to achieve any resemblance to a smooth frequency response curve. You've got to be very careful with the speaker location and try to figure out the best location in the room. Moving it an inch here and an inch there, once you have the room acoustically treated, could make a big impact, so you have to be careful with that and take that into consideration.

3. Comb filtering: This can occur when sound energy from your speakers strikes your console or studio furniture. Reflections from furniture and consoles produce a series of back and forth reflections that occur between the object and the speaker itself. It can also occur between an object that is energized by sound striking it and then reflecting that sound back and forth between the object and a wall. This series of unwanted reflections can produce “phantom images”. These images can produce a sound of their own and the only object you need in your room producing sound is your speakers. Two speakers producing two channel energy is all that is required.

4. Poor diffusion: This is an area most people don’t realize with small rooms. Small rooms really need to act like big rooms because big rooms have a lot more diffusion. So we have to add diffusion to our small rooms. A lot of rooms that you’re in are too dead, they’re not realistic and that’s because there’s poor diffusion.

Since space is limited you have all of this energy smashing into each other with no real acoustic purpose in mind. With poor diffusion, sound quality has no life to it. It is smothered in numerous reflections that are just responding to the boundaries or walls that they strike and then enter haphazardly into the room. This juxtaposition of reflected energy just causes more issues that confuse speech articulation and wreak havoc with your enjoyment of music.

Matching Correct Treatment To Your Acoustical Problems

If you need to address low frequency problems, the current free standing absorption technology in the marketplace (and I'm not going to mention any names) don't have the required rates and levels to deal with the room mode pressure issues that you face today. They claim to achieve certain rates and levels which will help you but I have tested all of them and they just don't. If they had worked as promised, there would have been no reason for me to create the technology that I created which all really came about because I was so unhappy with putting numerous units in the room and not having any real results from them.

Low frequency is where it's at. You must control low frequency if you're going to do anything else correctly in the room. Acoustic foams and building insulation, otherwise known as bass traps, just don't have enough horsepower down into the low frequency range.

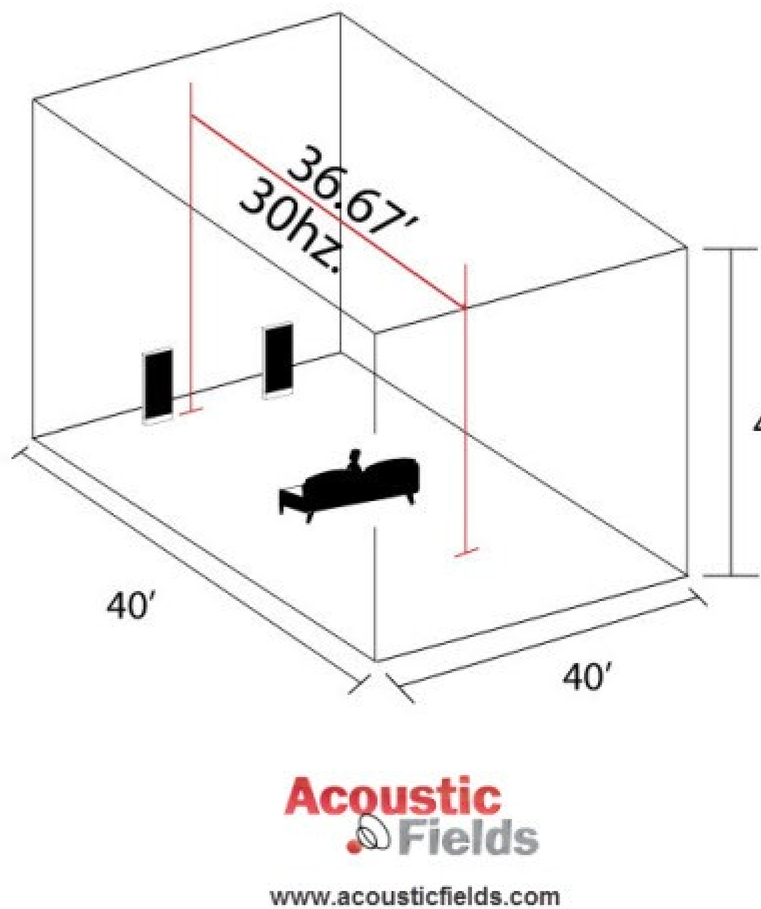
John Storyk, a real famous room designer for WSDG, claims that low frequency in small room starts below 80 cycles, that's where all the fun is and he's right. As an audio engineer, producer, musician or DJ, you really need to focus on the low frequencies because our rooms are getting smaller and the guy who can figure out how to make low frequencies work and sound good in small rooms is going to have a good future ahead of him.

Wave Room Treatment

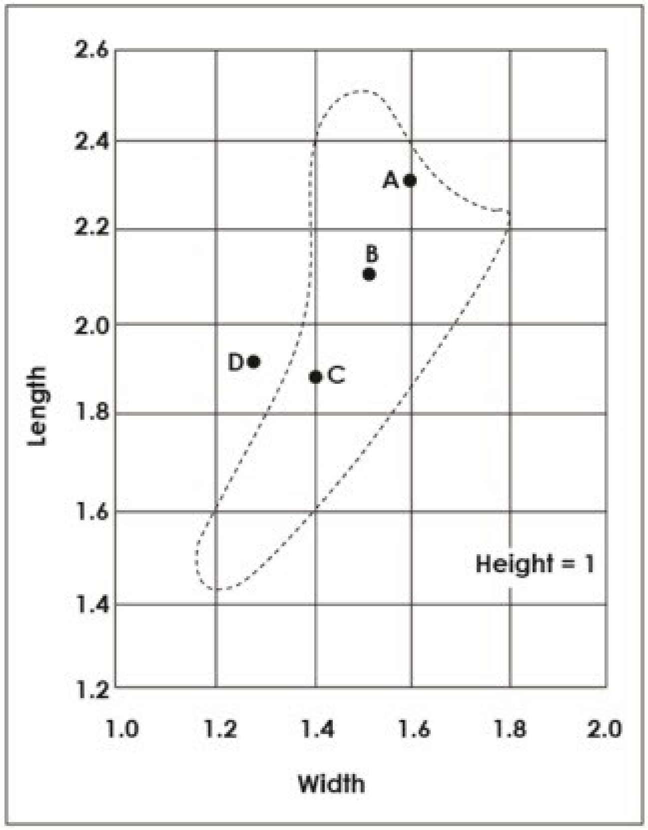
We want to minimize the pressure areas in the room. That's what we're trying to do when hunting room modes. We need to reduce their impact but you've got to do it at the right rates and levels. There are three technologies that are currently available in the marketplace to do that.

1. Helmholtz resonators
2. Membrane absorbers
3. Diaphragmatic absorption

Let’s go back to our thirty cycle room example. This size room is ideal as it wouldn't experience any pressure build ups if the dimensions were correct. As most of us don’t have such dimensions to work with, we have to come up with a balance of height, length and width in our rooms that gives us at least a fighting chance with room modes.



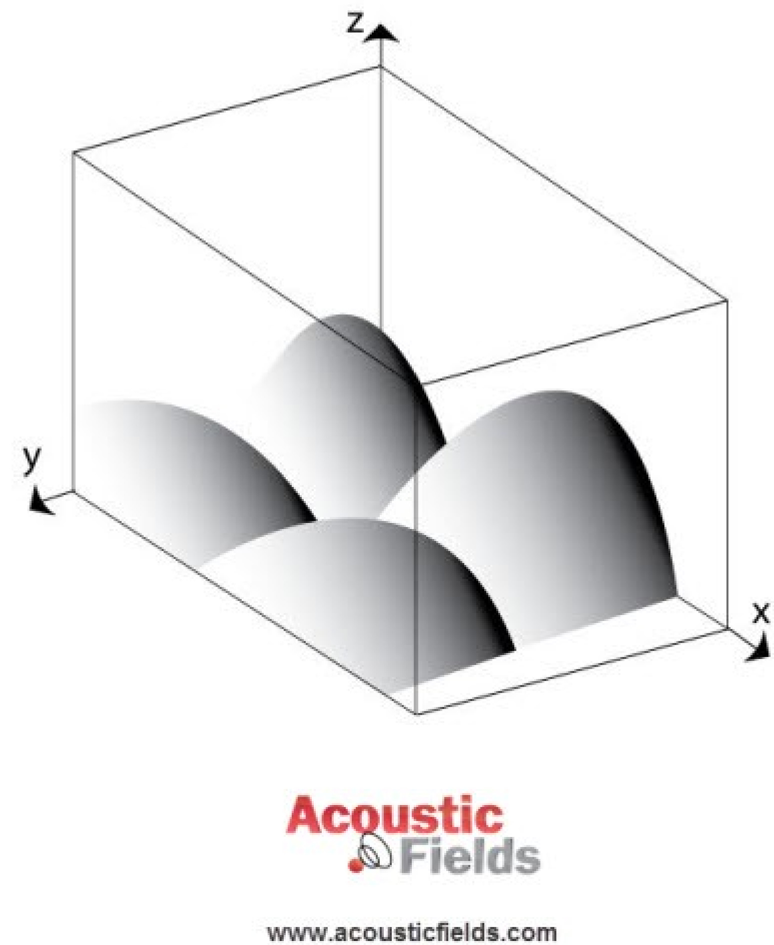
One of the physicists that has done this is called Bonella and he came up with the following graph which is a good start point if you’re thinking about building a room. I like to take these graphs that engineers in the past have done and overlay them upon the database we built up. When we do that we see some overlap, we see some similarities but we also see a few differences too. That's why there is nothing like building rooms and testing them for yourself in order to go from theory to hard earned experience and reality.



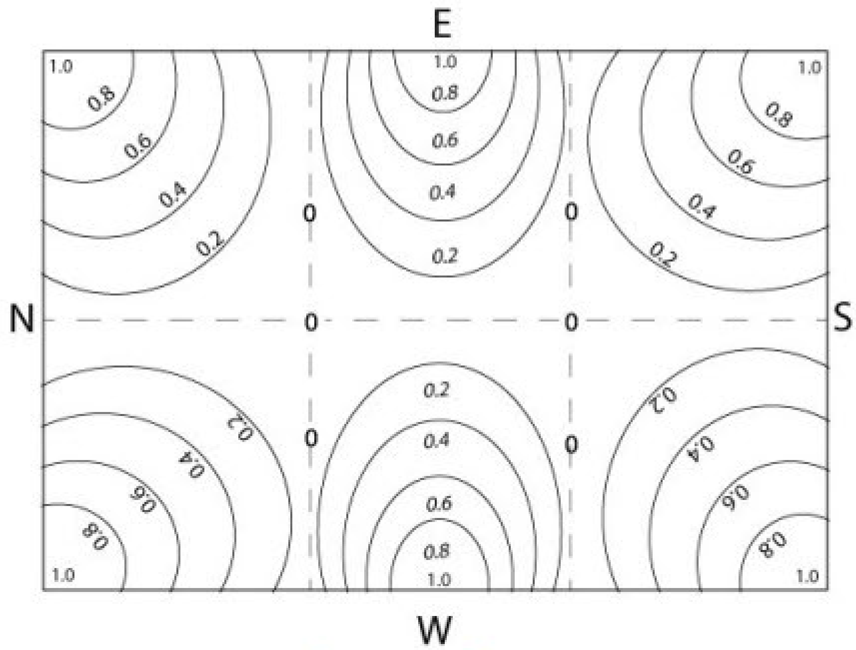
Basically if you look at the bottom index it's the width ratio, the left index is the height ratio or length ratio, and you want to try to pick a width, length and height ratio that falls within that amoeba like dotted area. So that's what you try to do and that's a good starting point. We found that the Bonella system works pretty good for a start point then we overlay that on our database, we could get you pretty close if you're building a new room.

Pressure Modes

The pressure modes we designed our diaphragmatic absorption technology for, have their own bandwidth. You have to understand that a pressure mode is an acoustic animal of its own. You have to go after it, you have to attack it as it has a frequency range it lives within. You've got to go through the front door and go after it.



It will boost certain frequencies, it’ll smother others you just have to deal with it and the following graphic shows some pressure zones in your room. Obviously you can see the areas of greatest pressure are closest to the boundary surfaces and as you work your way out you can see that they lessen.



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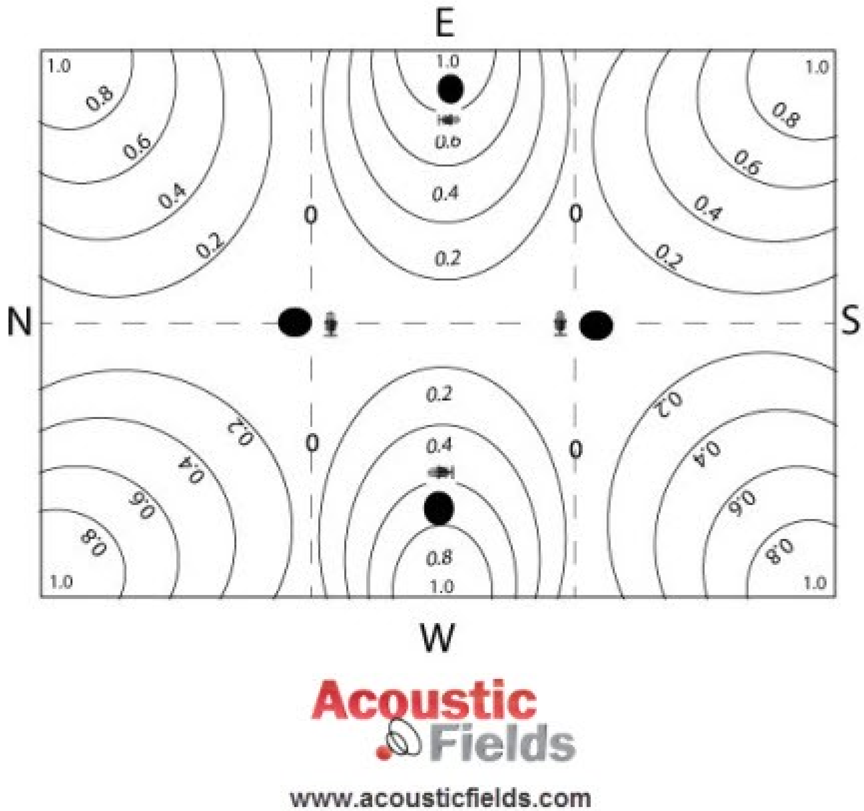
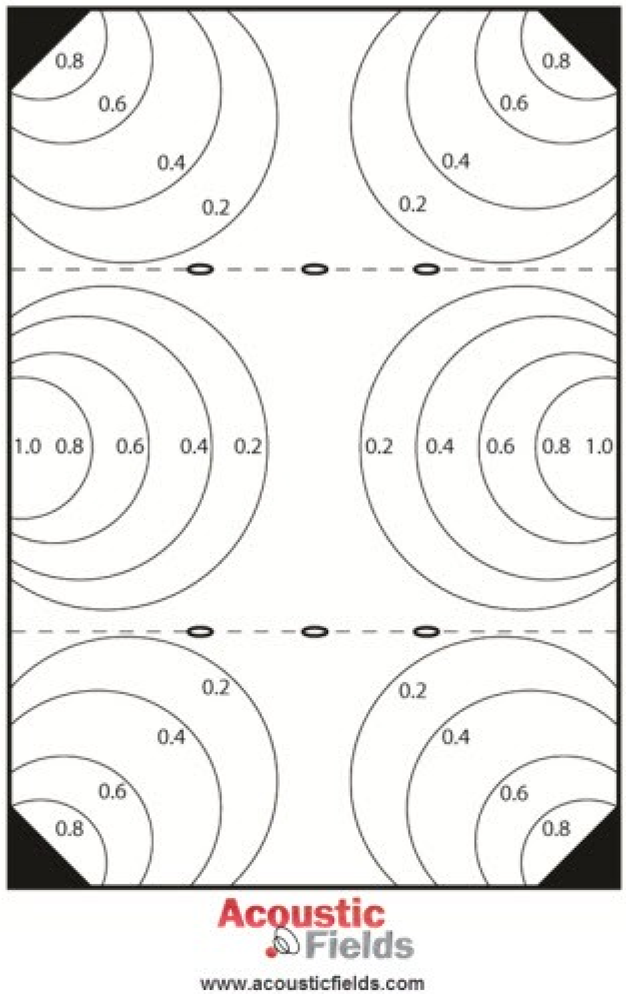
If you put a microphone in an area of high pressure, as illustrated below, you can see you're going to have blurred frequencies. You're going to have things that aren't even heard. Anybody that's done any recording that puts a microphone in a room mode knows that they'll hear certain things and also won't be able to hear others.



So it gets exaggerated. It can smother, it can be dependent on different frequencies and you just have to find those locations and treat them. If you treat the whole room correctly with more frequency absorption you'll have a nice smooth response through the whole room. Now one or two units is not going to do it, you're going to need multiple units because pressure is all throughout the room and you need to keep the units as close to the source of pressure as you can.

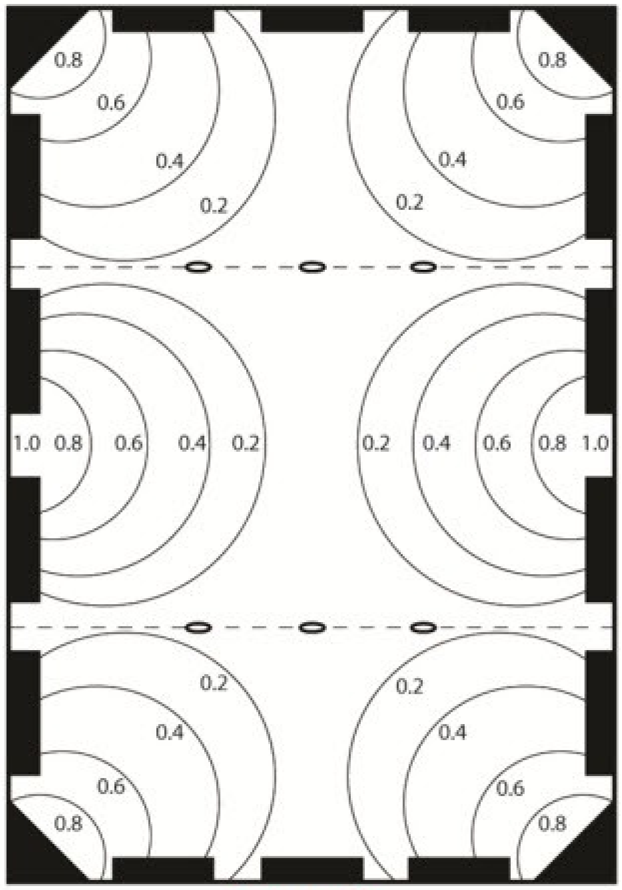
Obviously building the absorption technology into the room's walls is cool, and we do that with new build studios, but a lot of people can't do that. For example, you may not own the rooms you're in so you need stuff that you can take in and out or take with you when you move. As such, acoustic treatment needs to be elevated up to the component level as it is just as important as your speaker and your amplifier.

The following graphic shows a good placement option for low frequency that we talked about. All modes end in the corners of the rooms. Everybody kind of knows that. So you start with the corners of your room but that's not going to give you much in along the side walls in the long walls it's not going to help the pressure areas in the middle of the room.



Corner Absorbers

The next graphic shows a more realistic picture of what a professionally built studio would have in its walls. You just don't see it as its built into the walls but that's the area of coverage that one really needs to have if you're going to address the low frequency issues because putting things in the corner is just not going to deal with all the pressure issues you can see that you have in your rooms. So it needs to be spread out evenly and each unit needs to match the problem and the pressure in that particular area of the room.



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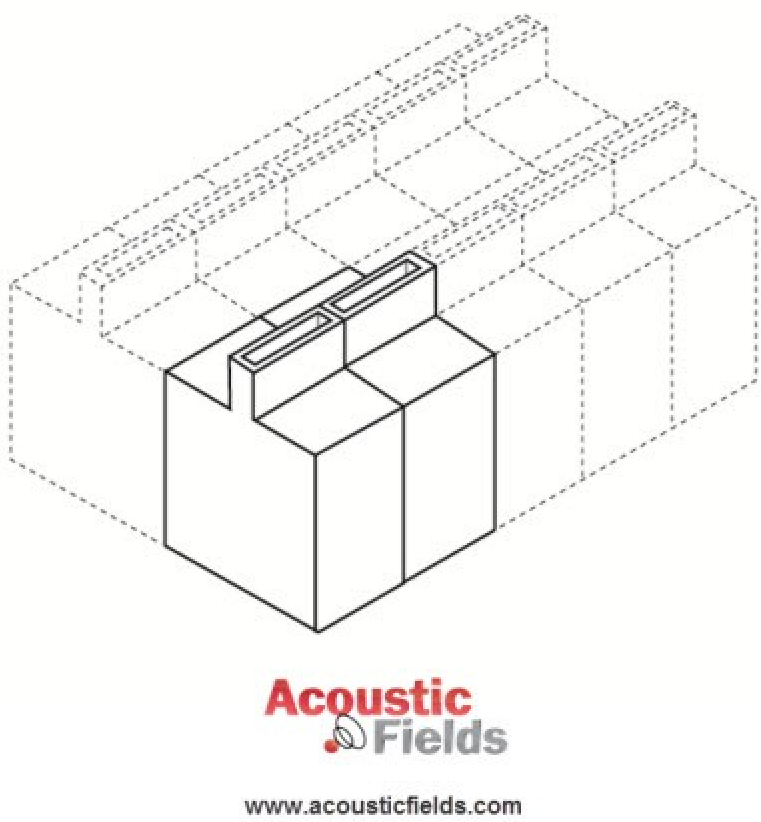
Three Types Of Low Frequency Absorption Treatment

What are the three types of low frequency absorption treatment system in the marketplace today? As mentioned above, there are two basic types, Helmholtz resonators, Membrane absorbers and Diaphragmatic Absorption.

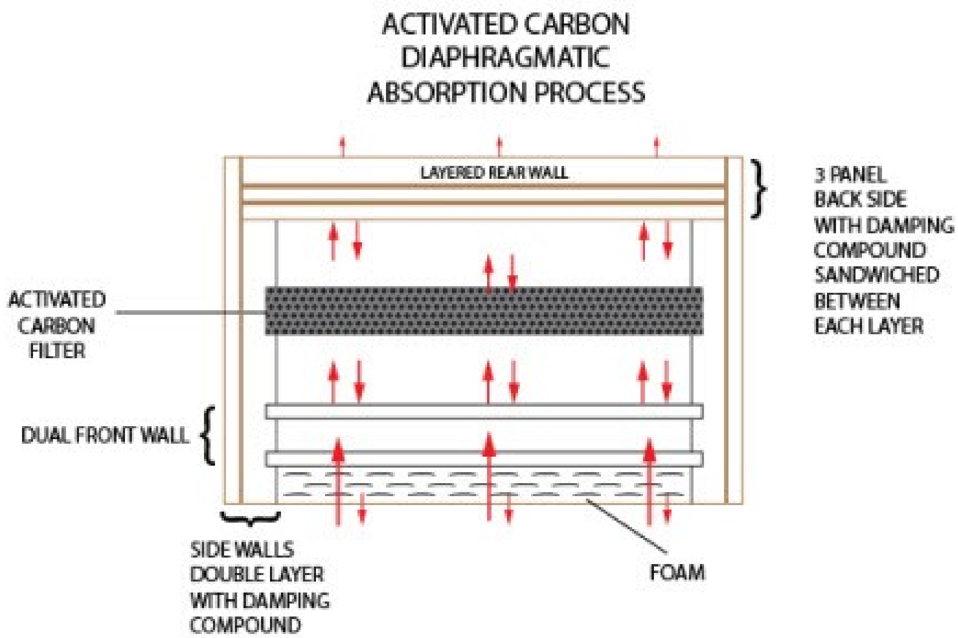
A Helmholtz resonator is really a tube or a bottle, if you will, with a slit in the top. The depth of that bottle determines the frequency at which it performs at and the depth and the slit determine the rate. You can increase the performance so they have ultra-resonators.

Here's the problem, they’re really difficult to design. The following is a picture of one. The actual dimension of the slot has to coordinate with the depth. You can get them down to point where they absorb one particular frequency or small group of frequencies really well, but they’re really hard to build, design and get right. If you don’t have the right equipment and, in all honesty the right patience, then you're going to fail. I’ve tried to build them, I’ve done well with some but they’re labor intensive, they take a long time to build and I prefer diaphragmatic absorption.



A Membrane absorber is similar to a diaphragmatic absorber in that it has a membrane that moves in sympathy to sound pressure for its front wall. It also has a cabinet that has an internal fill material, usually building insulation. Both the membrane and cabinet are made out of lightweight material. This results in low frequency levels of absorption but levels that do not have the required horsepower for today's smaller rooms. This methodology requires many more units than diaphragmatic and so can leave your room cluttered and without an acceptable absorption performance.

Diaphragmatic absorption is a lot different, it's a sealed unit so we don't have any slits, we don't have any holes. Low-frequency waves don't need a hole or a slit to go through into the cabinet, they just go right through the cabinet. They don't really have any qualms about leaking anywhere for, as you well know, when someone is in an adjacent room where there's a lot of low-frequency energy, it bleeds through.



So a diaphragmatic absorber is a sealed unit with a specific depth, a specific cabinet density and a specific cabinet fill material. Those are our three variables when we're using and building a diaphragmatic absorber. We have a formula which is 170, which is a constant divided by the square root of the density times the depth. So that's a good start point, would give you an idea of the resonant frequency of the cabinet. Obviously every frequency above it will absorbed and everything below it will be not absorbed.

Our ACDA 12 unit – the most powerful free standing bass absorber in the World.

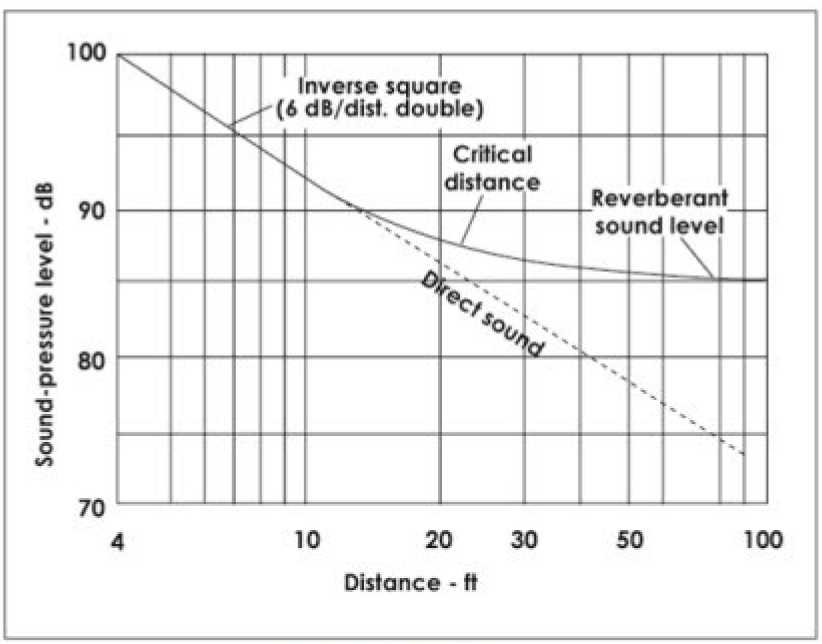
In Chapter 4 I'll show you how we effectively hot roded the Diaphragmatic Absorption process to create the most powerful bass absorbers in the market with a test sample size that absorbs 100% at 50 Hz. and 63% at 40 Hz. That discussion will help explain why boxes filled with building insulation, otherwise known as bass traps, are really nothing more than cosmetic. If you have a serious pressure problem, and all small rooms by their nature do, then you need a serious acoustical tool to manage the problem. After all if you've ever seen ocean waves crashing into a sea wall you'll know why they build those walls with stone and concrete and not just pile up a bunch of wooden boxes and tie them together with straw and hope against hope that they stop a town being flooded. Well the same applies to the management of low frequency energy in your room.

Rays And Reverberation Times

Rays are our shorter frequencies in length, higher frequencies in number and you have to manage these reflections in the room. You just simply do not have a choice because reflections are not real. They're almost like another image all by themselves and they can create phantom images and things like that so you want to be really careful with reflections.

You also want to be real careful about how you manage them. What are your choices? Absorption and diffusion. You're trying to bring the reverberation times down from reflections because you have side wall reflections, you have rear wall reflections and you have ceiling to floor reflections.

So if you think back to the graphic which showed all the pressure readings for low frequency, we have a similar kind of issue with reflections as displayed below.



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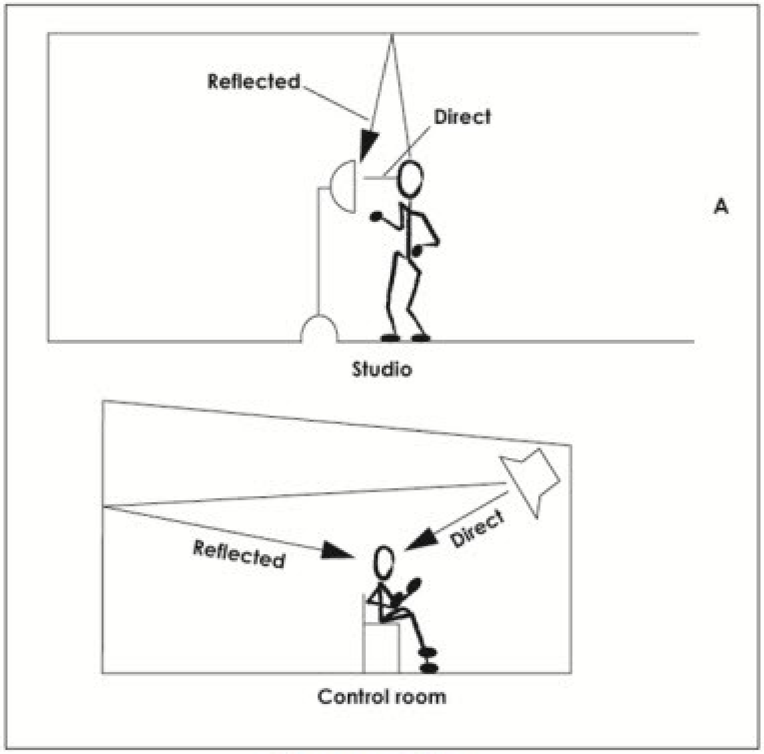
They're found throughout the room and you have to treat them accordingly. To get a handle on the reflection issues you're facing in your room, there's a cool thing that you can do to test for yourself and it's called critical distance. To understand the room acoustics of your particular room, set up your speakers, your two channel system as best as you can in the room. Divide the room into thirds, locate your speakers in the first third and then get your chair and move your chair back and forth forward towards the speakers and back towards the back wall. What you'll find is there's a critical distance there where the direct sound and the reverberant sound field are kind of even and matched and you'll hear that and you'll feel that.

That shows you how important a little positioning of the chair is within the room. So if you have to be that critical about where you sit within your room so that you can hear everything, you must be that critical about the technologies that you use to solve the issues you find.

Direct Vs Reflected

Obviously the direct versus the reflected energy is critical. You want a nice balance between direct and reflected energy. That's the goal of anything that we're trying to do acoustically.



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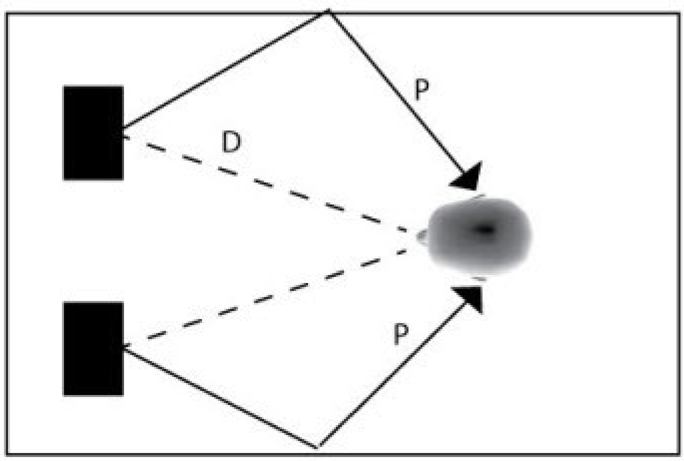
Absorption is one way to do that but when we absorb we change the energy form to heat. Once we change it, it is lost forever so we're losing energy in order to manage it. I think that's acceptable to a point but you have to be careful. You've no doubt been in rooms where you experienced over absorption and those rooms are not nice to be in. I was in an echoic chamber the other day, and oh my God I don't think I could breathe correctly. I mean it just throws everything off.

So reflections are really critical but you have to manage them in your music rooms if you're going to get out what you need to get out of them. If you're going to make livings in them, if you're going to listen to music and enjoy it, you'll have to manage reflections correctly.

The rate and level for mid-range absorption is very critical. We found you have to achieve the right amount of absorption at certain frequencies and you have to make the total absorption curve really smooth if you're going to grab all the image, spaciousness and timbre that's present in your middle ranges. You can do it with room acoustic treatment.

Primary Reflections

The next graphic shows our primary reflection. Okay, so where can we use absorption? We can use absorption on our side walls, we can use absorption to achieve a balance between the direct sound and the reflected energy and we realized that the reflection is basically a time delay.



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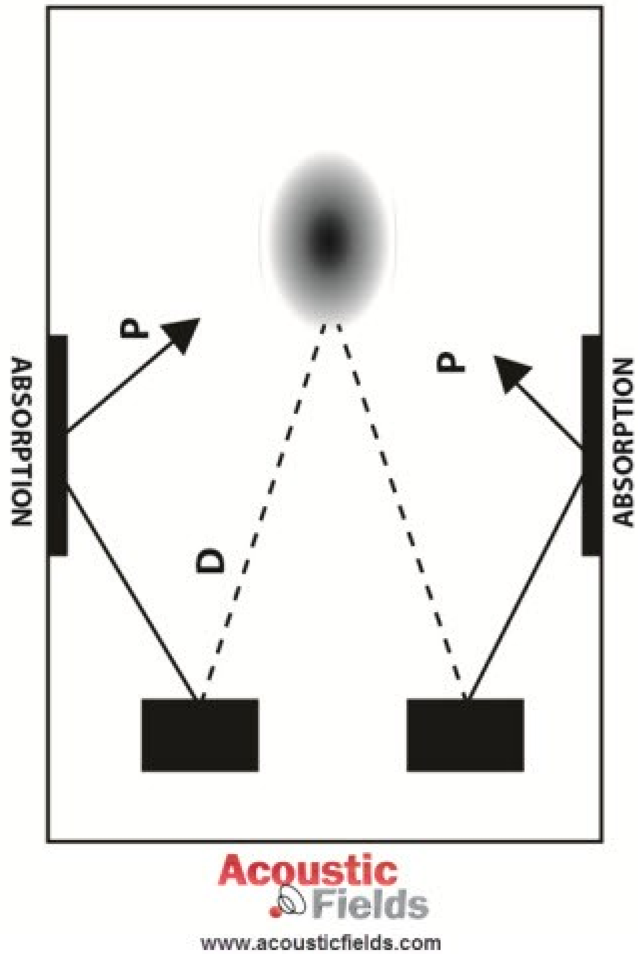
So you have to realize that absorption is a good way to treat that reflection and reduce its strength. Now there again you have to be careful about how much you reduce it. What kind of strength you're going to use and what rate and level that you're going to do it at.



People will often throw up blankets, they'll throw up towels, they'll throw up all kinds of absorption devices but if you don't know the rate and the level of that absorption, then that’s going to impact what you hear so you have to be cognizant of that.

Diffusion Sound Field Requirements

Diffusion is a great product, a great technology and if you remember from earlier in this book, one of the four main room acoustical distortions. Diffusion is what you find in free space most of the time when you're outside. If you go outside there’s lots of things bouncing around to cause the energy outside to bounce around. You get more of a balance of frequencies, there are no spatial irregularities so to speak.

So in order to qualify as a diffused sound field there are six areas that you must look at. They're a little bit complicated and I probably shouldn't even put them in here but I want to give you an idea of all the things that go into a properly diffused sound field and the following is a definition.

1. No frequency or spatial irregularities.
2. Beats in the decay characteristics must be negligible.
3. Decays must be perfectly exponential.
4. Straight lines on a logarithmic scale.
5. Reverb times same in all room positions (that's a hard one)
6. The character of decay must be the same for all frequencies.

So you have all these issues that define a diffused sound field and you have to be cognizant of what kind of diffusion will give you all of those six characteristics in order to achieve a diffused sound field. There's only one that I know of that will do that and that's called quadratic diffusion. You've no doubt seen these around, they've been around for a long time, 40, 45 years' time tested and proven in most studios.

Quadratic Diffusion Is Time Tested And Proven

A Quadratic Diffuser has a series of wells or troughs and each trough has depth at a diffused quarter wavelength on the depth, half wavelength on the width. You can position the diffuser vertically and you'll get horizontal diffusion or you can position the diffuser horizontally and get vertical diffusion. So whatever the position of the quadratic diffuser, you will have the inverse in terms of diffusion.

Our Quadratic Diffuser Absorber units in a customer's house. These units are an acoustic industry first marrying low frequency absorption with Quadratic Diffusion.

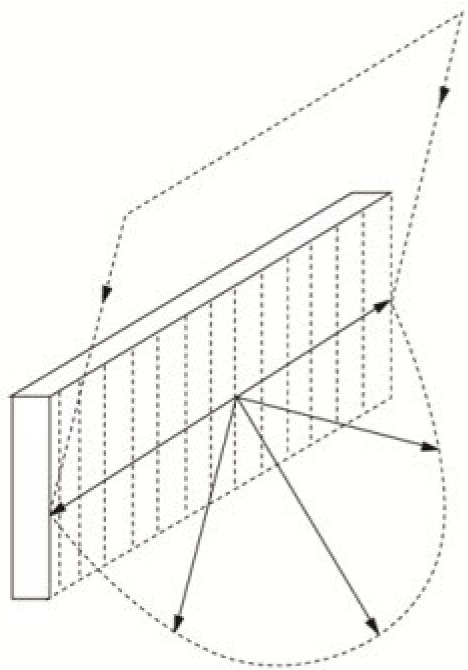
Our goal is to get a diffused sound field so with a quadratic diffuser, you get two of the three sound fields namely length, width and height. So you get two of the three dimensions in one product. And simply by positioning them in different ways you can achieve two sound fields and that's very critical if you're going to get to your goal of a diffused sound field.

So they are frequency predictable, you can design one or you can use prime numbers that are already calculated for you and achieve a frequency range. As a general rule, they're mostly mid-frequency diffusers. Quadratic diffusers start at 200, 250, 300 cycles and go to about 3,500 Hz., although you can go a little bit higher if you want to.

We found wood works best, not veneered but solid woods and we're even experimenting now with different wood types for different kinds of warmth and sounds like that.

Horizontal Positioned Vertical Diffusion

The following graphic shows horizontal diffusion from a vertically positioned diffuser. So you hopefully get a feel for how it works. It's a fan like array with no reduction in amplitude.



So what are our applications in control rooms, personal listening rooms, home theatres, live rooms and vocal rooms?

Control rooms: You can have a live and dead end approach. Rear wall diffusion is very popular in control rooms because you sure don't want that rear wall slap-back echo at the mixing or at the monitoring position. So you have to decide what frequency of diffusion you want to use on your rear wall. There's a lot of factors that you have to take into consideration but it's not that difficult. Room size and distance to the monitoring position are two real important ones.

The ceiling is used for low frequency absorption most of the time in our control rooms because it's where we have the most space to put it. It's an area out of the way over the listening position which can accommodate that. The side walls are usually used for absorption and the front wall is usually used for absorption. So those are some general guidelines in control rooms.

Home theaters & personal listening rooms: Home theaters have these multiple mono sources which produce a lot of energy in a room and you have to be careful about which wall you use for treatment and there's a whole process to go through to find the correct balance in that. Rear wall diffusion is usually something that we do. Side wall absorption on the front end is usually something we do in home theater rooms. Every room is a little different, every person is a little different. The ceiling is usually a balance of absorption and diffusion.

We just did a home theater room for a guy who has free standing front, center, side and rear speakers. He doesn't like in-walls and he doesn't like the kind that you hang on the wall so he has free standing ones and we have him firing into a diffuser so we'll do a little video on that, show you that.

Vocal rooms: Reflection management is the key for vocal rooms. How are you going to do it? Are you going to use absorption? Are you going to use some diffusion and some absorption? Are you going to use variable acoustics where you can decide based on the timbre and the tone of the singer's voice? How are we going to deal with the lateral reflections? What combination of absorption and diffusion are you going to use? Always remember that with absorption, the rate is always frequency dependent so you always want to keep that in mind.

Live rooms: With live rooms you have reverberation times you have to deal with. Direct versus reflected energy. The live room should be large enough to minimize low frequency resonances, that's always a hope when we're doing live rooms. You want it big enough so you can get the big, middle and upper frequency sound that you want but make sure it's big enough so it can handle the low frequency resonance. You can treat rooms and make the bass sound good but there's just nothing like a larger room when you're dealing with longer frequencies or longer wave lengths. So it's really good to have a room that has the correct volume.

Variable acoustics on the side walls can be a combination of absorption and diffusion. It all depends on your room size, it all depends on your room usage. It sounds a little complicated, it looks a little complicated but once you get into it you can usually figure it out.

So we have low frequency absorption, we have Helmholtz resonators, diaphragmatic absorbers; each room requires a different application of all technologies and it is regardless of what you hear and it is a blend of art and science.

* * *

CHAPTER 2
THE THREE PHYSICAL PROPERTIES OF SOUNDWAVES

In chapter 1 we looked at the difference between waves and rays and how that applies to a room acoustic setting. Well now I think we should take a deep breath, step back and get back to basics because if we're going to communicate in acoustics, sound and music, these are all interrelated subjects that each have their own nomenclature, their own vernacular and so we need to look at some definitions of terms and how they interrelate with each other. There's a lot of overlap for sure but it's the understanding of the differences that separates the paradigms that we use to process all this information and acoustics is complicated in and of itself. So let's do that in this chapter and look at the three physical properties of sound waves.

The 3 physical properties of sound waves

In simple terms sound waves are basically made up of Rate, Strength and Pattern. I'm trying to make this nice and descriptive. Sometimes the words I will use are not scientific because I'm trying to illustrate the concept for you so that you'll understand the concept without the need to understand the technical.

1. Rate

What is the rate? How fast are the vibrations? We know that all sound energy is created by something moving, something vibrating. So rate is nothing but the speed of the vibration. So graphically you end up with 3 different types of wavelengths, where the distance between the peak and the trough are tighter or longer. This all speaks to the rate or how fast are the vibrations.

Now here's where the overlap starts to occur and here's where the confusion also arises. In music we refer to that rate as the pitch of the sound. You've heard of musicians having perfect pitch, well what are they able to do in terms of vibrations? They're able to take their vocal cords and achieve the same rate, thus the same rate of the sound translates to pitch in music.

In acoustics we really don't care about any of that. We do when we're breaking down the technologies to use in a room for articulation, however it's not that big of a process for us as it is in music.

How do we express this? Everybody knows this term, it's expressed in frequencies, and the term we use is Hertz and we all are familiar with that one. So rate is how fast are the vibrations, in music it's the pitch, in acoustics it's expressed in terms of frequency and frequency is heard a lot about.

Now if we take all this and we add it into a sentence and try and tie everything together let's see what it looks like. So we could say as an example, any note above middle C resonates at a frequency of four hundred forty cycles. Okay so what does that tell us? We have a rate which resonates at a particular frequency which is expressed in hertz.

So I think that example kind of illustrates rate and how it moves between music and acoustics and that's just two paradigms being considered. There are many others but I think if we look at the relationship between the disciplines, we'll just get a better understanding and we may be able to understand it in one dimension like music but not in acoustics. Well if you just make a simple shift in your mind of how the two are correlated, you'll be okay.

2. Strength

What is strength? Strength is the intensity of the rate of vibrations. Above we learned it was the speed and the rate of vibrations that was critical for rate well this is a measure of their strength if you will, their intensity and whenever something has strength or intensity in one area, it all has to work. It all has to fit within what you're trying to do.

So in music what do we call that? Well the strength, which is one of the three physical properties of a sound wave is, perceived as loudness and we all have heard this term. "Well it's loud, the music is loud, turn the music down its too loud". So loudness is the vernacular in the perception that we use in relationship to strength.

Now in acoustics it's kind of a different process, kind of the same but kind of different and here's where that overlap occurs. They both kind of separate and go their own way and this is the difference that you have to realize.

In acoustics its wave strength, the amplitude, the gain, how much over acceptable baseline is it? What is the acceptable baseline? Well it depends on your room. How much energy is in the room based on the volume of the room? How much energy is being worked in a room based on the dimensions, the ratio, height, width, length? All these factors have to be considered and taken into the analysis.

How do we measure in acoustics strength and the amplitude. Well it's in decibels so you know it's this common one that we see, dB. So here's a good example of where strength, in music we perceive it and use the term loudness to describe it, but in acoustics it has a whole different twist and a whole different process involved to it so one kind of forms the basis for the other.

3. Pattern

Pattern or the signature of the radiant strength that we've talked about. So that's the shape, the wave form, the pattern that it takes. Sixty cycles is different than two thousand so they do have different shapes, different forms. The simplest, and we've all heard this term before, is the sine wave, that's the simplest of all the waves of all this.

Now back to the differences between acoustics and music that we're using for comparison purposes here, for understanding. So in music, what is music? Music is multiple sine waves, many different sine waves to produce music. In acoustics, what is a sine wave? It's really a test signal force. So there are your differences. Because one is multiple sine waves to produce something and then we are testing for that multiplicity if you will, using just one frequency. So think about that and we'll talk about that in a future video.

* * *

CHAPTER 3

THE TOP FIVE ROOM ACOUSTIC PROBLEMS YOU FACE IN YOUR STUDIO

There are 5 common room acoustic problems that people commonly face in recording studios the world over. But to understand them you first need to accept that there are three, and only three, things that happen to sound energy within your studio. It can either be absorbed, reflected, or diffused. That's it. There are no other characteristics that we can assign to sound energy in our studios, unless we come up with some new laws of physics.

In your studio, you need to be concerned with all three. All three have an impact on your sound within your room whether it is a project studio that you set up in a spare bedroom or a full blown brick and mortar studio with different live, voice, and music rooms. Lets start with absorption and those nasty low frequency "bass booms" we talked about in Chapter 1.

1. Low Frequency Management

The first acoustic reality and treatment myth that we must address is low frequency energy management. This is the most important element of the top 5 room acoustic mistakes you are making in your studio. Let's start with an accurate definition.

Low frequency energy is any energy that is less than 100 cycles. This definition comes about because you need different absorption technologies for treating energy above 100 Hz. in small room acoustics than you do below 100 Hz. These sound absorption technologies require drastically different approaches to effect treatment and management.

Treating energy below 100 Hz. requires mass and depth or distance. Treating energy above 100 Hz. can be accomplished with technologies that take up much less space and can be wall hanging units like foam. The difficult management happens below 100 Hz. Get that out of the way and your mids and highs will pop. As such, low frequency treatment provides a good dividing line from a room acoustic treatment perspective so let's take a look at what you need.

Treatment Is A Must

Low frequency energy below 100 Hz. must be treated. The acoustic power of this energy is covering and smothering certain frequencies within your music that you are not hearing at all because of these room modal issues. Therefore, it is a musical imperative that they must be dealt with. You would not put up with a piece of gear that did not reproduce certain frequencies in its output and likewise you cannot put up with that in your room. This is your product that you produce which reflects your musical talent and production skills. Mess with that at your own risk!

You can't have things missing here. There is a lot of important music from 30 Hz. - 50 Hz. and it must be heard. It is the foundation on which the rest of the sonic presentation exists for. Do not short change this area. Your product will suffer and you will miss sounds that you need to hear during the recording and playback process.

Treatment Myths

The treatment myth is that you can get rid of low frequency issues in your room by placing a box filled with building insulation (otherwise known as a bass trap) or foam around your room. First of all, all you can do with frequencies below 100 Hz. within a room is manage them. Certain lower frequency issues can never be eliminated and thus a reason why some people move to larger rooms. Any concern for dealing with this area of the top 5 room acoustic problems you are facing in your studio, must be taken seriously.

Make Your Room Smaller

It's actually counter intuitive but in order to manage your low frequencies, you must make your whole room smaller using the correct technology, namely, diaphragmatic absorbers. You make it smaller by adding this proper low frequency technology around the room boundaries. You do not use boxes filled with building insulation (the aforementioned bass traps…which are good for one thing, trapping dust!) or foam. They do not have the acoustic horsepower to deal with 30 Hz. 40' waves of energy. Using these technologies is like using a feather to stop a tornado.

2. Appearances Are Deceiving

The second myth is that you can set up your studio any way that looks good or “cool”. Unfortunately, the laws of physics don’t give a damn about “cool”. They are simply there to dictate what you can and cannot do. I see studios every day that put decor ahead of acoustical needs. I have a simple question in such situations… “do you hear with your eyes or your ears?”

So here are some simple rules.

i. Speakers must be equal distance from both right and left channel side walls. You cannot have one speaker closer to the side wall than the other.

ii. Your seated position must be located a certain distance from your speakers and rear wall.
Here is why.

Sound Energy Is Constant

Sound energy moves at a defined speed, around 1,130' per second. Reflections from the side walls will be slower than the straight line sound that comes directly out of your speakers to your ears because it has to travel a bit farther leaving the speaker and then striking the wall. It is that straight line sound that is the purest. It does not contain room sound, but it soon will.

Side Wall Reflections

Reflections traveling from both side walls will transverse the direct sound or straight line sound coming from your speakers. It is the proper slowing down of this energy that you must accomplish with correct room treatment technologies. You need the sound energy striking the side walls to have even time signatures, so you can apply the correct rate and level of sound absorption technology. To achieve even time signatures, you need even distances. This is another critical issue in the top five room acoustic mistakes you are making in your studio.

Sound Triangle

Your speakers and listening position are a “sound triangle”. The speakers and listening position form the apexes of a triangle that must be moved as a single unit. It is that positioning of all 3 items that must balance with room dimensions and low frequency pressure levels. There is only one position of the “sound triangle within your room that will give you the best frequency response within your room. Most of the time the best position is not what looks the best within your room. Are you concerned with appearance or good sound?

3. Watch Rates And Levels

The third common acoustic problem that we see in most studios is that absorption rates and levels for sound absorption treatment can be all over the map. A lot of people will buy a product that absorbs a certain amount of energy and that since it performs on a limited frequency basis, they assume it can do everything acoustically within their room. It cannot, no matter what the manufacturer claims. Remember those laws of physics?

Minimal Absorption

You must absorb at a rate and level of absorption that does just enough to minimize the “acoustical damage” it causes upon your signal. There is no need to eliminate large amounts of your sound energy through absorption. Converting acoustical energy to heat using the process of absorption, eliminates sound forever. Ever been in a room that is just too dead? It is called “dead” for a reason.

Reflections Are Rate and Level Sensitive

Reflections from your room wall or boundary surfaces must be controlled at the correct rate and level using sound absorption technology. Most companies will tell you to absorb as much energy as you can to manage the reflected energy. If you do this, you “destroy” the acoustic energy and convert it to heat. You do not want to “destroy” sound energy in order to manage it, at least not all of it. You need to take just a little from each reflected frequency, that it slows down just enough, so that its arrival at your listening or monitoring position is less than the direct or straight line sound from your monitors or speakers. You want the time signature of each reflection to be below the time signature of the direct sound.

4. Don’t Forget Ceiling and Floor

Our fourth myth is that the ceiling and floor do not contribute any reflection issues that must be managed. Do you have ceiling treatment in your studio? Most do not. It is very important. Remember your side wall reflections that we needed to slow down, so that they arrived below the time signature of your direct straight line energy from your speakers? Well guess what, the ceiling and floor reflections actually arrive before the side wall reflections do.

Ceiling And Floor Closest Surfaces

Think about it. You are closer to the floor and ceiling in small rooms than you are the side walls. Floor and ceiling reflections enter your mix and music play back presentations. They must be managed with the same approach as the side walls. They account for 15 – 20 % of what you’re hearing. They need to be respected and treated.

Absorption Or Diffusion

Ceiling reflections can be treated using diffusion or absorption technologies. Each treatment has its own certain acoustic presentation, so you must decide what is the room’s use and what are you trying to do with music within the room. If it is a control room, everything must be heard within the mix and less room sound during monitoring is usually desired. Absorption technology, including low frequency technology, is generally used and located upon the ceiling to minimize ceiling reflection distortions. If your room is for music playback and listening enjoyment then a different room acoustic treatment is needed on room boundary surfaces.

5. Room Size And Volume Critical

Our fifth myth is that you can locate your new music room in any room size that you currently have available. Sorry, we see a lot of this and there are simply some room sizes that have a certain width, height, and length dimension that you cannot use because the real, low frequency energy, < 100 Hz., cannot be managed at all by current room acoustic product technologies no matter how good they work. In certain room volumes and dimensions, there is no treatment for the low end disease. Find another room size. Sometimes, only a foot here or there will make the difference. Middle and high frequencies also require minimum room distances to be completely heard without room distortions.

The Top 5 Room Acoustic Problems You Are Facing In Your Studio

It’s critical that you manage your low frequency energy, so that you can hear every note from the lowest 30 cycle note on an electric bass to the bass drum attack and decay of each note. Yes, I know it is not easy, but it can be done with the correct technology. Boxes filled with building insulation and foam (bass traps) will not do it.

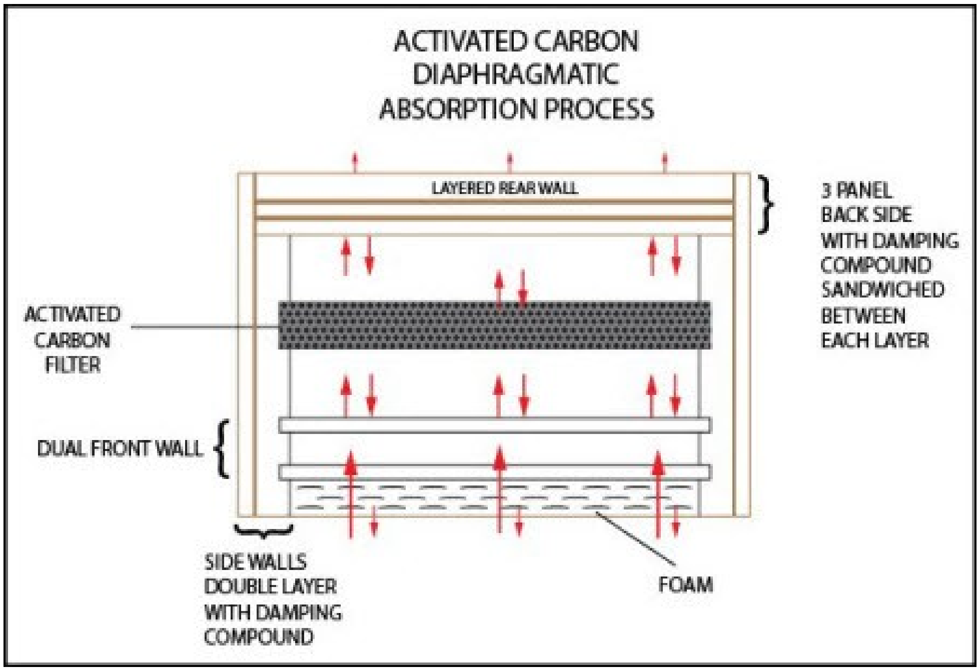
Room Treatment Balance

Once you have decided upon the use of the room, treat all room boundary reflections, so that those reflections are working with your room usage and not against you. Also choose a room based upon the needs of the music and not any of your human wants or desires. Your music room is not a living room. It is a room to make music in. Choose the room size and volume that gives you a good chance by adding the correct treatment technologies, to achieve a room sound that is energy balanced across the audio spectrum. Sometimes a few feet in just one dimension can make all the difference.

* * *

CHAPTER 4

HOW WE WENT ABOUT SOLVING THESE PROBLEMS WITH OUR TECHNOLOGY



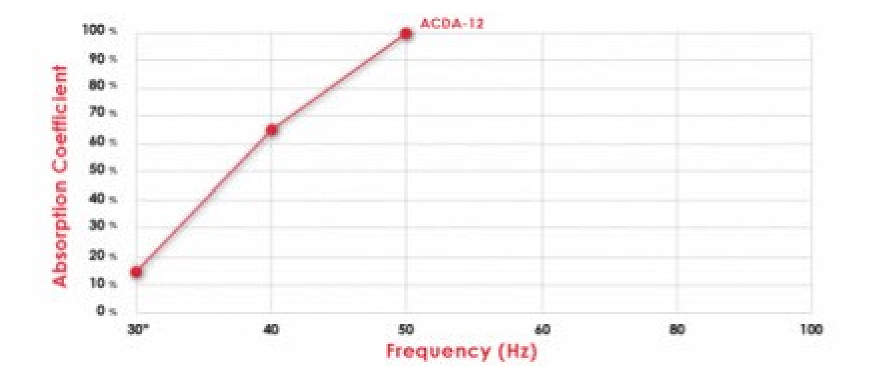
In the above graphic you can see what the team at Acoustic Fields have done to the classic diaphragmatic absorber design. Basically, and I'll go back to an analogy from my youth when I use to build cars and make them go faster, we took existing technology and we made it work a lot better. We hot rodded the technology in essence.

Let's start with the rear wall. Now I don't have all the layers in this graphic but I think you get the idea that the rear wall is really seven layers thick. Each layer is separated by a vibrational damping compound; the whole purpose of the structure is to get it to act as one unit. Both sides in the rear get attacked as one unit and work together so we've made the walls a lot thicker.

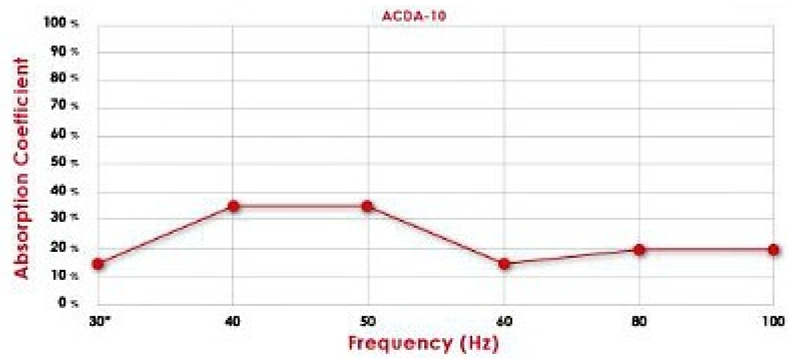
Let's move to the inside of the cabinet. There's our activated carbon fill material. We calculated how much carbon we need inside of it for the particular depth and for the particular rigidity of the cabinet. A normal diaphragmatic absorber has one wall, ours have two. My thinking when I designed it was that two would work better than one. When I'm dealing with 30, 40 and 50 foot long waves in high pressure areas you need as much in your tool kit as possible to manage them and I was right. It took a couple of years to figure out the density of both layers so that they move together in sympathy to slow the wave down before it enters the cabinet. But we did it, we figured it out and they really work well, you can see our test results on the Acoustic Fields website.

We also put foam on the face so you can have an absorber that's really broadband. Ours start at thirty cycles and our foam quits about 6500 cycles so you can enjoy a really powerful absorbing tool for your recording studio, home listening room, personal listening room.

Here's our Riverbank test results. Riverbank is now Alion labs but Riverbank was the name when I knew it, did years of testing there. This shows our ACDA – 12 test results at 30 cycles. As you can see a nice absorption with 63% at 40 cycles and 100% at 50 Hz. So you can really see how powerful this technology is.



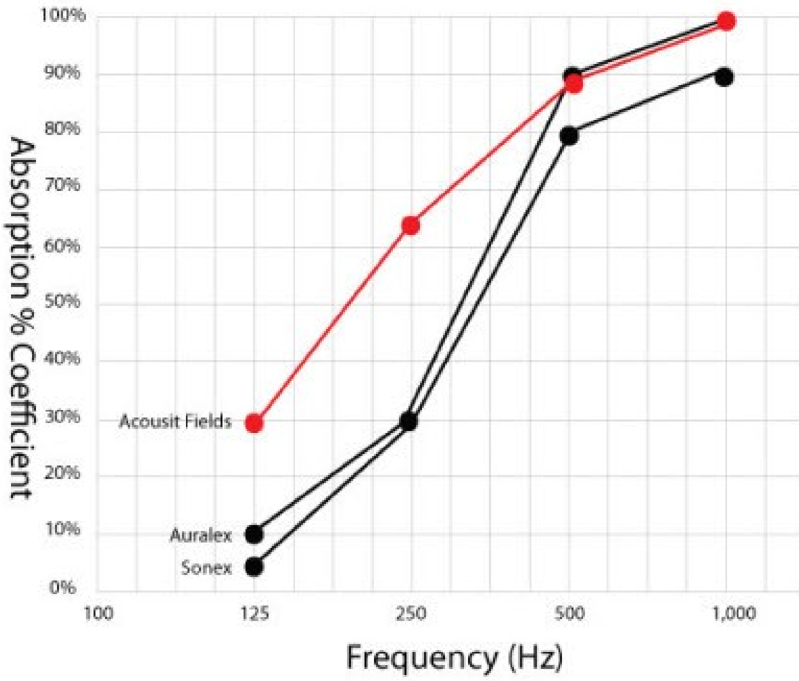
The second way I wanted to go with this carbon technology, based on our building of rooms, was that I knew we needed a low sponge at 30 Hz., 40 Hz., 50 Hz. that was really powerful because those were the frequencies that were the most problematic in our whole database of 116 rooms. So I came up with a broadband absorber that would give us about 23 to 25 percent average absorption across the whole range from 30 Hz. to 100 Hz. and as you can see in the following graphic, I did pretty good here also.



I'd like to get back in the lab and push the sixty up a little bit but all in all it's not a bad broadband absorber for absorbing that kind of energy across a wider spectrum range. Of course we put foam on the face and get a much broader coverage that way.

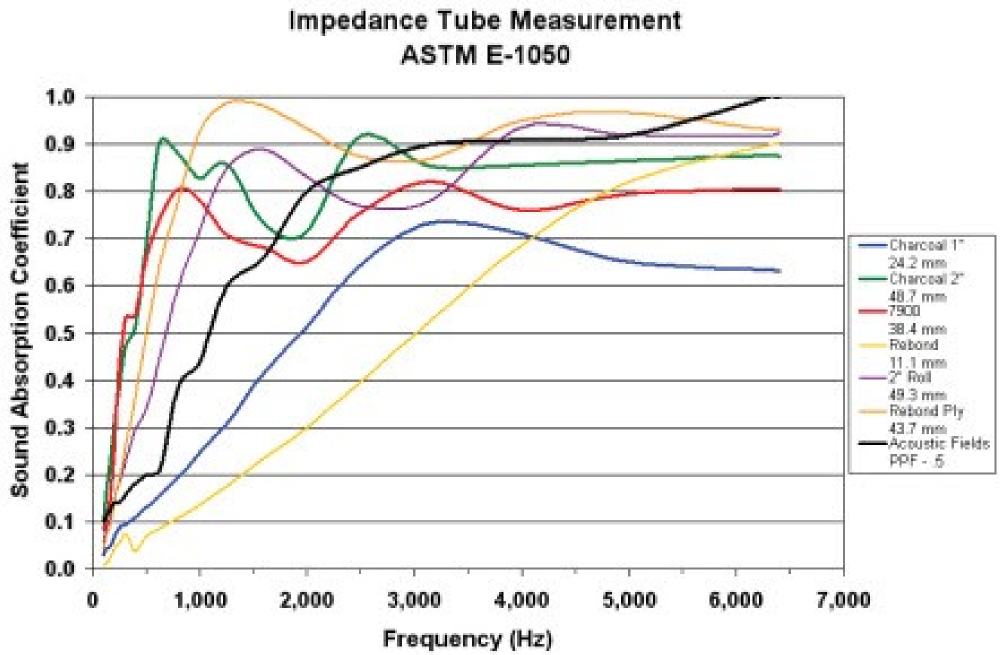
Acoustic Foam Absorption Curve

The below graphic shows our acoustic foam absorption curve. This is the reason graphically why I created our foam. You can see here this is our two inch foam, it's a comparison of Auralex' two inch, Sonex' two inch, it should jump out to you right away how much smoother the curve is and this is what I explained above.

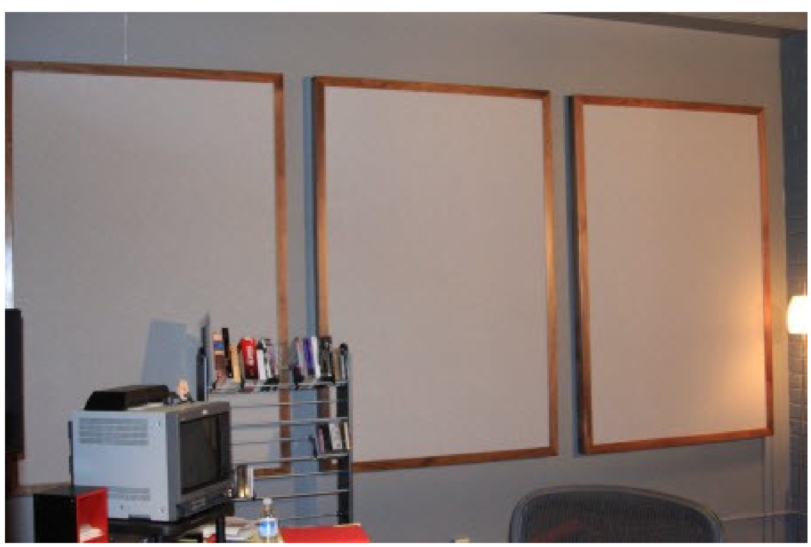


Everybody gets foam right above 500 cycles, that's easy, but look at the difference below 500 and those of us there in the business and the industry can, I think, see why this kind of absorption curve is much better than some of the other things that are out there. To compensate for that other companies will go a hundred percent. Well, we don't believe that you need to absorb a hundred percent of anything in order to manage it.

The next graphics shows just how smooth our foam was when we did an impedance tube test on it, the black line, and you can see there how smooth it was. That's just our half inch, we made three thickness, this is the half inch one and two inch. Each serves different purposes.



The following photo shows some of our PFP units, which contain our foam, hanging on a side wall in a video mixing room. You can see they're pretty. I wanted a product that didn't look like other products because this is important stuff in your room. This is important because it contributes fifty percent of what you're hearing and we all make our living hearing sound, sound we create, sound we play back, sound we record or whatever your purpose is. So I wanted something that looked as nice as everything else and the panels in the image are made from solid Walnut as we only use solid woods in our construction.



In Summary

Alright! We’ve covered a lot in this book. I’ve tried to keep it moving for you and not get too crazy. Maybe your head is spinning a little but that’s okay because I’m here to help. I want to give you answers to your questions if you have them. So I'm going to give you a free 30 minute consultation to give you a chance to get your room working for you.

I’ll look at the size of your room. I’ll compare it to our database and give you some ideas of what you can do. We’ll work together and work on your particular room with your particular problem. I've got to tell you in all honesty, that you won’t have a problem that I haven’t seen or heard a thousand times and you won’t have a problem that we can’t figure something out for. I want to take the simplest path and work from low frequency management on up as it’s easier if we get the bass under control as then we can go from there.

So here’s what you can do next, fill in the form at www.acousticfields.com/free-acoustic-treatment-room-analysis-tell-us-about-your-room/ Once I have analyzed your room I will shoot you back an email with my appointment schedule, you can pick the option that’s best for you and then we can take a peek at what you’re trying to do and go from there.

Thanks

Dennis

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