



# JdB Sound Acoustics

Presents

## Acoustical Tube Radiators and Sound System Distortion

### *Why don't you call your diffuser Poly Cylindrical Diffusers?*

A Poly Cylindrical diffuser is most often referred to as any spherical shape that is less than a half round. They are most often applied in a continuous pattern without flat spaces between the radiuses. When you see those drywall solutions on my website, yes, those are technically Poly Cylindrical panels/diffusers. Most Poly Cylindrical installations are used to scatter mid and high frequency sounds and moderate bass absorption in rooms less than 2000 sq ft. The bigger the diffuser the lower the frequency you can absorb.

### *Tube What!*

When you see half round diffusers with flat spaces in-between them, it is best to refer to them as Acoustical Tube Radiators. In these installations, the goals are different. Tube Radiators are to be used for very aggressive low mid range and bass control while doing some light duty at mid high scattering. The flat spaces are used to provide high frequency feedback to give the listener a better picture of the size of space they are in and to help them hear each other when singing or in large groups. It also puts life and sparkle back into a room.

In a church or large worship space where there are more than 200 people, bass, mid bass, low mids and mid range frequencies (30 to 1200 hertz) build up on any and all large flat or concave walls and windows. The larger the space the worse the problem. The dilemma continues as the space gets larger in churches or worship spaces up to about 8,000 seating or in spaces where walls are less than 350 ft apart. This excess energy masks the weaker higher frequencies that have a fraction of the power. Excess bass energy discourages congregational singing, it makes it hard for the choir to perform and it makes the sound experience of the worship team just awful with monitors out of control.

### *What Causes Distortion?*

The other problem with excess bass in a room is that it increases the amount of distortion coming out of the sound system. While loudspeakers have ports to balance the air pressure coming off the back side of bass drivers, the front of the bass driver adds air

pressure into a room. While rooms leak air, the air cannot move out of the way fast enough for a speaker to work 100% freely. As a result, this air pressure on the front of bass speakers creates distortion. The more resistance on the front of bass driver the greater the distortion.

When the bass cannot be absorbed or radiated out of the room fast enough in a large room, that bass adds feedback air pressure onto any speaker with an exposed cone. If you have ever pressed a finger on a speaker cone firmly, you know what I mean. This does two things.

First, it lowers the bass and midrange output of the speaker up to -6dB which is 4 times less the power output. The next thing that happens is that the speaker distorts. The distortion can increase between 10 to 20% regardless if the speakers are at full power or not (that is dependent on the acoustical condition of the worship space.) Distortion will make the speaker sound louder and offensive to the listener.

### *How does distortion affect me?*

When listening to speech or music through a sound system and the loudspeaker is producing 10% distortion, it is often perceived as being 6 to 10dB louder than a speaker with 0.5% distortion playing at the same level. This is what older people complain about. At 20% distortion the sound is perceived to be up to 15dB louder. When older people are saying the sound is too loud, they are complaining about the distortion. (This is why seniors don't complain about congregational singing when it is as loud as the sound system.) Most sound system designers try to solve that problem by using many smaller speakers or adding more



powerful amplifiers to make the speakers cleaner sounding. The cleaner the sound, the louder you can play the sound system without complaints. Those techniques work up to a point and then the distortion creeps back in.

(From some recent research, it is also speculated that distorted amplified sound is more damaging to people's hearing in short term listening than industrial noise exposure at the same levels over long term listening.)

For the record, congregational singing in a good worship space can hit 108dB during a familiar hymn. For the sound system to match the congregational singing, it also has to be able to perform cleanly at 108dB. (Those are Rock and Roll levels.)

### *No Distortion?*

This brings us to live sound. There is no distortion in live sound. Pianos, acoustic guitars, brass, woodwind, and stringed instruments have no distortion. Distortion only comes from anything that is amplified.

The only good amplified distortion is what comes from Electric guitars, Electric Organs and electronic keyboards. In those cases the purpose built speakers are actually musical instruments – not sound reinforcement speakers. At no time that I know of is distortion in sound reinforcement desirable or wanted. If anything, distortion is an irritant and a distraction to the listener. Here is the kicker, when a senior wants you to turn the system down and you do it, they come back later to complain that they can't hear. Seniors don't want the sound system turned down; they want you to get rid of the distortion! Make the sound cleaner!

### *How to lower the distortion*

Excess bass will reduce sound system performance up to 6dB and add up to 20% distortion. This means that if your goal is to have clean sound up to 100dB, then you need 4 times as many amps and speakers than a room with a properly laid out acoustical system throughout the space. For example; you have a 500 seat church with 2 main speakers and a sub. You have clean sound up to 94dB and then things start to sound awful. The speakers and sub have the maximum amount of power supplied to drive the speakers as cleanly as possible. The speakers are able to play up to 115dB but they can't because of the acoustical condition of the room. Now you need to bring the sound system up to 100dB clean. What do you do?

Option "A" would be to add 3 more subs and 6 more main speakers plus the amplifiers. What most clever sound designers will do is switch your speakers to more efficient speakers which can cost 4 to 5 times more to keep the number of cabinets down



or switch you to using line array technology. Either way, it gets expensive to make such upgrades. When you read most church sound magazines, this is all you read about. More speakers, more speakers, more speakers....

Option "B" is to treat the room with a Tube Radiator system and then optimize the existing speaker system unless the existing speaker system is underpowered or damaged or was never the right speakers for the job. What this also means is that if you only needed two speakers to do the job, you can have your 100dB target with 2 speakers and sub woofer after the acoustical treatment is done. (In some smaller churches, they don't need the subs) The next question is which is more cost effective and which has the most benefit?

The quick answer is; option "B" often costs ¼ to ½ the cost of trying the "brute force" method of increasing sound system performance and option "B" will help improve every other aspect of the worship experience. So what if option "A" is 6dB louder.

1. Did it help with congregational singing? No.
2. Are the performers on stage able to hear better? No –
3. Even with (IEM) In Ear Monitors? No.
4. Does it help the minister to preach with less effort? No.
5. Does it greatly improve the gain before feedback of the sound system? No. (Well slightly....)
6. Did the excess bass on stage clear up? No (You can't hear excess bass when you're in the sound field of it.)
7. Is it really helping people with minor hearing problems? No

Unfortunately, the majority of people in the audio industry only know how to use the Brute force method of making things louder and cleaner. Using a Tube Radiator system is not only better

stewardship but it has a higher profit margin for whoever supplies the readymade acoustical products vs. audio product profits. (I used to be a turnkey sound contractor and installer.)

### ***No Forgiveness when using Brute Force***

It is also worth mentioning that if you choose the brute force method, whatever maximum SPL level you choose, the moment you go over it, you are back to the distortion problem and at those higher levels, the amount of distortion increases at a greater rate. If 105dB is your target, at 108dB you will be already at 20% distortion. With Tube Radiators or other high performance diffusers, the onset of distortion overload is more gradual. At 108dB you might see 5% distortion and at 111dB it would be around 10% distortion and so on. This type of acoustical treatment is more forgiving if you go over your planned limits which in turn protects the equipment and has few complaints from the older people. (Anyone over 30)

### ***Back to acoustics:***

When it comes to bass issues walls don't have to be parallel for bass build up. All large rooms store excess bass energy no matter the shape or the ratios. A room is a sound amplifier. The walls, the ceiling and the floor are all amplifiers. Outdoors, the

ground amplifies your voice to be heard over distances. Indoors, every wall bounces the energy at all frequencies that you make back to you except for what is absorbed or diffused. In a rectangle room you have 6 surfaced – 4 walls, ceiling and floor. In an Octagon room, they usually have 8 walls, 8 ceiling sections and the floor for a total of 17 surfaces – all trying to amplify sound back into the space.

Parallel walls create standing waves and help increase the bass problem. Parallel walls also create sound effects like flutter echoes when the walls are far enough apart or large enough to support the sound effect.

1. Excess bass in a room just makes everything harder to do.
2. Excess bass makes hearing aids less effective and it makes hearing assist systems less effective. (Control the bass and people who are hard of hearing benefit.)
3. Excess bass degrades the performance of pipe organs and electronic organs.
4. Excess bass makes the grand piano sound less than what it is.
5. Excess bass gets transmitted outside of the church and can be a problem with neighbors.
6. Excess bass *reduces the gain before feedback in a sound system.*
7. Excess bass makes floor monitors harder to hear.
8. Excess bass lowers the performance of In Ear Monitors (IEM).





### *The Early Days*

In the early days of my acoustical education, I had used Poly Cylindrical diffusers with great success in a number of churches. They do work when you have a lot of wall space to take full advantage of them. When taking acoustical measurements of a church, I often find that you needed to be able to absorb sound energy at a greater rate than there is wall space available. With conventional panels or as I sometimes call it, “brute force acoustical treatments” where you kill every musical aspect of the worship space, you still don’t have enough wall space to cut 20 to 30dB of sound energy at 500 to 100 hertz. (These are wave lengths from 2.5 to 11.3ft long) You needed a bigger hammer or use a different approach.

Diffusion seems to be the best way to go but some of the readymade acoustical treatments that are available make the electronic solution much more financially appealing. In my quest for high performance cheap acoustical treatments, I stumbled onto the half round shape and discovered it was all about the

shape and not what it was made of. At first I suggested thin wall cardboard tubes. They worked great but found that Fire Marshals would only accept the thicker wall tubes or plastic tubes. Now there are fire rated tube radiators that are still low cost and cheaper than buying more sound equipment.

### *The Bible has the Answers for Modern Church Acoustics*

Acoustical Tube Radiators are not new or anything special. This method has been around for years but I don’t think it was explored enough in large rooms like churches. What tipped me off was when I heard a minister read from a pulpit 1 Kings 6:29. He read that all of the walls in Solomon’s temple had carvings of cherubs and palm trees. (I had read this passage before but this time I heard something different.) The cherubs were easy to understand but there is no known spiritual reason for palm trees in Solomon’s temple. Was this Solomon’s method of taming a room that would otherwise sound awful?



That is what set me off to the nearest Bible College and Home Depot. I went to the college to question the bible scholars and then bought a bunch of concrete forming tubes. I started experimenting with half round cardboard shapes. I had basically created a portable lab and tested this method in dozens of churches. It didn’t take long to discover what patterns worked the best and how much power these tubes could produce in noise reduction in a church. The rest is history.

In the end, for every dollar spent on Acoustical Tube Radiators or similar system, you can lower the sound system budget from 20 to 60%. Let’s say you are looking at a sound system budget of \$25,000, you could spend \$5,000 less when you combine the sound system and acoustical budget together. If you’re looking at



a \$100,000 sound system budget, adding an Acoustical Tube Radiator system would lower the total budget down to \$60,000 for a higher level of performance. As churches get larger, the amount of saving can be huge. Likewise, for smaller churches, there might not be any savings but you will get much more performance for the same money invested.

This approach to church sound is not popular with turnkey sound system experts as it cuts down on their product sales. This is not popular with audio manufacturers who are counting on high volume speaker and amp sales. This is not popular with some churches that feel they have to be on the leading edge of technology to attract people into church, only to discover that their high powered sound systems are only performing at a half of their potential.

When a church audience can choose between a high performance worship space and a high performance sound system, guess what they will choose every time – the high performance worship space. Research has shown that motivation goes a long way in how people experience sound.

Give people a great room to sing in and they will listen to a poor quality sound system all day. Give people a dead room or a room that sounds awful to sing in and watch what happens if the sermon is a minute too long. Even if you have a strong leader at your church and your church is packed, watch how fast the church empties out. Churches that sound great usually empty out slowly.

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#### **Summary**

When a church uses an Acoustical Tube Radiator system or similar system, it creates a level playing field. It means a modest 200 or 300 seat church can have the same level of sound system performance and worship experience as churches that seat 1000, 2000 or 8,000 people with similar acoustical systems. There are many smaller churches that already have such systems; they often report that when they visit other larger churches that have not deployed a similar acoustical system, the worship experience is much less dynamic or vibrant. Listening is stressful which make following the message a mission. Worship is more like a unpleasant task than a memorable experience.

Acoustics has a profound effect on people. Acoustics touches us 24/7. We can never escape from it. Acoustical Tube Radiators and similar acoustical system are one of the most powerful tools that help to deliver the word of God. It is one of the best methods of removing the barrier between the minister, the sound system and the listening audience. Fix the sea of air between the sound system and the listener and more people will get the message.

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