VERSION 2

Acoustic Problems & Solutions

FOR REHEARSAL & PRACTICE SPACES

Wenger®

Introduction

Why This Guide?

In this guide, Acoustic Problems and Solutions, we address some of the most common acoustic problems music educators face in their rehearsal and practice areas. We help define the problems and explain the steps you can take to fix or at least minimize them. A few solutions are simple, most will require some investment, and in some cases, very little can be done short of renovating your space. But in every instance, we believe this guide will help you better understand and evaluate your own areas — help you avoid spending time or money on remedies that don't actually work — and equip you with a starting point and some facts to advocate effective improvements to your spaces.

Also from Wenger Corporation

Planning guides for new construction and renovation used by thousands of music educators, architects and administrators, Wenger Corporation's original Planning Guides have helped set some basic facility standards for effective music education and performance areas. Even if you are not looking forward to a new construction project, these guides provide a strong foundation for understanding issues of layout, acoustics, storage and equipment.

Wenger Corporation works with the American Institute of Architects Continuing Education System as a registered AIA/CES provider.

Elementary Planning Guide

This guide covers the basics of creating a general music space for elementary education. It focuses on the merits of a space that is open and supports quick, easy transitions of activities, methods and equipment.

Acoustic Primer

Wenger Corporation's Acoustic Primer is written to be a partner document to Wenger Corporation's other facility guides. On its own, it is also an excellent reference tool to help educators better understand some of the key acoustic principles and definitions that affect the areas in which they teach and perform. The Primer breaks the physics and science of sound into simple terms, graphics and tables that educators, administrators and architects will quickly understand. Call Wenger Corporation and make these guides part of your personal library.

This Wenger Publication Was Reviewed By Professor M. David Egan.

Hon. AIA, is a consultant in acoustics and Professor Emeritus at the College of Architecture, Clemson University. He has been principal consultant of Egan Acoustics in Anderson, South Carolina for more than 35 years. A graduate of Lafayette College (B.S.) and MIT (M.S.), Professor Eagan also has taught at Tulane University, Georgia Institute of Technology, University of North Carolina at Charlotte, and Washington University. He is the author of Concepts in Architectural Acoustics, Concepts in Thermal Comfort, Concepts in Building Firesafety, and Concepts in Architectural Lighting (two editions). In addition to consulting, teaching, and writing, Professor Egan is a fellow of the Acoustical Society of America, member of the National Council of Acoustical Consultants, and an Association of Collegiate Schools of Architecture (ACSA) Distinguished Professor.

Educational Guides Based On Our Experience And Your Input

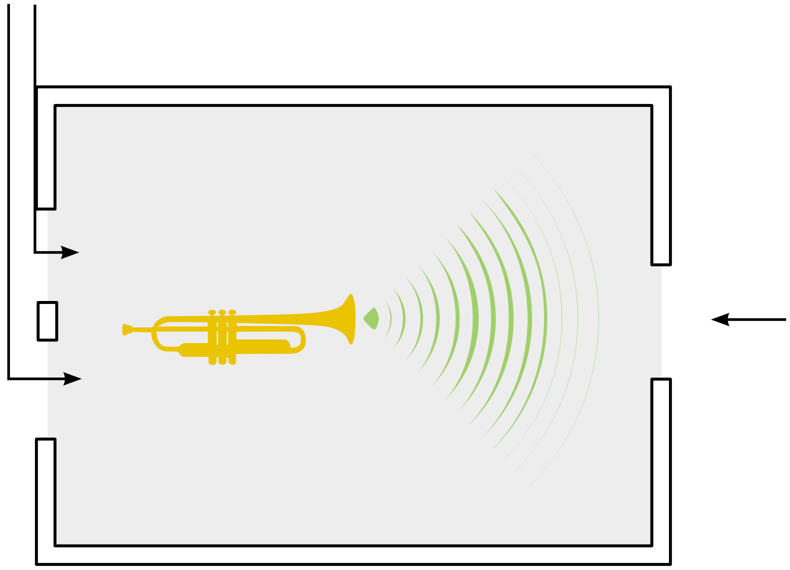
That's how Wenger Corporation puts our educational guides together. At Wenger Corporation we have over 54 years of experience studying music education and providing solutions to the needs you face. On staff, we have some of the industry's leading experts in the field of music education and performance facilities, acoustics, storage and equipment. We then went to the real experts — music educators. After more than 6,000 surveys, hundreds of interviews and site visits, we focused our attention on topics and problems educators face every day.

The topics we cover in our Wenger Corporation guides are a joint effort — a combination of our knowledge, input and writings from leading acousticians, architects and facility planners, and of course, the creative solutions of individual music educators. There are as many variations on these topics as there are schools in North America. Although every facility and every situation is unique, Wenger Corporation guides will provide a starting point for addressing many of the questions you have and the problems you face in your facility. We are always working on updated versions and new topics — call for a current list of Wenger Corporation guides for music educators and the spaces in which they teach and perform.

Table of Contents

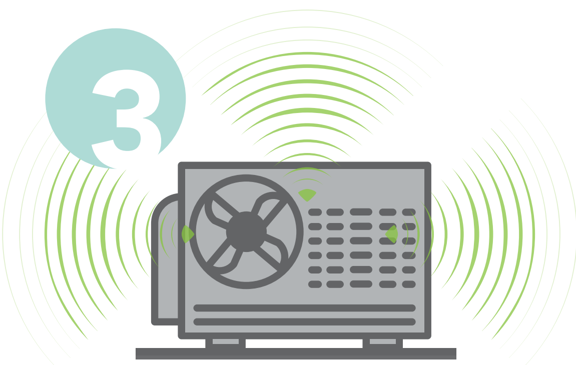
Sound Isolation

Here we provide some basic tips for identifying how unwanted sounds are leaking into your music areas and how your music may be disturbing classrooms or office areas nearby. We explain what can be done with doors, windows walls, floors, ceilings and ventilation ducts that are often at the root of these problems.



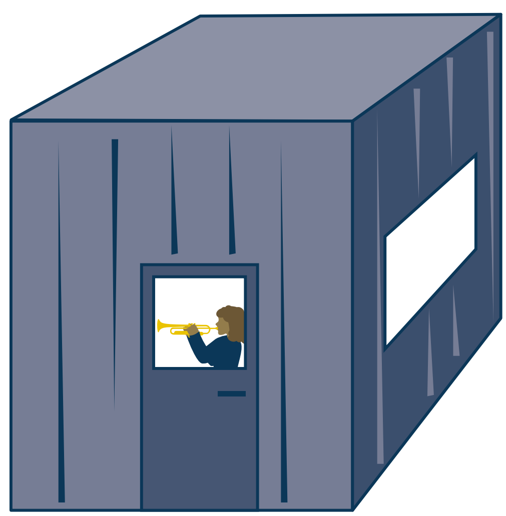
Interior Room Acoustics

This section addresses problems such as excessively loud rooms, boominess, dead spots, echoes and more. It explains how room size, shape and surface materials all affect interior acoustics and how they can be altered to more accurately reflect musical sound in your rehearsal rooms.



Mechanical Noise

Whooshing ventilation ducts, vibrating compressor units, buzzing light ballasts — these are all unwanted distractions in a music space. In this section we offer some suggestions on how you can minimize these noises in your rehearsal rooms.



Practice Room Acoustics

We expect a lot of musical growth to happen during student practice sessions, yet too often the practice rooms provided are terrible acoustical environments. Solutions for sound isolation and interior acoustic treatments or modular options can greatly improve these important environments.

AREA OF CONCERN

Sound Isolation

ACOUSTICIANS AND EXPERTS

There is no substitute for the consultation and direction of acoustic experts and professional acousticians. Their input will help you pinpoint acoustical problems and understand the appropriate corrective measures. On page 27 we provide some contact information to help you get in touch with acoustic professionals for assistance on your projects.

Poor Sound Isolation In Large Rehearsal Rooms

"Noise from other areas of the building gets into my rehearsal room."

"I am constantly reminded that when we rehearse we cause distractions in adjoining classrooms and administration offices."

"I share a wall with the band room and the noise is a real problem for our choir rehearsals."

"Whenever the building air-conditioning comes on we can hear it all — rhythmic squeaking, the rumble of the motors and the vibrations of the condenser."

Symptoms of Poor Sound Isolation

Sound travels from one area to another through:

- Closed doors and windows
- Walls
- Ceiling and floor
- Heating, ventilation and air-conditioning (HVAC) system ducts and vents
- Cracks and openings

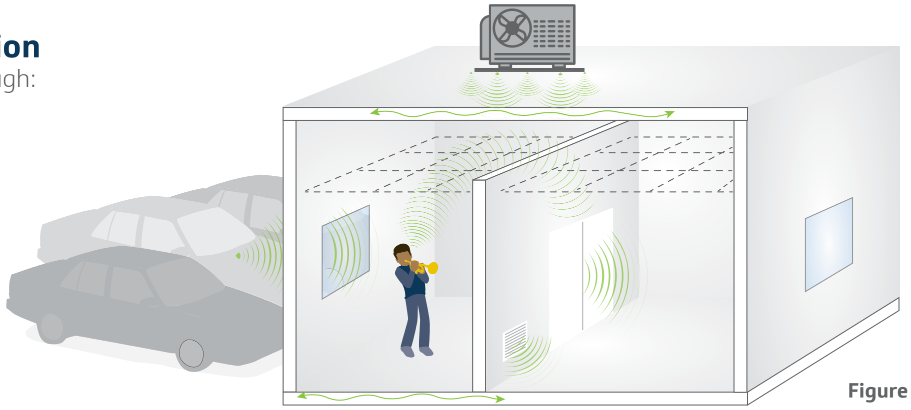


Figure 1

Doors and Windows

To provide effective sound isolation, doors need to be solidly built with sufficient mass. Most doors are 1-3/4" (44 mm) thick and not built for adequate sound isolation. They also must seal tightly around the jamb and over the threshold to contain sound.

Windows can provide effective sound isolation if they are constructed with two isolating panes. It is best if each pane is a different thickness over 1/4" (6 mm) so they do not resonate at the same frequency. Also, separating the panes with an absorptive air space of at least 2" (51 mm) greatly improves the sound isolation. Windows that open should also seal tightly with gaskets.

Door and Window Checkpoints

Check The Basic Structure For Problems

- Are your doors too thin? Are they hollow?
- Do your doors have louver panels?
- Are windows constructed with a single pane of glass?
- How thick is the glass?

Check Tightness

- Are door and window jambs without seals or gaskets, or are the gaskets worn out, torn away or out of alignment?
- Check seals by closing the door or window on a piece of paper. If the paper is easily pulled through the jamb, and you feel little or no resistance, your seals are not as good as they should be. Anywhere you can feel air movement or see light shine through is also a trouble spot.

Check The Sweep-seal At Bottom Of Door

- Does the door bottom seal tightly over threshold?
- Again, the paper test works well.

Check The Design

- Look in your building's design and construction documents to see if you can find any acoustic specifications for the doors and windows. Be sure they were followed.

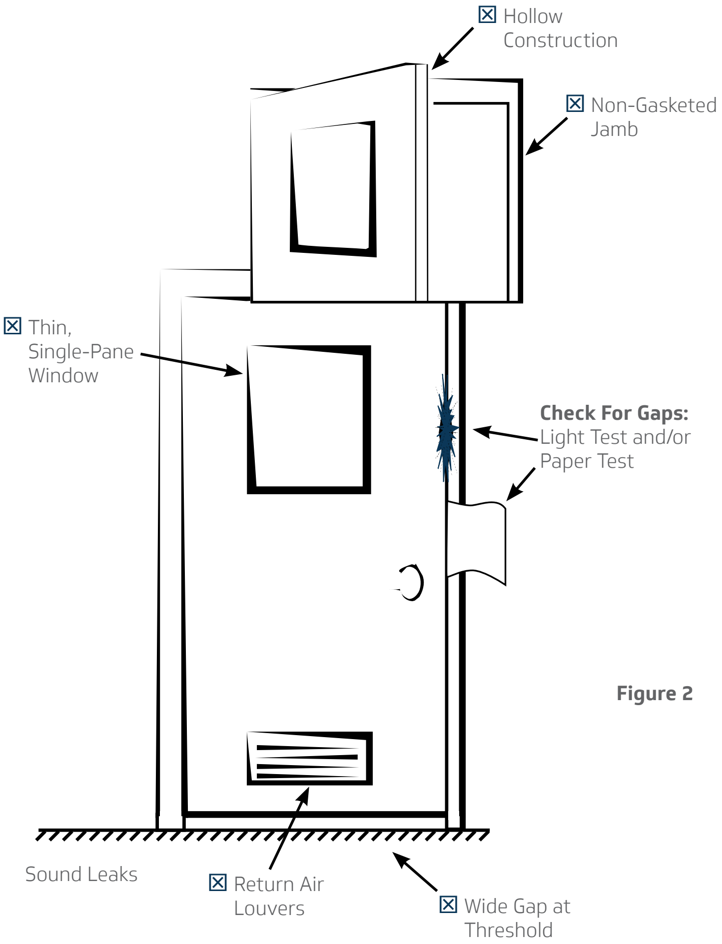


Figure 2

BEST SOLUTION:

If your doors or windows are not sound-rated, replace them with sound-rated products (STC 43 minimum, see glossary).

See that they are installed and sealed properly.

- For poorly constructed doors, it is possible to increase the sound isolation ability by adding mass with materials like 3/8" (19 mm) plywood or sheet metal applied to both sides. Evaluate how this may interfere with the leverset, hinges and jamb. For this solution we recommend working with a carpenter. Also, evaluate the costs of this compared to installing a new door.
- To eliminate sound leaking through a single pane of glass, consider adding a second pane of laminated glass. Use glass that is at least 1/4" (6 mm) thick and separate the two panes as far apart as possible. Make sure your alterations do not compromise fire codes and again compare the costs to installing new window units.
- If your doors and windows do not have seals, or they are torn or missing, add new seals. Magnetic seals work the best but, if they are not an option, make sure to choose a dense, flexible material like neoprene. When the door or window is shut, the seals should be in line with, and compress against, a flat clean surface. The goal should be an air tight connection.
- Many doors will have a drop-down sweep seal that seals against the threshold when the door is shut. Often these are simply out of alignment and can be adjusted with a screwdriver. If there is no sweep seal, have one installed. Typically they consist of a sweep-seal closure and threshold plate. They will require frequent checking to ensure proper alignment.
- For window panes that are loose in their mountings, re-glaze the openings or seal panes to be airtight.
- Evaluate the need for each door and especially windows. In some cases, you may be able to do without them. If you can wall them in, be sure to check building and fire codes for compliance.
- You can increase the sound isolation of your doorways by adding a second door in front of your original door — similar to the double doors common between adjoining hotel rooms. This is easiest if your door is recessed or in a slight alcove. Again the input of an acoustic expert and carpenter are necessary.
- Louvers in a door can simply be taken out and the remaining hole insulated and surfaced with solid boards. Make sure to check with a mechanical engineer or your building maintenance supervisor to be sure return air circulation will not be interrupted.

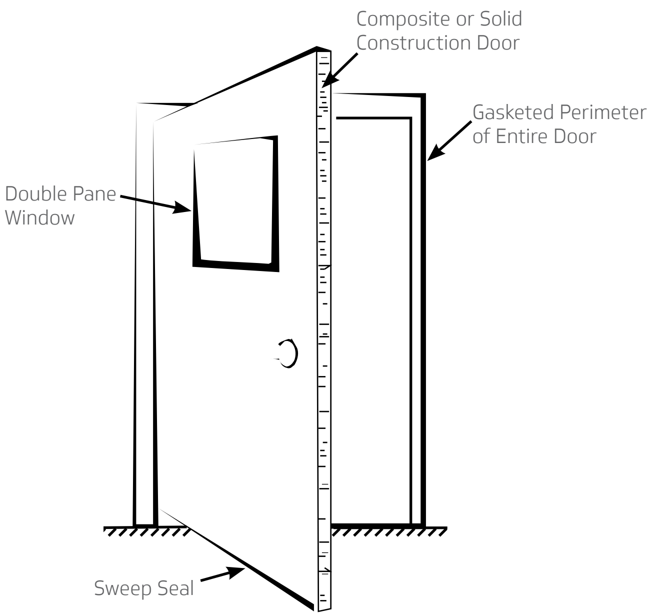


Figure 3

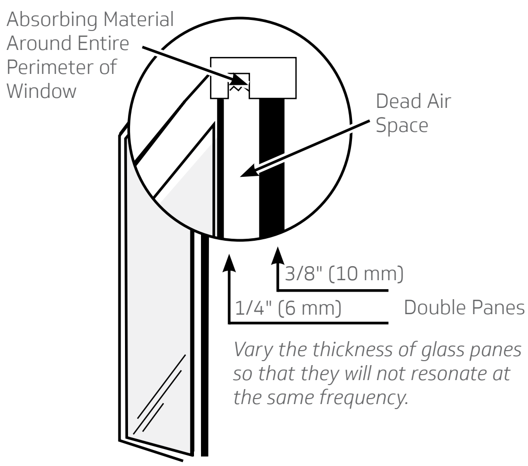


Figure 4

Walls

While walls are impenetrable visual barriers, they are often poor sound barriers. And keep in mind it doesn't take much to compromise the isolation effectiveness of a wall. In fact if you had a solid 4' x 8' (1219 X 2438 mm) wall and put a tiny hole in it the size of a quarter, you would reduce the effectiveness of the wall by 80%. Identifying the trouble spots will require some thorough checking. The walls you probably want to focus on are interior walls, especially those that are shared with adjoining classrooms or office spaces. To provide adequate sound isolation, walls need to have a great deal of mass, seal at the floor and ceiling deck, and contain a space of dead air and insulation.

Wall Checkpoints

- Start by inspecting your walls. Look for visible gaps or openings. Have someone go to the other side of your wall and generate noise, then pinpoint your trouble spots. To the best of your ability, determine the composition of your walls. Are they cement block? Some lightweight cement block is very porous and can actually transfer a great deal of sound. If you have wood or metal studs and a single layer of gypsum board without insulation, you will probably hear significant noise right though them (figure 7).
- Are your walls sealed along the floor? If you notice sound or air movement from along the bottom of the wall, check to see if they have been sealed with a caulking to the floor. You may have to pull back a small section of trim or mop board. Look for gaps and even light coming though from the other side.
- Is sound pouring in from the top? Look above your suspended ceiling to see if the wall extends to the roof deck (figure 5). Often with a suspended ceiling, walls do not extend all the way up to the roof deck. The walls should extend to and be sealed at the overhead construction.
- Look at all the places smaller holes have been cut into your walls — switch plates, electrical boxes, phone and data ports. Often these holes are cut directly through to the room on the other side and greatly compromise the sound isolation.
- Look at all of the larger openings in your walls. Doors, windows, ventilation ducts. Check along the framing to see that the wall is sealed and tight against the jamb, sill or duct. You may have to pull back some trim to find the leak.

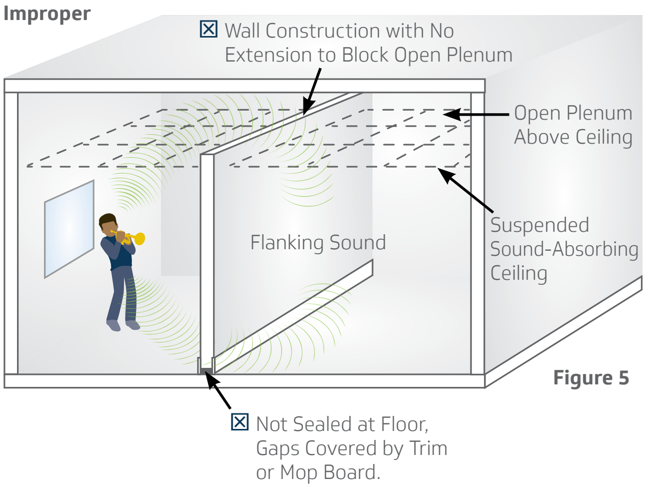


Figure 5

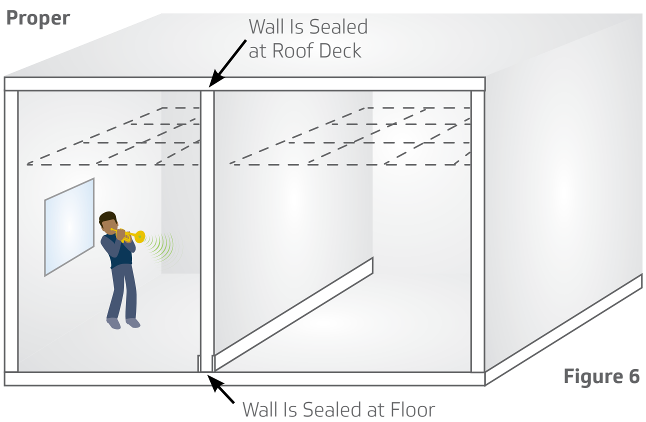


Figure 6

BEST SOLUTION:

If you have a wall that is just too thin, look into adding another wall in front of it or even tearing it out and building a correct, sound isolating wall (figure 8). If you go to this extreme you will also be able to address other issues like adding insulated, off-set electric boxes and cable runs. We recommend that you consult with an acoustician to create the proper specifications for reconstructed walls.

- Sealing your walls at the ceiling, floor and around window and door frames is very important and often overlooked during construction. These gaps can be as large as few inches or just a fraction of an inch and are often hidden under trim strips. For large gaps, use a material that will be dense and solid — like gypsum board as opposed to just stuffing the space with fiberglass. For small gaps the only solution may be a silicone caulking.
- Correcting improper wall construction (figure 5) is absolutely critical for adequate sound isolation. It will require a skilled carpenter to extend the wall to the ceiling deck and seal it correctly. Another option you can look into is a loaded vinyl sheet plenum barrier. Make sure any work is in keeping with current fire and building codes.
- Back-to-back electrical boxes and cable runs that leak sound can be fixed by horizontally offsetting the boxes and adding fibrous insulation. Again, hire a professional to do the work. We recommend offsetting the boxes by a minimum of two feet to assure that at least one stud separates the boxes.

Improper Wall Construction

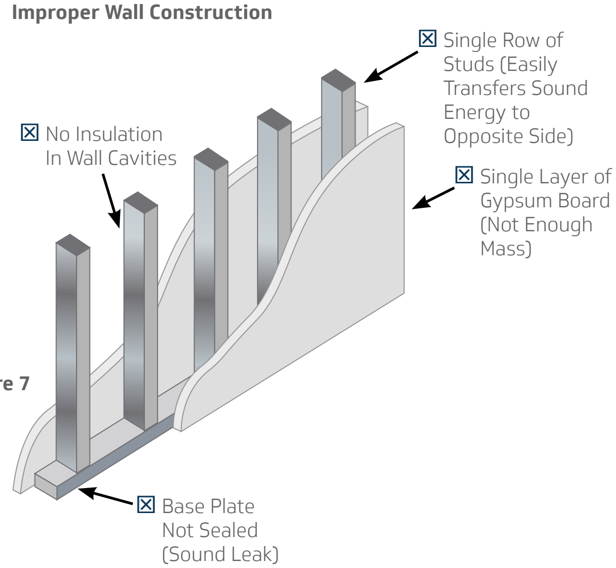


Figure 7

Proper Wall Construction

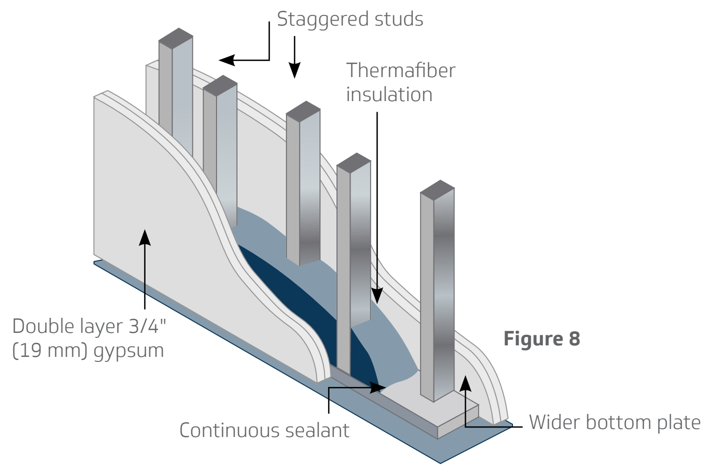


Figure 8

Ceilings And Floors

Like a wall, the ceiling and floor must have sufficient mass to isolate sound. Ceilings that are roof decks are often too thin or constructed with corrugated steel. And if the ceiling in your room is the floor for a room above, you may hear significant sound transfer. Holes cut into floors and ceilings for ductwork, electrical and plumbing can also cause problems unless correctly detailed.

Ceiling And Floor Checkpoints

- Check the construction of your ceilings.
  a. If it is concrete (figure 9), sound isolation problems are probably the result of sound transmission from loud class activity on the floor above, adjoining areas, or from building machinery.
  b. If your ceiling is also the building roof and made of corrugated steel, it may not have enough mass to isolate sound.
- Check your floors and ceilings for improperly sealed wall seams and holes. Look around conduit, ductwork, pipes and plumbing and check them for sound, light or air movement.

Figure 9

Ceiling And Floor Solutions

- If you suspect your ceiling does not have enough mass and you are hearing noise like airplanes or rain, add a suspended sound-isolating ceiling supported by acoustical hangers (figure 10) to increase the overhead sound isolation. Bring in an acoustician to evaluate your situation.
- Metal roofs are often corrugated and not sealed to the walls (figure 11). Trusses are another typical trouble spot for isolation. Make sure common openings between rooms are sealed.
- If you are experiencing sound transmission coming into your room from the floor, you may need to consider installing a floated floor (figure 10). Again, this is an expensive and complex solution that will require the input of an acoustician or architect.
- To seal holes around pipes, conduit, vents, etc., patch opening with gypsum board or other heavy material and caulk perimeter joint at penetration with an acoustical sealant.

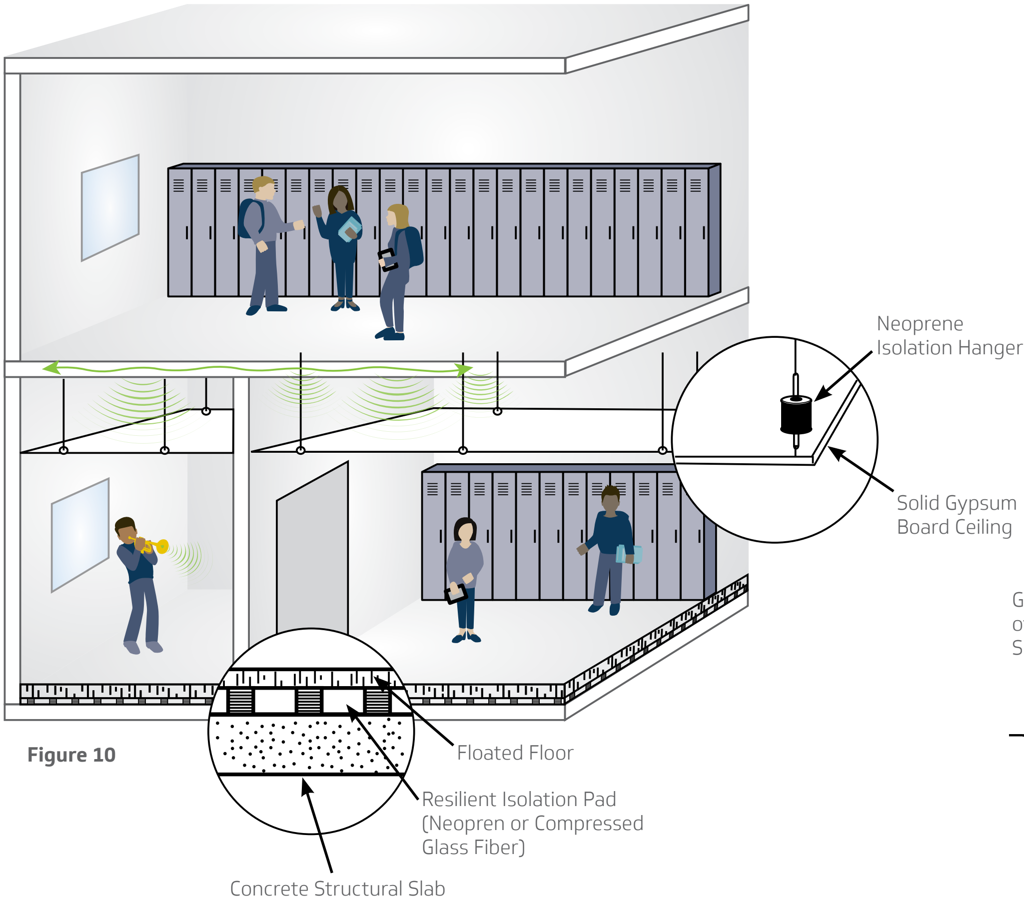


Figure 10

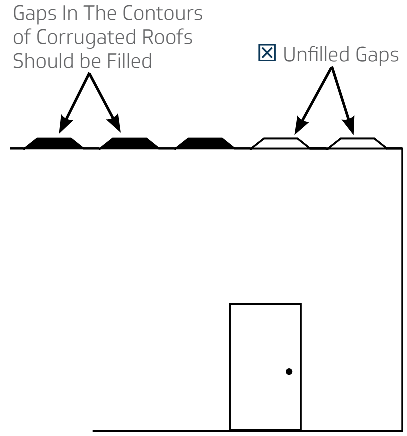


Figure 11

AREA OF CONCERN

Interior Room Acoustics

Music Room Acoustics Require Special Attention

Most of the classrooms in a school are designed for lecture-based education. Acoustically, these rooms need only support speech communication. Just the opposite is true in music areas where construction and finishes that are fine for classrooms can cause acoustic problems in the music area. A square room with carpet and a 9' (2743 mm) ceiling maybe fine for English, but disastrous for music education. We often find that while a bad music room can't be made acoustically perfect without major reconstruction, it can usually be improved. This section focuses on identifying the root causes of acoustic problems in music rehearsal spaces and suggests some of the steps you can take to make improvements.

Interior Acoustic Problems In Rehearsal Rooms Related To Size, Shape And Surfaces

"My room is too loud, my ears are ringing every day."

"The room has a boomy, bass-heavy sound."

"The room is hard to hear in, I can't pick out the parts and some sections are totally lost."

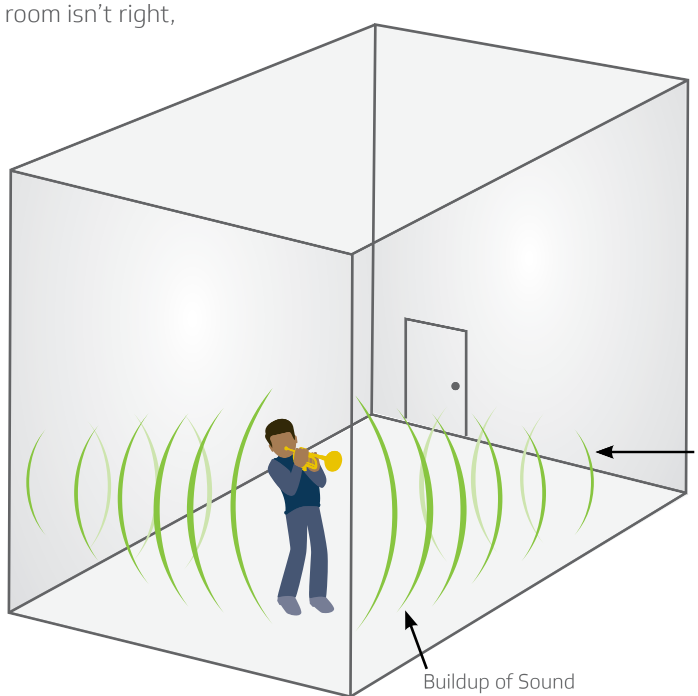
"There are strange echoes and some frequencies seem to buzz."

"The room eats up sound... so little comes back it's just a dead room."

Interior Acoustic Problems

The size, shape and surface materials of a rehearsal area all play key roles in defining the acoustics of the space. If something in your room isn't right, there are a variety of problems you may be hearing.

- The room is too loud
- The room is boomy and bass-heavy
- Echoes, flutters and frequency anomalies
- Difficult to hear in — hot spots, dead spots, muddy sound, excess reverberation



Loud Room

A loud room is one of the most common complaints in rehearsal areas. Usually this is a result of small rooms that do not provide adequate cubic volume. Hard, reflective surfaces in your room may also contribute to excessive loudness.

Materials To Avoid

Don't use thin drapes, foam, carpet or thin panels to absorb sound. These materials just do not have the physical properties necessary for broad-range musical sound absorption. In fact, when used they are almost guaranteed to create more problems than they solve. Remember, solutions that work in lecture-based class rooms may not work in music areas.

Loud Room Checkpoints

- Check your room's size, the crucial measurement is cubic volume — square footage multiplied by ceiling height (figure 12). Even if your room seems big, make sure it isn't all floor space — your ceilings should be at least 16' high. Compare with Wenger's rule-of-thumb guidelines (table 1), and make sure to factor in the size of your ensembles.
- Evaluate the surfaces in your room. Are you surrounded by hard reflective materials on your ceiling, floor and walls (figure 13)? If you are, excess loudness is just one of a number of problems you may be hearing (also see echoes and standing waves on page 18).

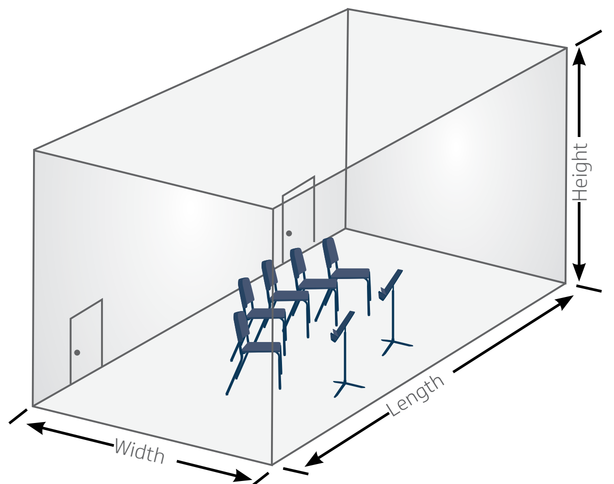


Figure 12

Cubic volume formula:
Length x Width x Height = Cubic Volume

How Much Cubic Volume Is Enough? Rule of Thumb

Room	Class size	Ceiling Height	Typical Floor Space	Resulting Room Cubic Volume
Choral Rehearsal	60-80 Students	16-20 feet (4877-6096 mm)	1,800 ft^2 (167 m^2)	28,800 - 36,000 ft^3
Band/Orchestra Rehearsal	60-75 Students	18-22 feet (5486-6706 mm)	2,500 ft^2 (232 m^2)	45,000 - 55,000 ft^3

Table 1

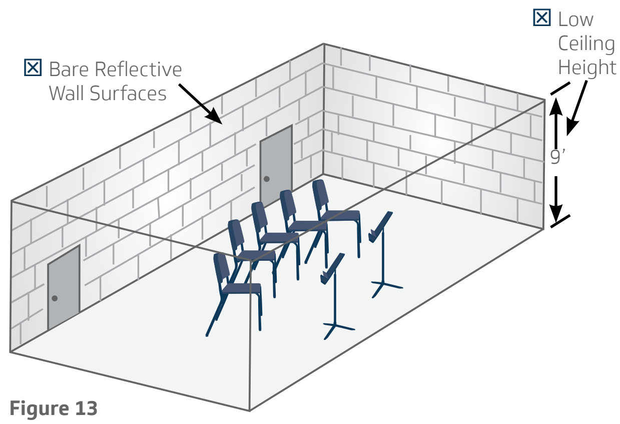


Figure 13

BEST SOLUTION:

Find a way to increase the cubic volume of your space. This can be done in a number of ways such as removing a portion of your suspended ceiling. If you have closed risers, see if they can be removed and rehearse on a flat floor or on portable open riser units that connect the cubic volume underneath to room. Remove a wall and expand your room (figure 14). No matter how you increase cubic volume, we first recommend the consultation of an acoustician. For any structural modifications, work with your architect.

- If your space is too small and can't be made larger, you will be limited in what can be done to reduce loudness. Look into other larger areas in the facility where you might be able to relocate rehearsals.
- Remove whatever you can to make more room for sound. Relocate cabinets, desks, marching band equipment, etc.
- If your room is surrounded by individual practice rooms, open their doors when they are not being used to increase the acoustic volume of your rehearsal room.
- Sound absorption panels, when properly applied, are another way to quiet a room. To be effective across a broad frequency range they should be at least 3" (76 mm) thick (figure 16). Absorptive panels are also used to treat a number of other acoustic problems and must always be used in conjunction with diffusive surfaces. Consult an acoustician or a company experienced in acoustical panel solutions.
- Heavy curtains can also provide acoustic absorption when properly applied. Use 18 oz. velour curtains hung at 100% fullness, about 12" (305 mm) in front of a reflecting wall. This trapped air space is critical to enhancing the low-frequency absorption effect of the curtain (figure 15).
- As a last resort, you can consider reducing sound energy by splitting rehearsal times and reducing your group sizes.

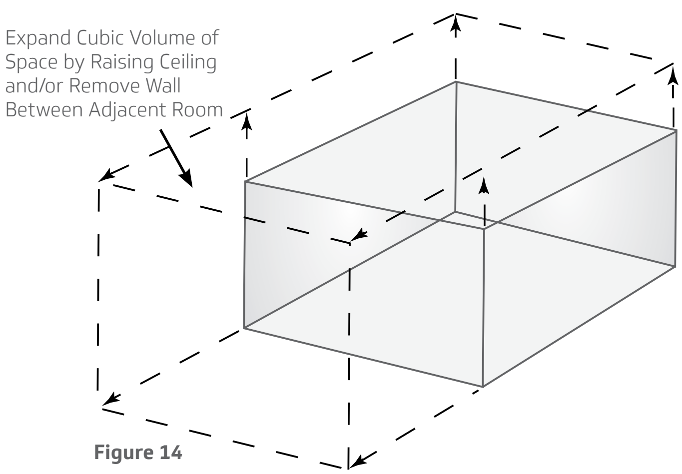


Figure 14

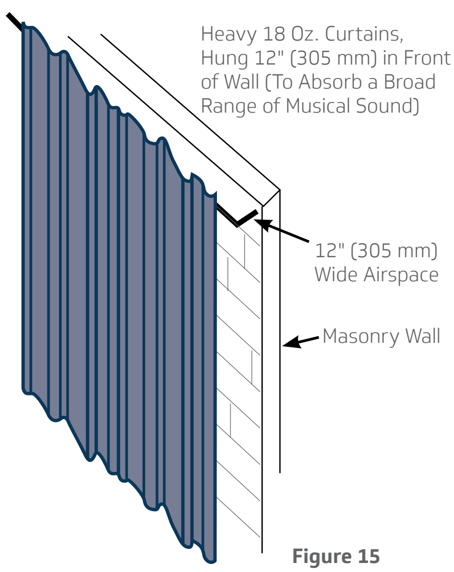


Figure 15

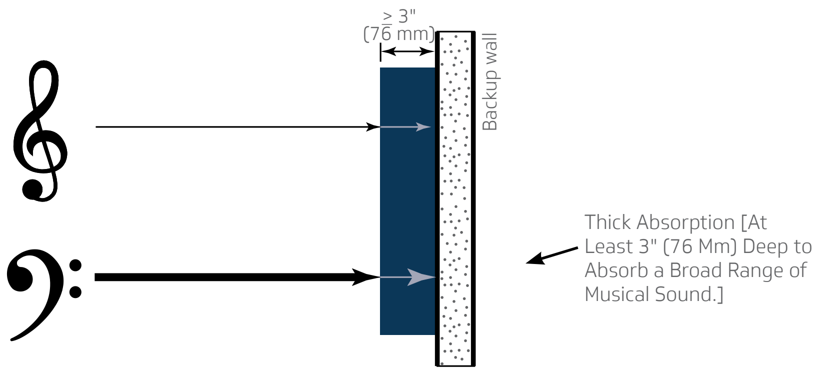


Figure 16

Boomy, Bass-Heavy Room

Sometimes rooms are mistaken to be too loud when in fact the real problems are exaggerated low frequencies which make the room boomy and bass-heavy. In a room like this, there are things happening that are stripping out the higher frequencies while leaving the lower frequencies unaffected. Usually this is the result of improper surface treatments. In simple terms, surface treatments that are too thin can absorb high frequencies like flutes and harmonic overtones, but do not have the physical characteristics to absorb powerful low frequency sound. The result is a room that absorbs high frequencies thereby accentuating the low end.

Boomy, Bass-Heavy Room Checkpoints

- Check your room's cubic volume and compare with Wenger's rule-of-thumb guidelines (table 1, page 14).
- Evaluate the surface materials in your room. Boominess is often the result of attempting to quiet a room with the wrong materials — carpeted walls, egg-crate foam, thin absorber panels, thin drapes, standard ceiling tiles. These are all problem materials that will strip out the higher frequencies leaving lower frequencies unaffected.

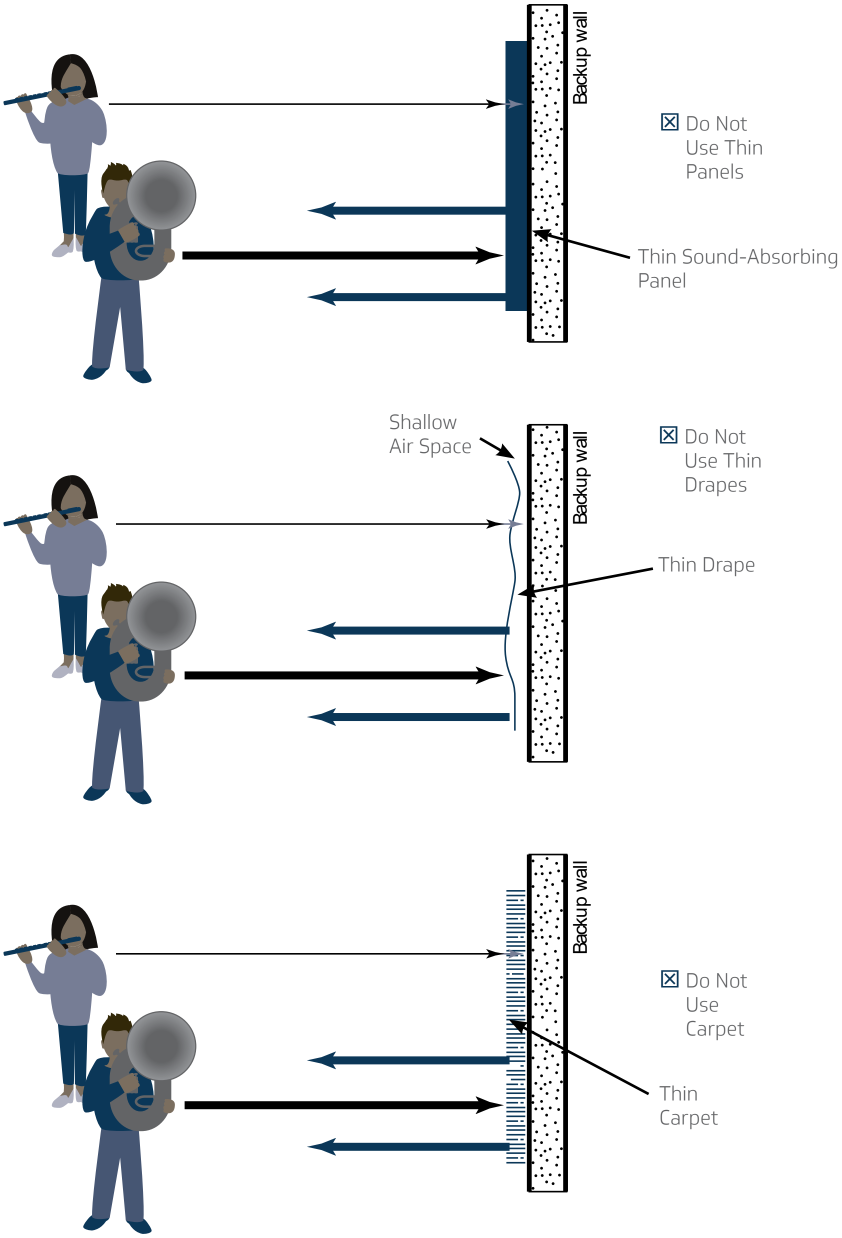


Figure 17

Boomy, Bass-Heavy Room Solutions

- Remove thin curtains and carpet (especially on walls) and replace with materials that will provide effective absorption across a broad frequency range.
- Apply absorption panels at least 3" (76 mm) thick. The thicker the absorber, the more the loudness of bass frequencies is reduced. These solutions may require the involvement of acoustic professionals.
- Replace reflective ceiling tiles with 1" (25 mm) thick acoustically absorptive (rated at NRC 0.95 or higher) fiberglass panels (figure 19). Remember the more space above these panels, the better the low frequency absorption.

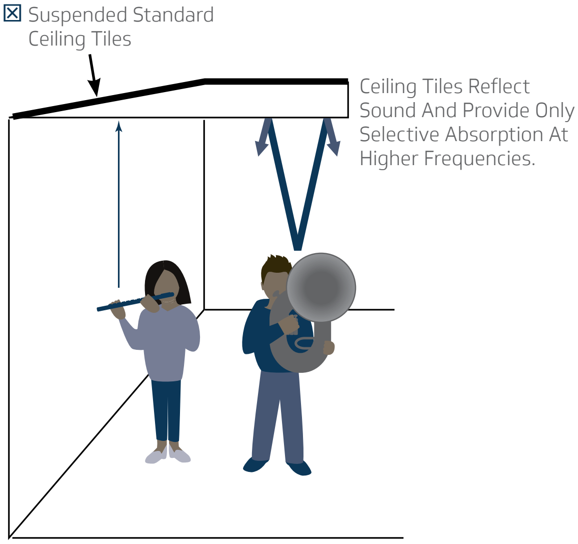


Figure 18

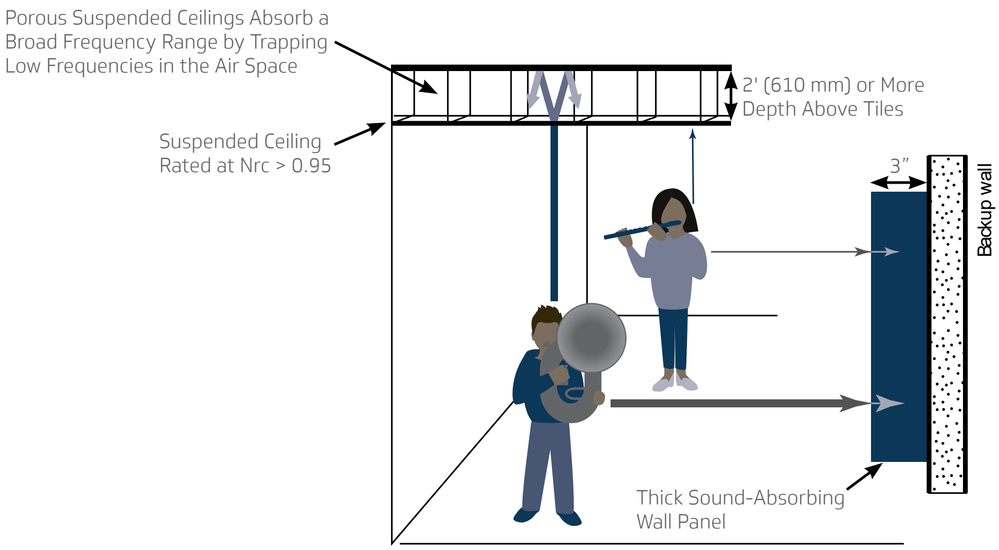


Figure 19

Echoes And Standing Waves

Room shape and surface materials play the biggest role in creating unwanted echoes and frequency anomalies such as standing waves. Parallel, flat untreated reflective surfaces such as brick or concrete block walls facing each other are usually to blame. Keep in mind that the two largest facing surfaces in most rooms are the floor and ceiling.

Leave The Floor Untreated

In most cases, musical sound reacts best to a wood or tile floor. Surfaces like this provide quick, early reflections to each musician. Carpet will strip out the higher frequencies providing only selective reflection. Rooms that generally provide the most satisfaction have untreated floors with acoustical treatments on the walls and ceiling.

Echoes And Standing Waves Checkpoints

- Look at the shape of your room.
  a. Square rooms are the worst for echo and standing wave problems.
  b. Rectangular rooms, have large reflective walls which often create slap echoes and flutter echoes.
- Look at the surfaces of the walls and ceiling in your room. Are they brick, concrete, ceramic tile, glass, or other flat reflective materials? If so, they will need to be treated.

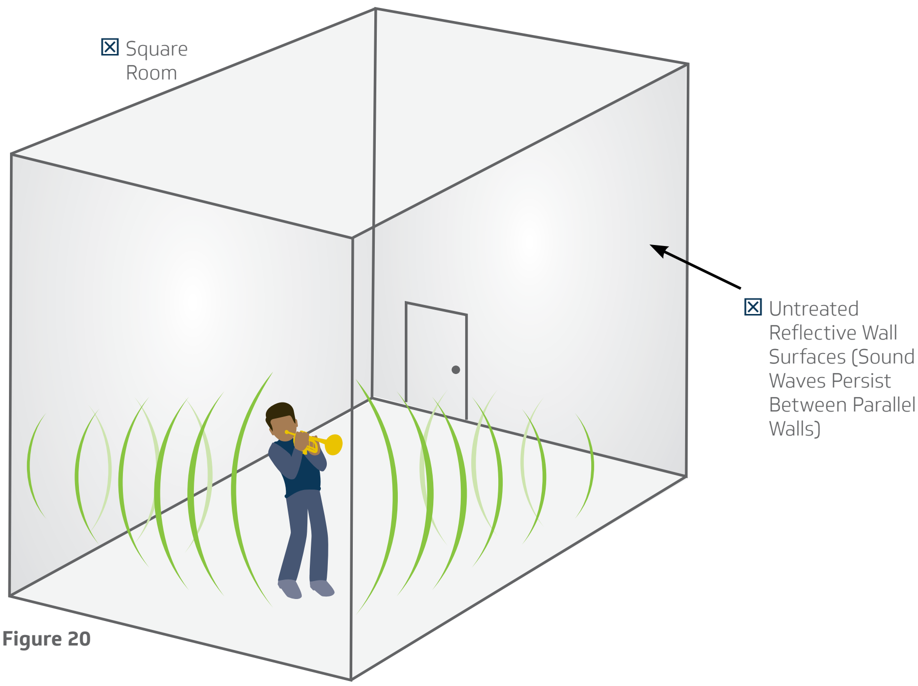


Figure 20

Echoes And Standing Waves Solutions

- The primary goal is to minimize parallel, reflective paths between the surfaces in your room. This is best accomplished with a combination of diffusive and absorptive treatments. These are easily applied to walls and ceilings. Again, we recommend the consultation of professionals experienced in rehearsal room acoustics and treatment solutions.
- To treat large glass surfaces, add heavy, velour drapes over sections of the windows.
- Walls may be splayed or angled but to be effective this must be done on two planes - for example a sawtooth wall would also need to be slanted from floor to ceiling. You will need to consult an acoustician.

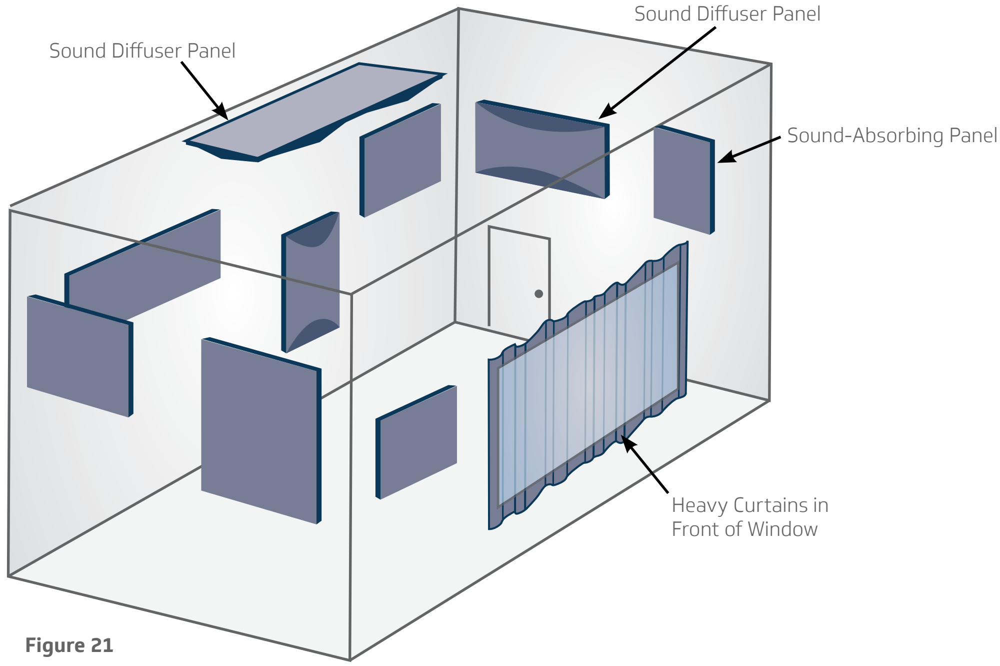
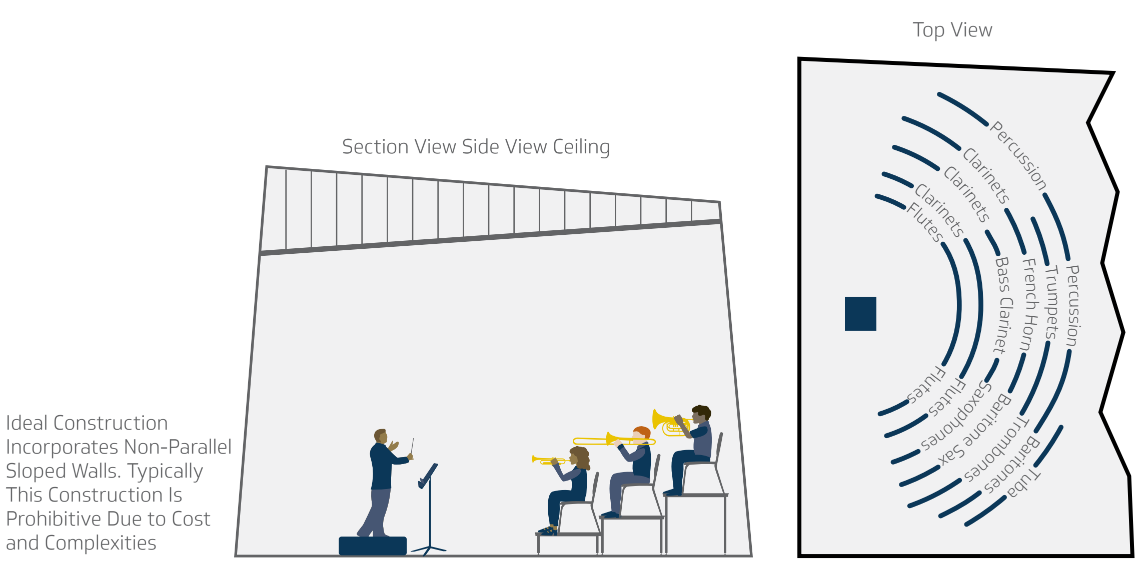


Figure 21



Poor Ensemble — Difficult to Hear

Rooms that are simply described as “difficult in which to hear” usually are exhibiting problems related to room shape and interior treatments. Hot spots, dead spots, excessive reverberation, a lack of clarity or a combination of these types of problems make proper ensemble difficult if not impossible. These problems are usually treatable with the proper mix of absorption and diffusion. If your room is difficult to hear in as a result of competing noise, see the Sound Isolation section (page 6-11) and Mechanical Noise section (page 22-23).

Absorption And Diffusion Work Together

Too often absorption treatments are applied without properly integrating diffusion. It is important to understand that for a music space to support critical listening, qualities of absorption and diffusion must interact. While proper absorption can balance the dynamics of frequency and control loudness, diffusion must also be present to scatter and blend musical sound. An acoustical consultant experienced in music rehearsal rooms will be able to recommend the proper interaction between absorption and diffusion.

Poor Ensemble — Difficult to Hear Checkpoints

- These problems are often the result of a number of variables and are difficult to pinpoint to one treatable issue. The best thing you can do is to concentrate on what you are, and are not, hearing in your room. Make sure to move around the space to evaluate the acoustical differences within the room itself.
- Be sure to look at room shape. Concave ceilings and curved walls focus sound energy creating hot and dead spots (figure 23).
- Surface material also plays a critical role.
  a. An overly sound-absorbing space with lots of carpet, drapes and/or panels can create a very dead room.
  b. Conversely, a lack of absorption creates an excessively reverberant room.
- A room without reflective diffusive surfaces will almost always result in poor ensemble.

☒ Low Ceilings

Figure 22

☒ Concave Surfaces

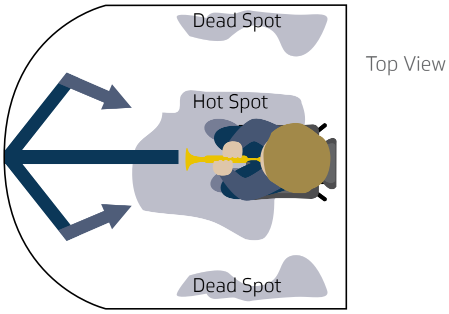


Figure 23

BEST SOLUTION:

Have your room evaluated by an acoustical consultant experienced in rehearsal room acoustics. The solution should be a proper balance of absorption and diffusion on the walls and ceiling (figure 24). Make sure to use proper materials that will be effective across a broad frequency range.

- If your structural ceiling deck is less than 10' (3048 mm) above the floor (figure 22), you will need to start looking for a new space. Ceilings this low make proper diffusion and the resulting ensemble impossible to achieve.
- Be prepared if your acoustical consultant wants to undo some improper treatments in your room. If your walls are carpeted for example, you may need to remove the carpet. Suspended ceiling panels are another existing treatment that may need to be altered.
- Another key element of proper ensemble are reverberation times that, among other things, give a musical space a quality of presence. A space that provides musicians with a sense of presence will return reflections to the musicians with enough delay after the primary sound so that the human ear can process the information. Musicians often refer to a space like this by saying that they can "hear their sound out in the room." See table 2 for Wenger Corporation guidelines of reverberation times that create a musically supportive space without being overly reverberant. A trained acoustical professional can help evaluate the reverberation in your areas.
- Assure that your treatments are properly located to the exact specifications of your acoustical consultant.

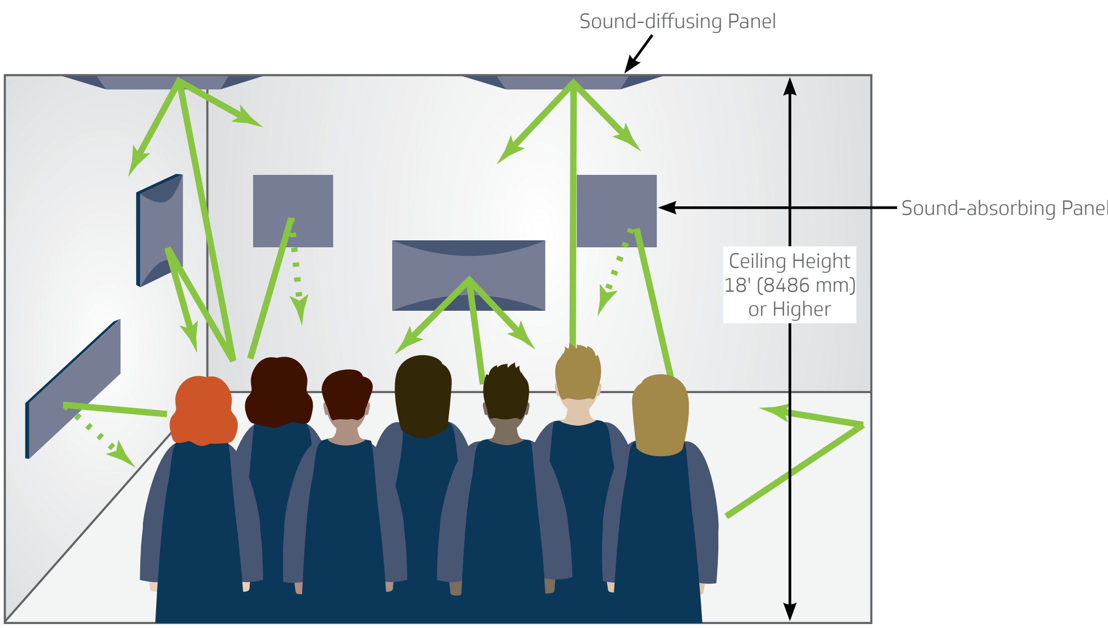


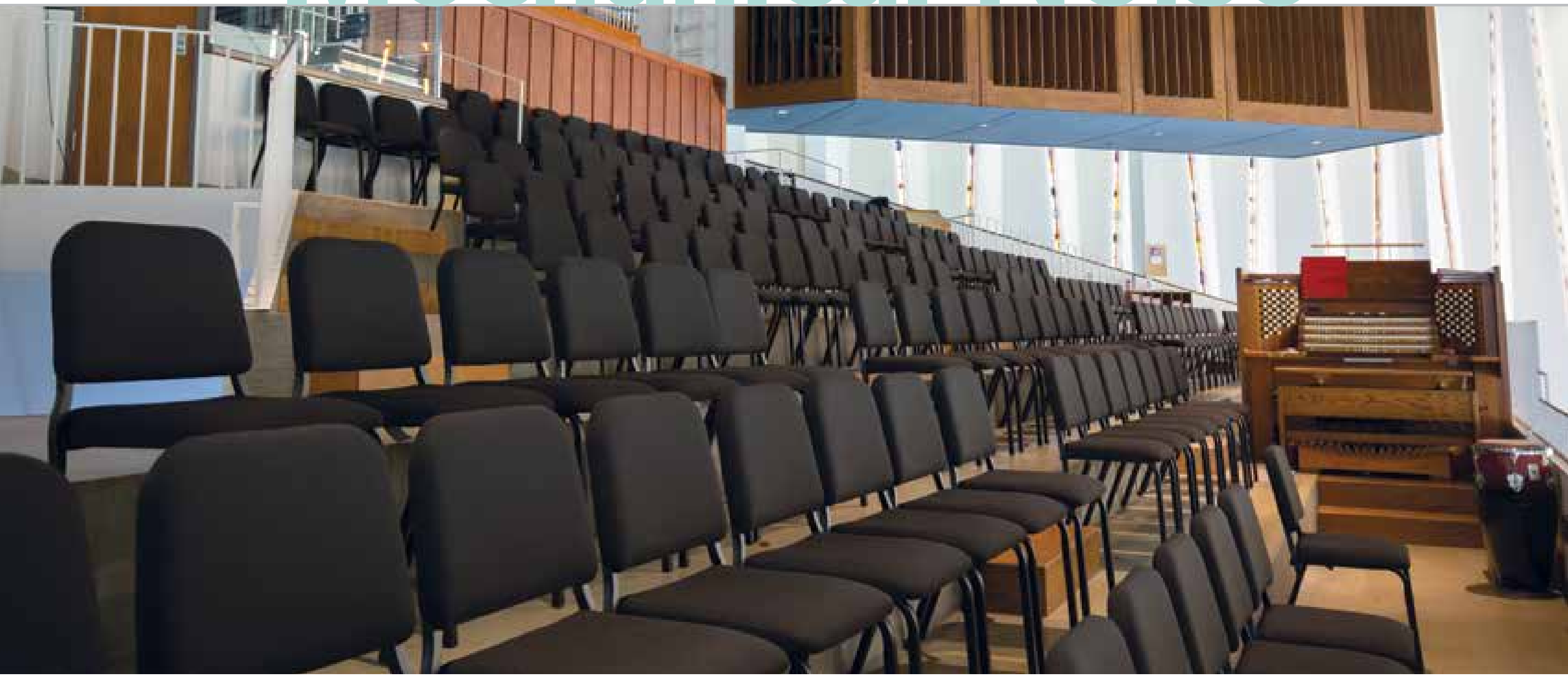
Figure 24

Recommended Reverberation Times	
Room	Reverberation Time
Choral Rehearsal	Up to 1.3 Seconds
Band/Orchestra Rehearsal	0.8 - 1.0 Seconds

Table 2

AREA OF CONCERN

Mechanical Noise



Mechanical Noise

There are a wide variety of building systems and equipment within a room that can generate unwanted noise. The biggest culprits are the heating, ventilation and air-conditioning (HVAC) systems. However, lighting systems, in-room appliances, and even the compressor on a drinking fountain can all create nuisance sounds in a music room. Not only do they create distractions from musical sound but they can mask certain musical frequencies making them difficult or impossible to hear. With proper isolation and treatment, unwanted mechanical noises can usually be fixed or quieted.

Mechanical Noise Problems

"The whooshing of air from the vents in my room creates a white noise and makes it really difficult to focus on the subtleties of our music."

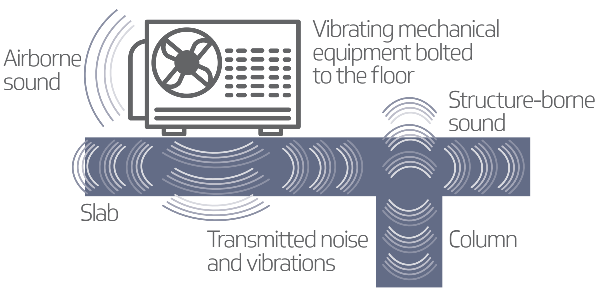
"The air conditioning units for the building are right over our room."

"Our ductwork channels the noise of our heating system and we hear the rattles and squeaks from the boiler room like it was next door."

Mechanical Noise Checkpoints

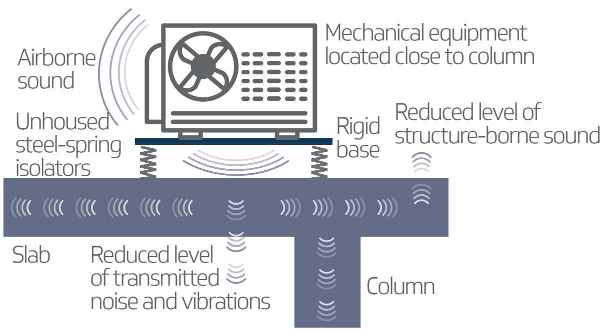
- Are you hearing an annoying whooshing sound from your air outlet vents? This is usually the result of openings that are too small and/or tight grillwork (such as perforated metal) that restricts the airflow (figure 27).
- If the HVAC systems mechanical rooms are near or adjacent to your music room you will probably be distracted with compressor noise and vibrations. Find the equipment — look on the roof over your room, outside your room on the ground level or below your room in a basement. If this equipment is not properly isolated it will transfer low-frequency sound right through the building structure (figure 25).
- Listen for sound coming from your vents. If your HVAC equipment is far away, and you are still hearing compressor noise, rattles and squeaks, your ductwork is channeling the noise into your room. If you are hearing the sounds of adjacent rooms through your vents, your ducts again are creating a channel for the noise.
- Noise often is created by worn bearings and belts, lack of lubrication, or even improperly balanced air distribution systems. Be sure to regularly maintain HVAC equipment.
- Are your lights buzzing? Transformers and old-style (electromechanical) fluorescent light ballasts create a very distinct and buzzing noise that masks musical sound. Be sure ballasts are rated for low noise output.

- Remember, music rooms need nearly twice the rate of fresh-air exchange as a classroom of equal size due to the physical activity of making music. As a result, vent openings need to be large with open grillwork (figure 28). Work with your building engineers to solve the problem of small vents and heavily screened grills.
- If the HVAC system mechanical rooms are too close to your room the best solution is to relocate them. If this is not a possibility, contact an acoustic professional and determine what type of sound isolators could be installed to resolve the problem. Often, springs and neoprene isolators can "decouple" the equipment from the surrounding structure (figure 26).
- Ductwork that is channeling sound can be quieted with sound absorptive linings or baffles (called "sound attenuators"). Again the help of an acoustical professional and your building engineer will be necessary.
- Squeaks and rattles are usually an indication that HVAC systems need some maintenance. Ask your building engineer if lubrication, new bearings and belts or any other procedure might quiet the system.
- Quieting noisy light transformers and ballasts is easy and saves energy. Electronic ballasts with an "A" sound rating are quiet and consume less energy. Work with your building engineer to get your lighting systems updated.



INCORRECT
Mechanical equipment bolted to the floor transmits vibration directly to the structure. This construction method is unacceptable in the music suite.

Figure 25



CORRECT
Mechanical system vibration can be reduced by mounting the equipment on steel spring isolators.

Figure 26

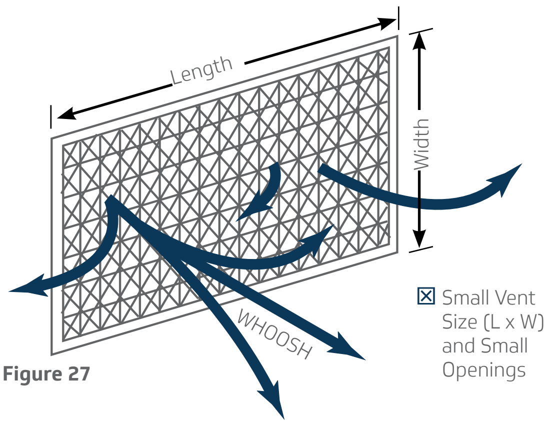


Figure 27

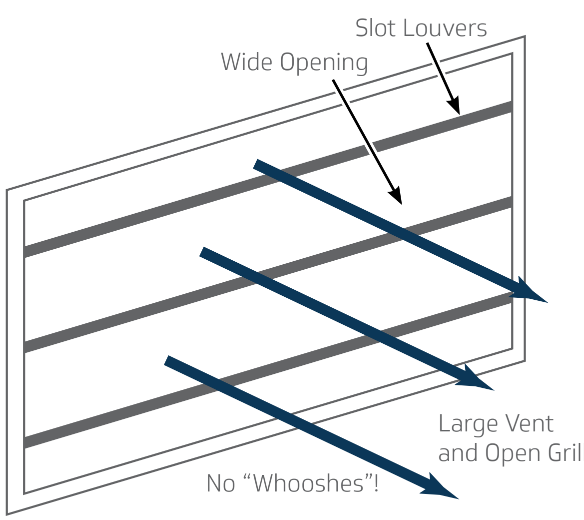


Figure 28

AREA OF CONCERN

Practice Room Problems

The Practice Room Paradigm

Just like large rehearsal rooms, good practice rooms must provide sound isolation and musically supportive interior acoustics. Unfortunately practice rooms are among the worst music spaces possible because they break the first rule of good acoustics — they do not provide enough cubic volume to properly dissipate the sound energy created within. The best of these rooms will be heavily absorbed so that the sound in the room is balanced across a broad frequency range. An unavoidable result of the heavy absorption is a room that is acoustically very dry. While these dry spaces can be appropriate to work on basic technique and the mechanics of making music, they are acoustically opposite of the environments in which musicians would choose to perform.

Practice Room Acoustic Problems

"We haven't used our practice rooms for years because they don't contain sound — in one we store candy, in the others we keep our marching band equipment."

"We have a row of practice rooms, but we only use every other room. It's the only way to control the sound."

"We've put a lot of money into thicker doors and insulated walls, but you can still hear the practice rooms loud and clear from the band room."

Active Acoustic Technology

Active Acoustics utilize electronics, computer technology and digital signal processing to acoustically treat an environment. This cutting-edge technology is used to create virtual acoustic spaces and is rapidly being adopted around the world to turn poor musical environments into great environments with the push of a button. In music practice rooms, active acoustics has changed the practice paradigm — now it is possible to recreate the acoustic support of a world-class auditorium in a practice room that may not be any larger than a closet. Active Acoustics can also be used to treat a large rehearsal room, not only giving it variable acoustic options, but also solving acoustic problems without renovation or construction.

Practice Room Checkpoints

Practice Room Problems Checkpoints

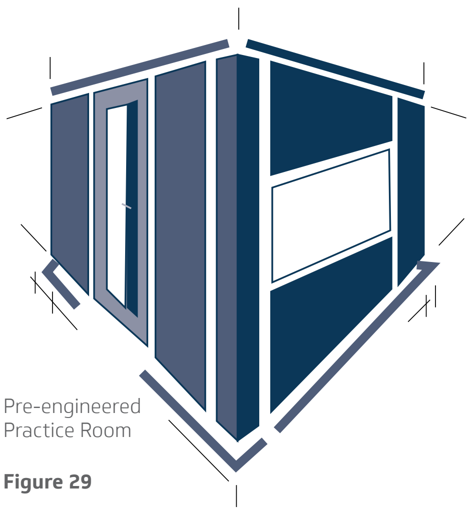
We recommend the input of an acoustic professional to help evaluate your rooms.

- Evaluate sound isolation. Do your practice rooms leak sound? Have someone play an instrument in the room and if possible pinpoint the trouble spots — pay close attention to the door, window, electrical boxes, ventilation ducts and walls. With most built-in practice rooms, it is common that there are a number of trouble spots and it may be difficult to identify them all. Refer to pages 4-11 — all of the same rules apply for checking things like gaskets on doors, wall construction, sealed ceilings, etc.
- Evaluate interior acoustics. Is the room treated with any absorption? If not, hard reflective surfaces in a practice room will further complicate the acoustic qualities of these small areas. Because practice rooms have such limited cubic volume, you will typically experience a wide range of overlapping acoustic shortcomings. Most often the room will seem too loud and will accentuate the bass frequencies. You may also notice that it is difficult to hear all of the sound qualities you would expect. This is due, in part, to the fact that reflections are returning too quickly for your ear to distinguish the critical components of the sound.
- Evaluate HVAC and electrical system noise. Pay attention to other possible problems like noisy ventilation ducts, HVAC systems or buzzing light ballasts. Refer to pages 22-23 for a broader explanation of diagnosing and solving unwanted mechanical noise.

BEST SOLUTION:

Practice rooms need to isolate sound and the type of construction necessary to ensure good sound isolation is very complex and costly. The best way to ensure that your rooms will function properly is to replace them with pre-engineered, modular solutions (figure 29). Too often we have seen time and money invested into isolating doors and construction only to have the rooms fail due to small, overlooked details such as back-to-back electrical boxes. As a result, the guarantee of pre-engineered solutions, combined with the ability to relocate them, ensures a sound investment that will last well into the future.

- With the consultation of an acoustic professional, you may be able to improve the isolation qualities of your built-in rooms. Typically this will require many of the same steps described on pages 4-11. Walls will need to be built with sound-isolating construction techniques (figure 8, page 9) and sealed at the floor and ceiling (figure 6, page 8). Doors and windows will need to be properly constructed and gasketed (figures 3 and 4, page 7).
- Ventilation ducts will provide the best isolation if they are lined internally with absorption and separately feed each room off a main duct (figure 31).
- If you are fortunate enough to have a practice room that isolates sound, the best thing you can do for the internal acoustics is to add a significant amount of thick absorption material. The rule of thumb for a practice room is 3" (76 mm) thick fibrous absorption covering more than 30% of the room's surfaces. The result will be an acoustically dry space, but at least it will provide balanced absorption across a broad frequency range.
- Active Acoustic treatment (figure 30) is another way to solve the acoustical shortfall of practice rooms, and also provide musicians with virtual music environments that can be changed with the push of a button. These solutions are based on digital signal processing and computer models of acoustic spaces that are musically supportive. For these treatments to work, your room will first require a heavy application of absorptive material.



Pre-engineered Practice Room

Figure 29

INCORRECT Ventilation
Direct ventilation supply ducts channel mechanical noise and carry sound directly from room to room.

CORRECT Ventilation
Individual takeoff branches feed each room from the supply duct positioned outside the rooms.

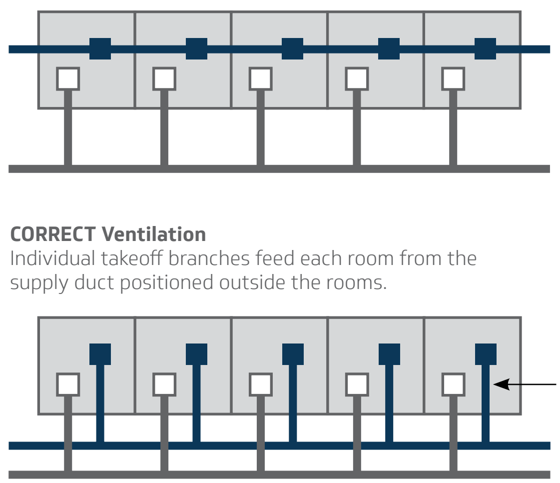
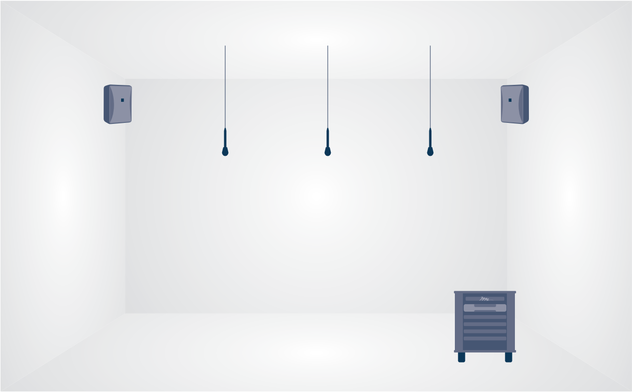


Figure 31



ACTIVE ACOUSTICS
Using a base of wall and ceiling absorber panels, active acoustics use speakers, microphones and digital signal processing (DSP) to simulate acoustic environments for practice and performance.

Figure 30

Additional Acoustic Terms

Active Acoustics:
Also referred to as electronic architecture or "virtual acoustics." Electronic devices (such as microphones, loud speakers, digital signal processors) are used to enhance the natural acoustics of a space. Effective active acoustics are also dependent on the correct room treatment with passive acoustics.

Echoes:
Echoes are produced when surfaces reflect sound to the listener after the direct sound from the source has been heard. For example, horn sections on stage may create a distracting echo off the back wall of an auditorium. Although both absorbers and diffusers can help correct this type of echo, diffusers are generally preferred because more sound energy will be conserved.

Flutter:
Flutter echoes occur when a sound source is situated between parallel, sound-reflecting surfaces. The effect is a prolonged buzzing sound. For example, a rim shot off a snare drum in an untreated room will produce a distinct flutter echo.

Masking:
Masking occurs when an unwanted noise conflicts with or masks a musician's ability to hear musical sounds of a similar or higher pitch. For example, the whooshing noise of air coming out of an air supply duct can mask musical sound.

NC:
Noise Criteria is: A single number rating to quantify the level of background noise. The lower the NC, the quieter the space.

Passive Acoustics:
This term refers to the use of architectural (non-electronic) design and acoustical surface treatments to create a musical space. Primarily broken down into absorptive and diffusive properties, elements such as geometric wall and ceiling shape and acoustic panels on walls and ceilings are examples of passive acoustics.

Reflection:
Sound reflection off a hard surface can be compared to the reflection of light off a mirror. Without reflective surfaces such as acoustical shells and overheads on a proscenium stage, for example, sound energy may be dissipated or absorbed without ever reaching the audience.

Sound Transmission Path:
Air borne: Sound that is transmitted through the air than strikes a barrier and is retransmitted on the other side.

STC:
Sound Transmission Class is: Single number rating system for describing the amount of sound isolation provided by a construction element (i.e. wall, door, window). Typically the STC rating best represents a construction ability to isolate speech. The higher the STC number, measured in the lab, the greater the sound isolation by the construction element.

Structure/Flanking:
Sound that is transmitted by direct contact with the sound source, such as an air compressor attached to a room duck or the legs of a ground piano in contact with the floor.

NIC:
Noise Isolation Class is: Similar to STC, but takes into account all parts of a structure enclosing a room.
The higher the NIC, the greater the sound isolation between rooms.

NRC:
Noise Reduction Coefficient is: Single number describing the average amount of absorption (measured in percent of perfect absorption) at octave band frequencies at 250Hz, 500Hz, 1kHz and 2kHz. It provides a good estimate of absorption when used for the speech range, but has limited value when used for music applications since it ignores frequencies below 176Hz and above 2825Hz.

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A Guide to the Principles of Sound Design by Robert E. Apfel; 1998 by Apple Enterprises Press; ISBN: 0-9663331-0-1

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