SUCCESSFUL Sound Control

These wall details softened the roar of an industrial-strength wood shop for a nearby office

There are benefits to having your business office in the same location as your workshop. It's nice to discuss projects with clients in the comfort of a well-organized office, then slip into the production facility to show off the custom cabinets that are almost ready to ship to the job site. On the downside, trying to communicate over the scream of power tools can be impossible. But there's no need to shout: You can create a quiet attached office with a modest investment, as we found out.

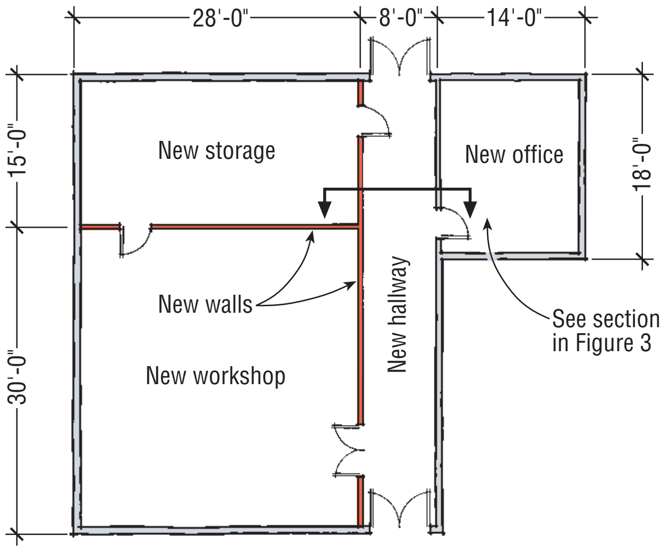
by Paul Fisette and Daniel Pepin

Design Challenge

Our situation is somewhat unusual, as the office-shop combination is located in an institutional building. But the sound-control strategy we used would work for many structures. We began with an open workshop area that measured 36x45 feet, plus a 14x18-foot storage room attached to the northeast corner of the shop (see Figure 1, next page). The problem began when the storage room was converted into office space. The workshop is used daily for a variety of noisy woodworking projects, and, unfortunately, the common wall separating the office from the workshop was not built with any special sound-attenuating details. Office staff quickly found that they could not conduct a normal conversation while

Figure 1. This woodworking shop created noise levels equivalent to the sound of a jet plane taking off. The noise was like a loud stereo in the adjacent office. The solution was to shrink the shop, adding a sound-dampening wall and a buffering hallway (below).

Isolating Shop From Office



carpenters ran oak trim through the 16-inch industrial jointer in the abutting workshop.

Because the workshop and office had to coexist in this location, a design fix was put on the fast track. We explored a staggered-use schedule, but that wouldn't work: The shop has to operate during office hours. Next, we studied the shop layout to see if we could build a sound barrier separating the shop and office. As we played with the floor plan, we realized that our shop equipment was not organized efficiently. The assortment of woodworking tools was scattered over a broad area. We could compress the layout, improve the workflow, and build sound control into a new design plan.

Measuring the Noise

Our design goal was to keep sound transmitted into the office under 60 decibels (dB). Before developing a construction plan, we wanted to know what we were up against. So we took a series of readings using a hand-held sound meter (Figure 2, next page), both in the shop (sender location) and in the office (receiver location). The measurements were taken with all equipment turned off (ambient), with individual pieces of equipment simply turned on, and with individual pieces of equipment cutting wood. The readings showed that three pieces of equipment were clearly the most offensive. The 24-inch Baxter Whitney surface planer, the 16-inch 4-cutter Newman jointer, and the 16-inch Delta radial arm saw really howled. Ambient sound in the shop and office with all equipment turned off was about 50 dB — roughly equivalent to the sound of a normal conversation. But these three tools cutting wood generated about 120 dB in the shop — roughly equivalent to the sound of a jet taking off 300 feet away. Inside the office, the sound meter recorded 85 dB, equivalent to a loud stereo. Surprisingly, the 16-inch Baxter Whitney table saw was more than 20 dB quieter.

How Sound Control Works

Sound is a vibration of something that causes the layer of molecules or air particles next to it to vibrate. The particles transmit the vibrating motion to the next layer of molecules and then to the next and so on. A popular demonstration used to illustrate this concept is to drop a stone into water. The ripples of water in this analogy correspond to the motion of sound waves. Keep in mind that while water ripples along two dimensions of the water's surface, sound waves radiate in three dimensions, like a sphere.

Logarithmic scale. Sound pressure developed by the source can be measured, but the range of pressures is so broad that a logarithmic scale is more useful. Decibels are sound-level units used to express the ratio between a reference level of sound and the level of sound at some other point, like comparing the sound right next to a table saw to the level of that sound 20 feet away. One decibel equals the smallest change in sound that the human ear can detect. A 5-decibel increment is noticeable. And each 10-decibel increment is perceived as a doubling of loudness. The science related to sound control is complicated, but at a practical level, it can be distilled into source, path, and receiver.

The prevailing sound in our workshop is not structure borne like footfalls on a floor or water hammer in a pipe. The noise generated by woodworking tools is airborne. Floors, walls, and ceilings are all possible pathways. The sound in the shop causes the surfaces of these building assemblies to vibrate. And, in turn, these vibrating elements excite air molecules on the other side of the assemblies, carrying sound into the office. We had to minimize vibration of the building assemblies. We also needed to seal all air leaks connecting the office to the shop to block sound transmitted by direct air leakage.

Overall, the best approach to block airborne sound is to:

- increase the weight of building materials
- design discontinuous construction details
- add sound-absorbing materials to structural cavities

Concrete helps. We were lucky. The floor and ceiling are poured concrete. Heavy materials like poured concrete reflect sound and resist vibration. Concrete is simply too dense and difficult for air pressure to set into motion. Poured concrete is also continuous and airtight. We aimed to build a wall between the shop and

Figure 2. Using a hand-held sound meter, the authors measured the sound levels of the machinery in use.

Sound Readings

	Shop (pre-const.)	Office (pre-const.)	Office (no door gaskets)	Office (with door gaskets)
Jointer	120 dB	82 dB	57 dB	54 dB
Radial Saw	114 dB	81 dB	51 dB	43 dB
Planer	122 dB	88 dB	58 dB	51 dB

*All measurements were taken while machining 2-inch oak boards.

office that was similarly airtight and capable of resisting vibration. We also designed the wall cavities to absorb vagrant sound that leaked through the wall face. The sound exclusion of the wall assembly could be predicted to some extent.

The ability of a wall, floor, or ceiling to resist the transmission of airborne sound is expressed by its Sound Transmission Class (STC) rating. For example, if sound is measured at 100 decibels on one side of a wall and drops to 60 decibels on the other side, the wall blocks 40 decibels of sound and earns an STC rating of 40. STC ratings are given to a variety of wall assemblies, based on acoustical testing. Construction details that show how these walls should be built are available in many sound-attenuation handbooks. Keep in mind that many different frequencies of sound can be generated by a source. Building assemblies do not block all frequencies equally well.

The Construction Process

First, we reorganized our existing floor plan into a more compact and efficient layout, putting a barrier wall along the entire 45-foot length of the original workshop on the office side and leaving an 8-foot-wide hallway between the office and shop. The redesigned shop was shrunk to 28x30 feet, providing us with enough space to build a new and much needed 28x15-foot storage room along the north side of the shop.

A couple of considerations guided the plan. The workshop ceiling was 11 feet 6 inches high. However, an 8-foot-wide section of the ceiling along the entire length of the shop abutting the office (over the new hallway) was 2 feet 6 inches lower. The space above this drop ceiling was used as a utility chase. Unfortunately, the chase also functioned as a flanking path, allowing sound to travel through it from shop to office. So we decided to build an 11-foot-6-inch-tall wall on the shop side of the dropped ceiling, forming a continuous seal along the entire length of the shop (Figure 3). The office staff would

Sound-Control Wall Details

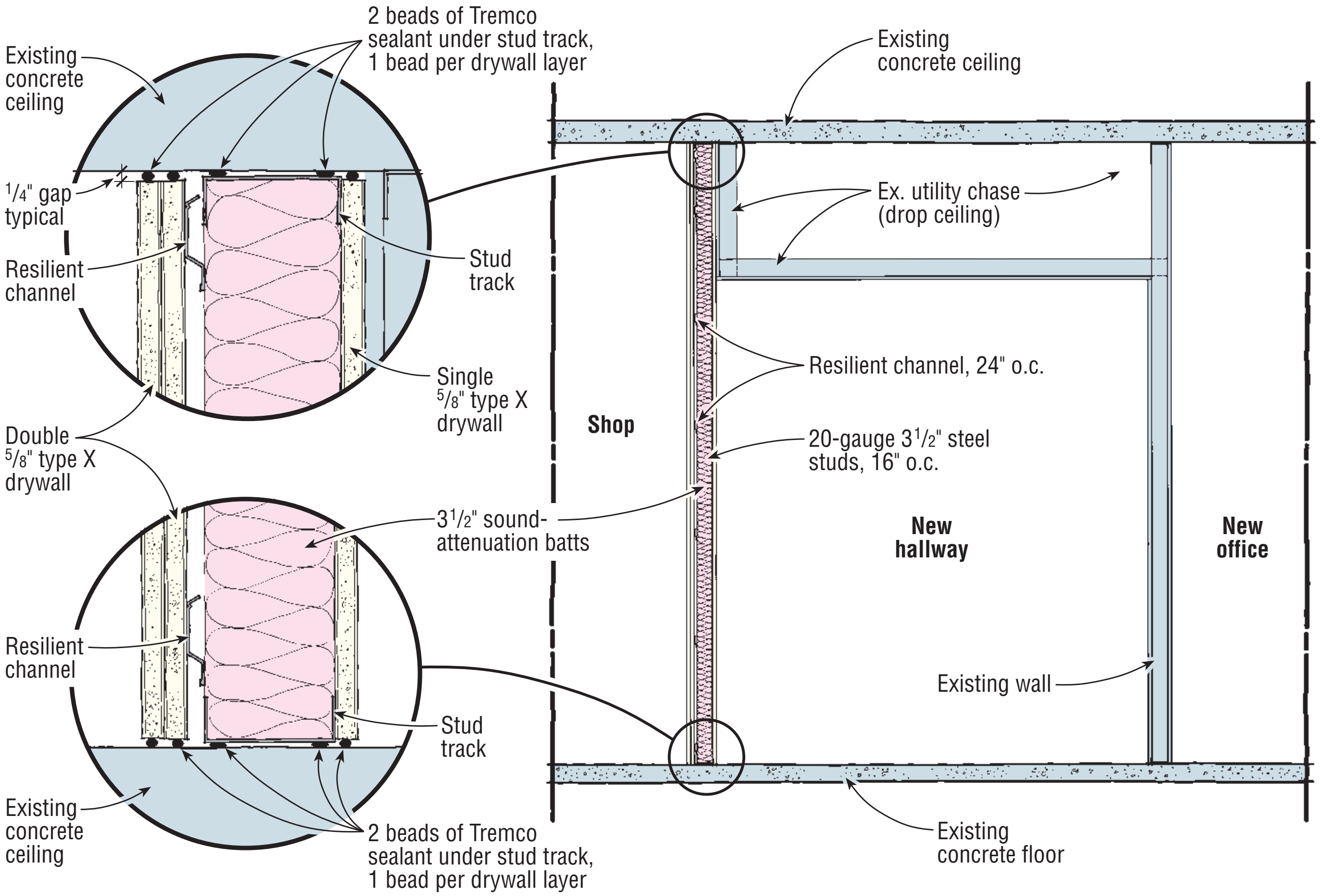


Figure 3. Two layers of 1/2-inch drywall installed over resilient channel on the shop side provided extra mass to help buffer the shop noise. The resilient channel helps prevent the transmission of vibration into the wall framing.

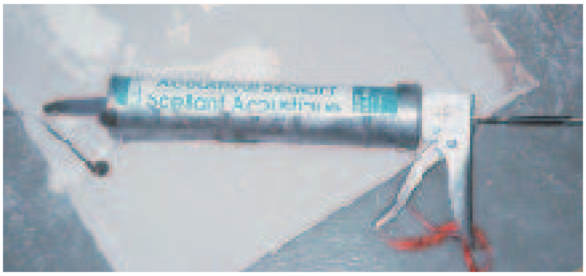


Figure 4. Acoustical sealant under wall plates and around drywall edges seals tiny gaps that might allow transmission of airborne sound.

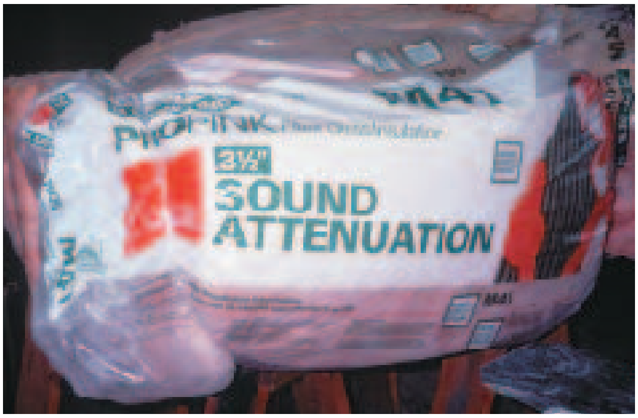


Figure 5. Sound-attenuation batts sized specifically for steel studs can improve partition STC ratings by as much as 10 dB.

have more privacy and less dust, and the new storage room would serve as a sound buffer.

We were convinced the critical sound-blocking element would be the new hallway wall. We then reviewed a variety of construction options. USG (800/874-2450, www.usg.com) provides a wealth of good information for anyone building sound control into a structure. A visit to its website is a must. We used the *USG High Sound-Attenuation Steel-Framed Systems* technical directive to design our walls. The plan called for 20-gauge steel studs spaced 16 inches on-center. Resilient channel was screw-attached to the shop-side of the wall. The wall would have a double layer of 5/8-inch type X drywall fastened to resilient channel on the shop side and a single layer of 5/8-inch type X drywall fastened directly to the studs on the hall side of wall. It earned an STC rating of 56 and a two-hour fire rating.

The steps in the construction phase were straightforward. First we snapped lines on the floor and ceiling to locate wall plates, then cut and dry-fit the track. We predrilled 1/4-inch holes through the track into the concrete floor and ceiling at 16-inch centers to receive the 1 1/2-inch-long anchor pins that would hold the track in place. Before the track was permanently fastened with the anchor pins, we ran a double bead of Tremco acoustical sealant (800/321-7906, www.tremcosealants.com) under the entire length of the track to form an air seal (Figure 4).

Tremco was also applied behind the end studs of the wall. A word of warning: Tremco is affectionately called Black Death — you'll need mineral spirits to remove any misplaced globs. If you cut the nozzle on the tube too small, the sealant comes out like molasses and will blow out through the back of the tube. Cut a healthy 3/8-inch-diameter hole, and you'll develop a good steady flow.

Once the track was permanently secured, the studs were fastened 16 inches on-center. using self-tapping pan-head screws. We used a small pair of vice grips to hold the studs in place while the screws were driven. Otherwise, the screws tend to deflect the stud and roll around while you are trying to drive them through.

Next we installed resilient channel (RC-1) horizontally to the shop side of the wall with self-tapping pan-head screws at 24-inch centers (see photo, page 83). Resilient channel is a U-shaped steel product that minimizes contact area between members in a building assembly. It has a 2-inch-wide face that drywall is attached to and a small, 1/2-inch offset flange that extends back from its face. You screw the channel to the studs through this flange, and it interrupts the connection area between the drywall and the stud. The pathway is reduced to a 1/2-inch-wide spot every 24 inches vertically and 16 inches horizontally. As a result, sound transmission through the assembly is reduced.

Top and bottom channels were held off the ceiling and floor by 2 inches to disconnect the wall from floor and ceiling assemblies. If you have not worked with resilient channel, you are in for a surprise. It is laid onto the wall frame with the fastening flange located along the bottom edge. The channel hinges down, away from the frame and toward you, under the weight of the drywall. At first this seems wrong, but when you think about it, it makes sense. This hinge action opens the space required to separate the channel from the frame.

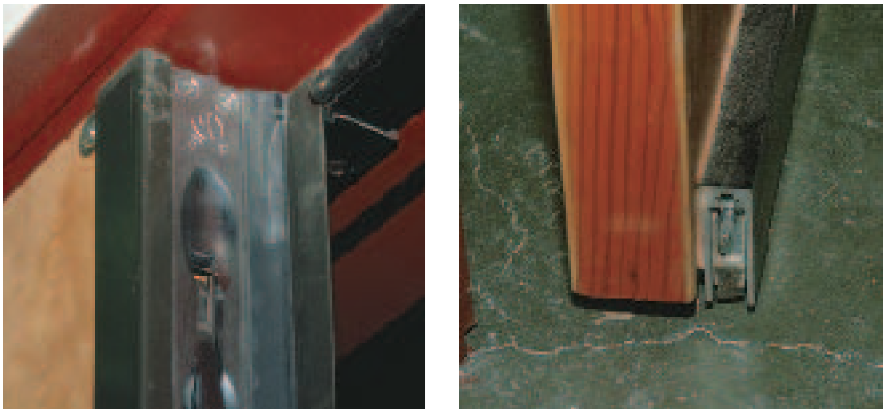


Figure 6. Soft rubber gaskets (left) and an adjustable threshold (right) help close gaps around the shop's doors.

Soundproofing batts. We carefully installed 3 1/2-inch-thick sound-attenuation batts (Owens Corning, 800/438-7465, www.owenscorning.com) in all stud cavities after the resilient channel was fastened to the wall. We purchased batts that were sized for steel studs (Figure 5, previous page). These larger batts extend into and completely fill the hollow profile of the steel studs. Language on the package claims that they can improve partition STC ratings by up to 10 decibels.

Double drywall. We built a multi-layered wall. One layer of 5/8-inch type X drywall was installed vertically to the hallway face of the wall. We left a 1/4-inch gap around the perimeter of the drywall attached to the wall and filled this gap with Tremco sealant to block air leakage. On the shop side, we applied a double layer of 5/8-inch type X drywall vertically across the resilient channel already fastened to the wall. The idea here is that the added density provided by a double layer of gypsum board resists more of the vibration caused by air pressure.

The seams in the first of the double layers installed to the shop side of the wall were taped and mudded before the second layer of drywall was applied. We offset the seams in the second layer. We installed all panels vertically to minimize the amount of crack length. A 1/4-inch gap was maintained around the perimeter of this face and filled with Tremco. The nice thing about fastening the vertical drywall to horizontally run resilient channel is that you don't have to hit a stud with the seams. There's less cutting and less waste. We built the wall separating the shop from the new storage room last, following the exact same procedure used to construct the hallway wall.

Dealing with doors. Now the walls were built, but we still had door openings to deal with. The standing rule is to avoid using doors in sound control partitions when possible. Research shows that hollow-core doors are terrible sound barriers. Solid-core doors with tight-fitting perimeter gaskets and thresholds are best. Doors in hallways should not be placed directly across from each other. And the swing of adjacent doors should be arranged so sound will not be reflected between them.

We needed to provide walking access into the new storage room and wide access into the shop from the hall. So we installed a double, solid-core birch fire door leading into the shop. A single-door version was installed in the storage room. Both were outfitted with knock-down metal slip-jamb frames. The space around the frame was sealed with pieces of attenuation batts and Tremco. The doors were sealed with face-mounted bulb-type perimeter gaskets manufactured by National Guard Products (800/647-7874, www.ngpinc.com). A self-sticking gasket was used on the astragal of the double door (Figure 6).

Installing a threshold was out of the question because we are always moving material into and out of the shop. So we did the next best thing. We installed retractable door sweeps, also sold by National Guard Products (model #220NDKB). You can adjust the height of the sweeps to fit tightly against the floor when the door is closed. They retract as the door is opened and don't drag on the floor.

How We Fared

The project was a tremendous success, as sound measurements (and happy office workers) proved. Sound readings were taken in the shop and inside the closed office in three stages: The first readings were taken before construction began. The second set was taken when the walls were built and the doors were installed with no gaskets or sweeps. Then a third set was taken with gaskets and door sweeps in place. The critical readings are outlined in the table on page 85. Materials for the entire project cost $3,000.

__Paul Fisette__ is director of the Building Materials and Wood Technology program and __Daniel Pepin__ is a technical specialist, both at the University of Massachusetts in Amherst.