Appendix E
Property Enhancements:
Sound Insulation of Homes -
A Very Approximate Self Diagnosis

SOUND INSULATION OF HOMES:
A VERY APPROXIMATE SELF-DIAGNOSIS

Sound insulation of homes can reduce interior sound levels from nearby highways. As described more fully in an accompanying booklet, your home is like a tow chain—the kind you attach to your rear axle to tow another vehicle. If you have a weak tow chain and wish to improve it, you must start by replacing its weakest links.

This booklet contains a very approximate measurement method to identify your home’s weakest acoustical links, from outdoors to indoors—using a calculator, an inexpensive sound level meter, and a child’s rubber ball.

Disclaimer

The measurement method on the following pages is very approximate. It cannot be guaranteed accurate for your home. For that reason, neither the City of Scottsdale nor its consultants can assume any responsibility for money you spend that seems wasted as a result of this method. That is your risk. If you are not willing to risk that, then please hire an acoustical professional to identify your home’s weakest acoustical links, from outdoors to indoors.

DIAGNOSIS TOOLS

A Calculator

Any calculator will do, as long as it can "raise 10 to a power." Some calculators do this with a key labeled $\mathbf{10^x}$. Others have a key labeled $\mathbf{y^x}$, where you will set **y** equal to 10.

A Sound Level Meter

Obtain any sound-level meter that can make an "integrated average measurement" of the sound over a preset time interval. This type measurement is also called the energy-equivalent sound level, and is often abbreviated as L_{eq}. The new digital-display sound-level meter from Radio Shack (model 33-2055, cost $50) is satisfactory, although Radio Shack's older analog-display model is not.

Examine your sound level meter and read its instruction book. Learn how to:

- Turn it on and off
- Read values on its output
- Adjust its sound range for loud sounds
- Adjust its sound range for quieter sounds
- Force it to use "A-weighting"
- Force it to use "Response Slow"
- Make an "integrated average measurement."

A Child's Rubber Ball

Obtain a hollow child's rubber ball, 2-to-3 inches across. With a knife, cut the ball in half and place it on the table, cut edge downward (like a dome). Then cut a hole in the top of the ball, just big enough to insert the microphone of the sound level meter. The microphone should fit rather snugly in the hole, though it is not necessary for the fit to be perfect. A little raggedness is preferred, actually, for acoustical reasons. Always use the same ball, with its particular amount of raggedness.

To measure sound coming through solid surfaces (like a window pane), you will need to insert the microphone into the ball. When properly inserted, the microphone will look like it's "inside" the ball. Then if you aim the microphone at the wall, the cut edge of the ball will contact the window and trap sound coming through.

The ball is not used to measure sound coming through air gaps.

Now you are ready to diagnose each room of your home. Most likely, only rooms on three sides of your home will need diagnosis. Rooms on the side facing away from the freeway will not.

DIAGNOSIS INSTRUCTIONS

These instructions will guide you in diagnosing your home, room by room. Following these instructions, you will first measure the sound coming through each part of your home's outside shell. Then you will compare the strengths of each possible sound path, to identify the strongest paths—that is, the weakest links.

List of all possible sound paths

1) Air gaps. Using your ear, listen for sound coming through air gaps around your windows and outside doors—and also any other holes into the room from outside (chimney opening, through-the-door mail slot, window or through-the-wall air conditioner vent). If you hear sound coming through these air gaps, include them on the list.

2) Solid surfaces. Also include on the list every window and outside door in the room—plus the outside wall, itself. If portions of the outside wall have different construction (one portion may be stucco, another portion brick), then include each portion as its own item on the list.

Sound-level measurements for each air gap

1) Number of measurement positions. For long gaps, you will need to measure at several places—perhaps every three feet or so—along the full length of the gap. For exterior doors, this includes the gap at the top and the bottom, as well as the gap on both sides.

   For large holes, you will need to measure at several positions in front of the hole—for example, three positions along the front face of a fireplace hole, or three positions along the vent of a window air conditioner.

   For small holes, one measurement position is enough.

2) At each measurement position. Hold the microphone about two inches from the air gap, aimed at the gap. At that position, measure the "total integrated average sound level" during a 20-second time period. At the end of that time period, write that value down and then go on to the next measurement position for that gap.

   With the Radio Shack sound-level meter: At each position (1) press DH for about 3 seconds, (2) press MAX enough times to show "20" seconds in the display, (3) position the microphone properly along the gap, (4) press RESET to start the measurement, (5) after DH shows up on the display, write down the integrated sound level.

3) Averaging decibel values. You will have one decibel value for each measurement position along the gap. Convert all these decibel values into "normal numbers" and then average all these normal numbers. See the box called "Working with decibels" on this booklet's last page.

4) Combining that average with the gap area, to get the gap's source strength. Finally, multiply this average by the area of the air gap (length times width). Use either square inches or square feet, but do not mix the two. The result is that gap's source strength.

Sound-level measurements for each solid surface

1) Number of measurement positions.

   a. For windows with small panes of glass, choose one-third of the panes and measure about 1/3 the way across the pane (in both directions).

   b. For windows with one or two large panes of glass, choose three positions on each pane. Spread them out, but keep them all at least six inches from the pane's edges.

   c. For doors, choose three positions on the door's surface. Spread them out, but keep them all at least six inches from the door's edges.

   d. For walls, choose six positions on the wall. Spread them out, but keep them all at least six inches from the wall's edges.

2) At each measurement position. Put the half-ball on the microphone so that the microphone is "inside" the ball. Rest the cut edge of the half-ball against the surface. At that position, measure the "total integrated average sound level" during a 20-second time period. At the end of that time period, write that value down and then go on to the next measurement position for that surface.

   With the Radio Shack sound-level meter: At each position (1) press DH for about 3 seconds, (2) press MAX enough times to show "20" seconds in the display, (3) position the microphone properly on the surface, (4) press RESET to start the measurement, (5) after DH shows up on the display, write down the integrated sound level.

3) Averaging decibel values. You will have one decibel value for each measurement position on the surface. Convert all these decibel values into "normal numbers" and then average all these normal numbers. See the box called "Working with decibels" on this booklet's last page.

4) Combining that average with the surface area, to get the surface's source strength. Finally, multiply this average by the area of the surface (length times width). Use either square inches or square feet, but do not mix the two. The result is that surface's source strength.

Deciding what to fix first

In this method, gaps are ranked separately from solid surfaces, because they are measured with different microphone methods (no ball for gaps, with ball for surfaces). As a result, relative weakness between gaps and surfaces is not computed well with this method.

Fix air gaps first, starting with the highest-strength gaps. Air gaps are often the weakest links and they are often the least expensive to fix. Then fix solid surfaces, starting with the highest-strength surfaces.

If any item is relatively inexpensive, you may wish to start with it instead of the highest priority. Try to balance cost and priority. But remember that lower-priority items will not have much effect, even though inexpensive to fix.

When comparing strengths, remember the following rules of thumb. If one source strength is ten times another, it is ten times as important to fix it. That is the purpose of using "normal numbers" instead of decibels. On the other hand, if one source strength is only two times another, this whole method is too approximate to really distinguish between the two of them.

Working with Decibels

Decibels are strange units used in acoustics. They don't behave the same as normal numbers, so you must always convert them to normal numbers first, before using them. This box shows you how to do that, and then how to average "*n*" of them together.

To convert decibels to normal numbers: On a calculator, divide decibels by 10 and then take 10 to that power:

$$10^{(\text{decibels}/10)} = \text{normal number.}$$

For example:

$$10^{(52/10)} = 158,489.$$

To average "*n*" normal numbers: On a calculator, add them all up and then divide by *n*:

$$\frac{\text{sum of the "}n\text{" normal numbers}}{n} = \text{average.}$$

This is the regular way of averaging. It works properly only after decibels are converted to normal numbers.