The Golden Rules for Quiet Product Design

Consumers are interested in products that do not intrude on their environment. Here’s how to make this happen.

By Gladys Unger Ph.D.
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When challenged with the task of designing, or redesigning, an appliance, the team is confronted with a myriad of requirements. Style, price point, size, weight, cost, and UL restrictions all make the list and often present conflicting requirements. Bringing other considerations into play is the last thing designers and engineers would likely choose. So why complicate the design process by adding noise to the mix? The answer is straightforward: consumers are interested in products that do not intrude on their environment, but they are also drawn to products that they believe are well made and perform properly. A “suitable” sound conveys these characteristics. But the road to design resulting in a product for which sound is a positive attribute is not straightforward. What follows are some simple golden rules, by no means an exhaustive list, which can assist during the design process.

Rule 1: Determine what you are trying to achieve with sound. Initially, designers might think they want to
eliminate all noise. This may, in a few rare cases, be appropriate (think steam iron or a drip coffee pot with clear glass carafe), but generally users need some indication and feedback that a product is performing as expected. Sound often provides that information. The quintessential example is the sound made by closing a car door. With a robust sound and no rattles, the car buyer gains confidence in the quality of the entire vehicle. Sound also provides cues as the appliance moves through its cycle. The sound of the steam wand skimming the top of the milk guides the barista to create the perfect latte.

The design team should ask themselves noise-related questions: Are there characteristics of sound that are expected from this category of products? Is this product something that needs to be perceived as powerful, and if so, can sound add to that perception without becoming annoying? How much noise would be intrusive based on where the consumer is likely to use this product? How does noise factor into the pricing of the device?

**Rule 2: With components that have moving parts, buy as much quality as you can afford.** Gears, motors and mechanisms can be made of various materials, made with different balancing tolerances, and made with structural designs that directly affect the noise. This may be one place to spend more money. A fan that is not well balanced will emit a tone at the frequency of its fundamental rotation rate. Plastic gears may rattle and wear. DC brushless motors will generally be quieter when the driving waveform is well designed. Bearings need to move smoothly, without sticking or banging. Sleeve bearings are often quieter than ball bearings. Buying and testing several components from various manufacturers, before you are locked into a design, can provide options that may not be available as the design progresses.

**Rule 3: When buying parts from suppliers that report noise levels, don’t just buy the noise rating—listen for the quality of the sound.** Fans, for example, are often rated in sones. Sones provide a measure of the overall loudness of the noise, but the rating does not address the tonal quality of the noise. When a fan is enclosed within a product, the overall broadband level will often be reduced but an annoying tone may still be prevalent or even be created due to the blades being close to nearby edges. Thus, choosing a fan simply by its measured sones would not be the most informed approach. It’s wise to listen to and analyze the sound of candidate components, especially before the real estate within the product has been assigned. In some cases, an off-the-shelf component may need to be modified to end up with a satisfactory sound. This is often observed with scroll fans. Poorly designed scroll cut-offs will create tones at the blade passage rate (the frequency at which sequential blades pass the cut-off) and its harmonics. The cut-offs can sometimes be redesigned, without a loss of efficiency, or an altogether different fan chosen, with the result being a more desirable ratio of broadband to tonal noise.

**Rule 4: With products that move air, thought should be given to:** the design of the flow path, the location of the inlet and outlets with respect to the user, the location of a fan or motor with respect to openings in the product, and the proper sizing of the fan with respect to its operating point. Flow paths should be smooth, with gentle turning radii, and without protuberances that can create turbulence. If fans can be placed outside of the line-of-sight of an opening, noise can be reduced. Directing outlet flow away from the user is also prudent. A digital projector that was investigated had several of these problems. The inlet fan was mounted on the entrance grill. The cooling air traveled through the fan and immediately made a sharp bend before being forced between a narrow set of circuit boards. The outlet air impinged on the loudspeaker. And, sadly, the design was so locked in that little could be done to make the unit quieter. Additionally, product noise consultants are often surprised by how often fans, and axial fans in particular, are improperly sized and running in stall. Because axial fans of the same physical dimensions are quite common, it should be possible to specify one with the proper operating
characteristics.

**Rule 5: Pay attention to how moving parts are mounted to a supporting structure.** Too often fans, motors, pumps and other sources of vibration are mounted on grommets to “isolate” them from the structure. But then they are mounted on an exterior surface that is floppy and lightweight, while the fan itself is heavy. This turns the housing into a speaker because the vibration in such situations is easily transmitted to the case. In this scenario, the effectiveness of the isolation is lost. A better approach is to build in stiffness and weight, not just for structural integrity, but also for mounting mechanical parts. Equally important is to look carefully for flanking paths. Stiff electrical connections can transmit vibration even when a motor has been successfully isolated from the case. Flow ducts need to be soft somewhere along the path from the blower to the outer housing.

**Rule 6: Choose materials with noise and vibration in mind.** One garbage disposal manufacturer advertised that its products made use of noise quieting materials, but filled a cavity with Styrofoam. A sound absorbing open-cell foam, with high absorption in the frequencies being emitted, would have been a better choice. An enclosure that makes use of a mass barrier can sometimes be an effective way to reduce noise, so choosing denser or thicker materials can be beneficial if there is a noise source within the appliance that cannot itself be reduced. However, even the most carefully designed enclosure can be rendered useless if gaps or other penetrations are present and left untreated. Vibration damping of structural components, or choosing materials with a high loss factor, is another approach that can be effective in limiting resonant response in a structure that could potentially contribute to the radiated noise. However, such resonant responses are usually difficult to predict ahead of time, and while adding a damping material can sometimes reduce noise, any reduction is primarily caused by the added mass that the extra damping material provides—possibly an expensive way to achieve added mass density.

**Rule 7: Let your customers know that sound is important and that you have worked at producing an appliance with sound that complements the use without encroaching on the user.** Your customers, and others listening to the product, will appreciate your efforts. A very innovative example of the recognition of noise comes from a well-known garbage disposal company. This company has produced three different models of its disposal, each with a different price point and an inversely related noise level. A push button display in the store allowed potential buyers to listen to the sound these disposals made when they were all mounted under the same conditions. By offering a comparative demonstration of the sounds in the store, the consumer can choose how much to invest for the amount of quiet they favor.

As acoustical consultants, we too often receive a panicked call from a manufacturer who has a product ready to ship—except that the noise is unacceptable. We listen to the appliance, examine its interior and more often than not find that simple design rules, like those discussed above, have been ignored. We’re then told that molds have been produced, parts have been fabricated, and components have been ordered. The manufacturer wants the appliance to be quieter—but there are numerous constraints on what changes can be made, and while the addition of noise control materials can sometimes be effective, it increases the cost of each unit. After assembly is not the time to start thinking of noise. We encourage our customers, and you, to give noise the priority it deserves, starting at the beginning of the design process.

Gladys Unger, Ph.D. is a senior consultant at Acentech Inc. (www.acentech.com), specializing in acoustical noise and vibration control for all types of products.