# Controlling Structureborne Energy From Air-Moving Devices

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## Introduction

Electronics today are operating faster than ever. Manufacturers are packing more Integrated Circuits (ICs) in less space. ICs in today's laptop computers can generate about 50 $W/cm^2$ of heat. Intel's Pentium® 4 CPUs today can produce from 60 to 70 Watts of heat. As chips get stacked and circuits are downsized, next generation ICs might produce 100 $W/cm^2$.

These IC-loaded devices require cooling systems to prevent overheating. Utilizing heat sinks and cooling fans, two common methods of removing heat from electronic components, raises the design questions, "How big" and "How many." That is, what size and how many fans and heat sinks does a particular system require to eliminate the heat load without adding unnecessary costs and space requirements.

The tradeoff for cooler operation may be increased noise, however. The more air one moves and the faster one moves it, the more noise is created. Modern technology has come a long way to reduce the noise created by airflow devices, but there is a limit. Moving air will always generate noise.

Generally, the more airflow the fan can produce, the better the cooling that results. Two basic ways of increasing the airflow of a fan are to increase the speed (RPM - revolutions per minute) and increase the size of the fan, so that the blades move more air. There are drawbacks for each:

- Both will increase the power draw of the fan. This could potentially burn out the circuitry on the board that supplies power to the fan.
- Increasing the fan RPM dramatically increases the noise level. It also causes the fan to produce a higher pitched sound, which may have a higher annoyance factor.
- Increasing the fan size doesn't increase noise as much but will require more room to accommodate its larger size and will not operate at peak efficiency.

Fan performance can be estimated over a wide range of sizes and speeds using basic scaling relations (ref. Handbook of Acoustical Measurements and Noise Control, by C. Harris, 1991).

$$L_{Wa} = L_{Wb} + 70log_{10} (d_a/d_b) + 50log_{10} (n_a/n_b)$$

where:

$L_W$ = sound power level, decibels re 1 picowatt

$d$ = rotor diameter, meters

$n$ = rotor speed, number of revolutions per minute

subscripts:

$a$ = data at required performance conditions

$b$ = data at base curve performance conditions

Mathematically, when two fans are both members of a similar series, their performance curves are similar, and at the equivalent point of rating on each performance curve, the efficiencies are equal.

Speed is the major contributor to fan noise. For every doubling of fan speed, the sound pressure level (SPL) rises around 15 dB.

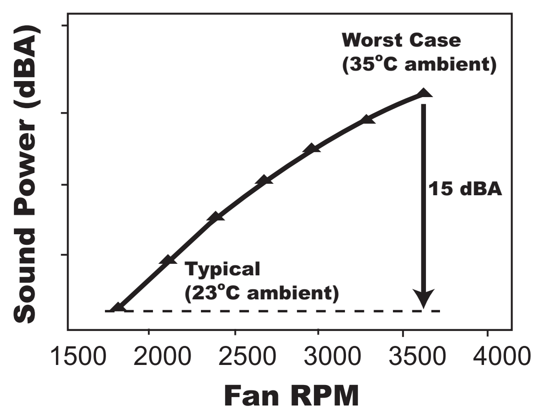


*Figure 1*

A fan generates both airborne and structureborne noise. When suspended in air, a fan is fairly quiet. The noise level increases significantly, however, when the fan is coupled to a structure or enclosure with high radiation efficiency, i.e., thin, stiff and lightweight.

Studies have shown that fan-generated structural energy contributes more to the overall noise level in electronic devices. When fans run faster to get more airflow, an imbalance often occurs, either from the ball bearing or inconsistencies in the fan blades. The result is that vibration energy transfers to the structures to which the fans are mounted.

*Figure 2: E-A-R's fan mount designs feature tool-less installation and require no additional hardware.*

## E-A-R Solutions for Fans

When a vibration source, like a cooling fan, is coupled to a structure, the vibration energy transferred will radiate and amplify the noise level. This vibration can create unacceptable noise, interfere with equipment accuracy and ultimately shorten product life.

E-A-R Specialty Composites offers a family of highly damped elastomeric mounts designed for the types of cooling fans employed in electronics and electromechanical equipment. E-A-R's fan mounts are designed to provide a "soft," damped connection, thereby preventing the transfer of structureborne vibration energy from the fan to the mounting structure. The fan size and RPM determine the design of the fan mount or isolator

E-A-R's standard fan mount configurations are designed to accommodate the most commonly used fans. Their unique design—resembling a golf tee—facilitates assembly and provides secure fastening. In most cases, each simple-to-install fan mount replaces a metal screw, nut and washer, reducing the number of parts required to mount the fan. When a standard mount does not meet requirements, an E-A-R applications engineer quickly designs a custom option, which can be molded from a damped elastomer with the isolation efficiency needed.
E-A-R fan mounts are injection molded from ISODAMP® thermoplastic, offering excellent manufacturing economics and a range of performance options.

## Why Damping?

E-A-R's ISODAMP damped elastomers offer great advantages for noise control, shock and vibration over poorly damped materials, such as natural and synthetic rubber, silicone and commodity TPEs. The graph below shows a comparison of fans mounted with ISODAMP fan mounts, with rubber isolators and with no isolators. The C-1002 mounts reduced the noise levels significantly.

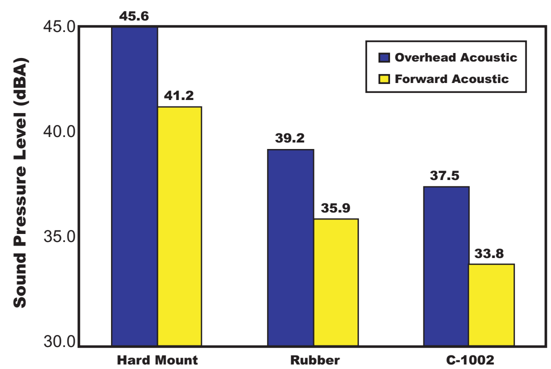


*Figure 3: Sound pressure levels from two positions*

## Fan Mounts: Performance Data

E-A-R tested the vibration and acoustic spectra of a 12-volt DC axial fan, 60 x 60 x 2.5 mm, mounted in an enclosure the size of a set-top cable TV box. The hydrowave-bearing (HWB) fan is rated at 32.0 dB(A).

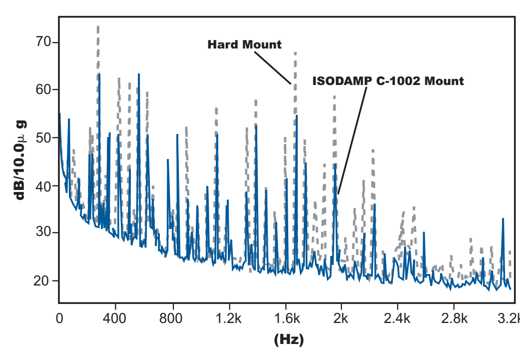


*Figure 4: Vibration spectra of top chassis cover, using an FFT analyzer.*

Tests compared two different mounting conditions: a hard mount (without an isolator) and a fan mount molded from ISODAMP C-1002 thermoplastic. Results showed that one can attenuate 7 or 8 dB in both sound pressure level measurement and vibration energy reduction. Figures 3, 4 and 5 contain graphs that compare the fan's noise and vibration levels in the two different modes.

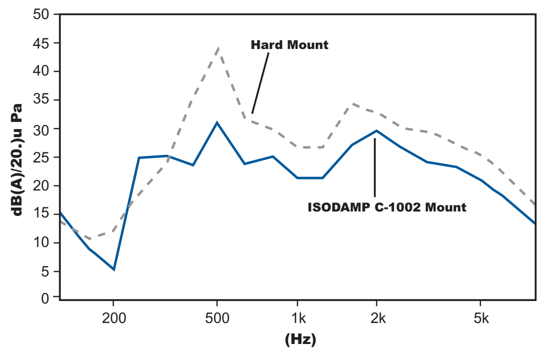


*Figure 5: Noise spectra from overhead position, using a CPB analyzer.*

## Applications

*Communications equipment, such as switches and routers*

- Numerous small fans used to lower the temperature in a communications equipment bay caused the lightweight metal support racks to vibrate and make noise. The fans transmitted vibration to the shelves through attachment points, causing the lightweight metal to ring and rattle.
- E-A-R determined the requirements and reduced the noise level by 6dB with ISODAMP material as an isolating gasket to decouple each fan from its frame.

*Set-top boxes or projectors*

- The vibration from a small cooling fan that controls the heat buildup in the electronics caused other lightweight components to vibrate as well, creating unacceptable noise levels.
- E-A-R's golf tee-shaped fan mounts isolate the fan from the housing and other components and prevent noise from resonating through the chassis.

*Computers, including laptops and workstations*

- Structureborne vibration and unacceptable noise resulted from a cooling fan rigidly mounted in the enclosure of a computer.
- Larger computer designs with sufficient space employ fan mounts or grommets for isolation. For smaller computers with limited space in the design, E-A-R designed special die-cut gaskets of energy-absorbent ISOLOSS® LS and CONFOR materials to isolate fans.

*OEM equipment, such as refrigerators and air purification systems*

- Disturbing noise from fans and blowers created both airborne noise and structural vibration.
- Due to temperature constraints, molded isolators from VersaDamp™ thermoplastic elastomer are used to treat the structureborne energy. TUFCOTE® acoustical foam is used to absorb the airborne noise.

## Conclusion

Everyone wants a thermal management system or cooling system that cools as efficiently as possible, and is as quiet as possible. These goals, however, often tend to have conflicting design elements. By involving E-A-R early in the design cycle, product designers can help ensure that the acoustical requirements will be closer to the design specifications.

*For additional information, material samples and design assistance, phone us on our toll-free hotline-(877) 327-4332-or contact us by e-mail at* solutions@earsc.com.


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