The Basics of Noise

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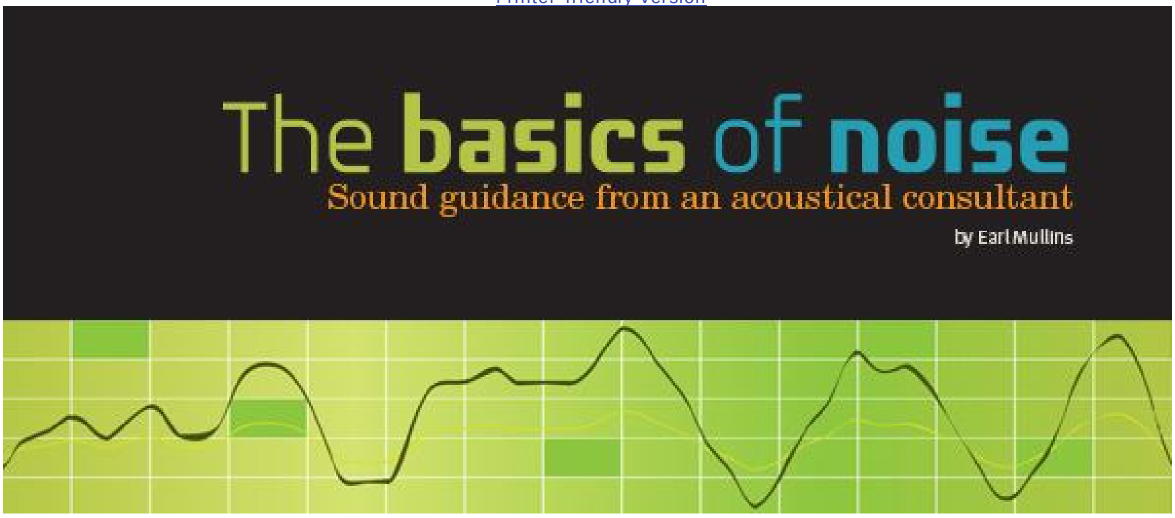

Written by Earl Mullins
Sound guidance from an acoustical consultant.
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Noise is one of the major issues threatening RC airfields and many other recreational activities. What you consider to be a pleasant sound from a glow engine at 17,000 rpm can be an unbearable racket for the neighbors who do not share your passion for RC flight. Part of the definition of noise is, “sound that is unwanted or undesired.”

The sound factor draws many into RC aircraft flying—a big part of the fun is the engine noise. Some hobbyists avoid electric-powered airplanes because of the lack of engine sounds.

I choose to ride a large Honda touring motorcycle which is no louder than a typical car. My neighbor down the street loves his Harley, complete with loud aftermarket exhaust pipes. For him, the noise is an integral part of the experience. The neighborhood is not as enamored, especially at 7 a.m.

During engine run-up the pilot is exposed to significant short-term noise levels. Although seldom used, hearing protection is a good idea, even with limited exposure. Sound levels at the pilot’s position during a flight are typically 75 dBA or less.

The Basics of Noise

Our eardrums sense tiny fluctuations in air pressure, which we interpret as sound. The decibel scale is used for expressing sound levels because we do not perceive loudness in a linear fashion. We detect loudness in a logarithmic way, similar to the Richter scale for earthquakes.

Although an increase of 3 decibels (dB) doubles the sound energy or amplitude, it takes a change of 10 dB to be judged as twice as loud. Each similar decrease of 10 dB is considered to be half as loud as the original sound.

Changes of 1 dB are not perceptible. A 3 dB change can be heard by a critical listener under ideal conditions. A 5 dB change is normally the threshold where a difference is readily noticeable, either up or down.

A-weighted decibels (dBA) are commonly used to measure sound levels. The A-weighted scale deemphasizes low frequencies to directly compare loudness from different sounds. Theoretically, a diesel locomotive measuring 80 dBA has the same loudness as a cymbal at 80 dBA, although the frequency content is much different.

Our ears and hearing system are constructed to put more emphasis on high-frequency sound than low tones.

It is important to hear a twig snap (high-frequency) from behind as the grizzly bear stalks you. Low-frequency rumble from distant thunder miles away is less critical. Most of the information content from speech is in the middle and higher frequencies, 500 Hz to 2000 Hz.

The time of day, duration, and variability of sound affects the annoyance factor. Steady sounds are less annoying and more easily accepted than a varying sound. Sounds with pure tones or major fluctuations in level are more noticeable, which is why those sounds are used for alarms and sirens.

In the case of RC airplanes, the sound levels change throughout the flight. The variability makes the noise more noticeable and annoying to the public.

Two common ways to express sound levels are the equivalent continuous noise level (Leq) and the momentary maximum level (Lmax). The Leq is the summed total of the sound energy occurring throughout the event or a time period. Although not mathematically precise, Leq can be thought of as the average sound level.

The Lmax is the loudest noise that occurs, if only for a second or two. It takes a more sophisticated sound meter to measure Leq and calculate the running average. A decent sound meter of reasonable accuracy will cost at least $300. An integrating sound meter that can directly measure Leq typically costs $1,500 or more.

Noise Limits

There is no magic number to make everyone happy and avoid annoying or offending others. There also is not a definite dB value where everyone agrees that noise becomes a problem. Because humans are involved, there is always a certain amount of subjectivity and variability.

The U.S. Army has noise criteria for military firing ranges that define acceptable noise levels when up to 15% of the nearby population is annoyed. The Occupational Safety and Health Administration allows a workplace level of 90 dBA for an eight-hour shift, without running an undue risk of hearing damage throughout a career.

Not all jurisdictions have a noise ordinance. Even if a city or county has an ordinance, it may be flawed and incomplete. I formerly lived in a small city that has an ordinance adopted in the 1950s. It lists octave bands (different component frequencies rather than the overall dBA value) that have not been used since the early 1960s.

In my 28 years as a full-time acoustical engineer, I have never seen a sound meter that can measure the octave bands that are listed. If the text of an ordinance has technical flaws you are usually stuck with them. A knowledgeable expert can sometimes make a case for different interpretations, but the letter of the law is usually what counts. Often, the government staffers do not understand their own noise ordinance.

Many noise ordinances will express noise limits as either Leq values or Lmax values. In the case of Leq, the wording is usually something similar to: "…noise level shall not exceed Leq 60 dBA for any given daytime hour."

Another approach is listing the maximum permissible level (Lmax) regardless of duration such as, "…noise shall not exceed 70 dBA at a residential property or property line at any time." Noise limits are typically 10 dB lower between 10 p.m. and 7 a.m.

Another approach to noise limits is ambient plus five dB. In this case, the average existing background or ambient noise in the area is measured without the noise in question. While the RC aircraft are flying, another set of sound levels are observed. The two levels cannot differ by more than five decibels.

If the background noise is Leq 59 dBA for example, the noise when RC airplanes are flying cannot exceed Leq 64 dBA. This option is helpful in areas that are already noisy.

If the stated limit is 60 dBA but the highway traffic is 64 dBA, you cannot easily demonstrate compliance with the lower limit. The ambient adjustment can be a double-edged sword. If the area is quiet and the background noise averages 40 dBA, then your noise limit becomes 45 dBA.

Some ordinances do not have any numerical limits. They simply use vague language such as, "…shall not create a nuisance at nearby residences" or similar phrasing. But what constitutes a nuisance? One's sweet sound is another's awful racket. A numerical decibel limit is more understandable and less open to interpretation, and more defensible in court should it come to that.

Noise-Control Techniques

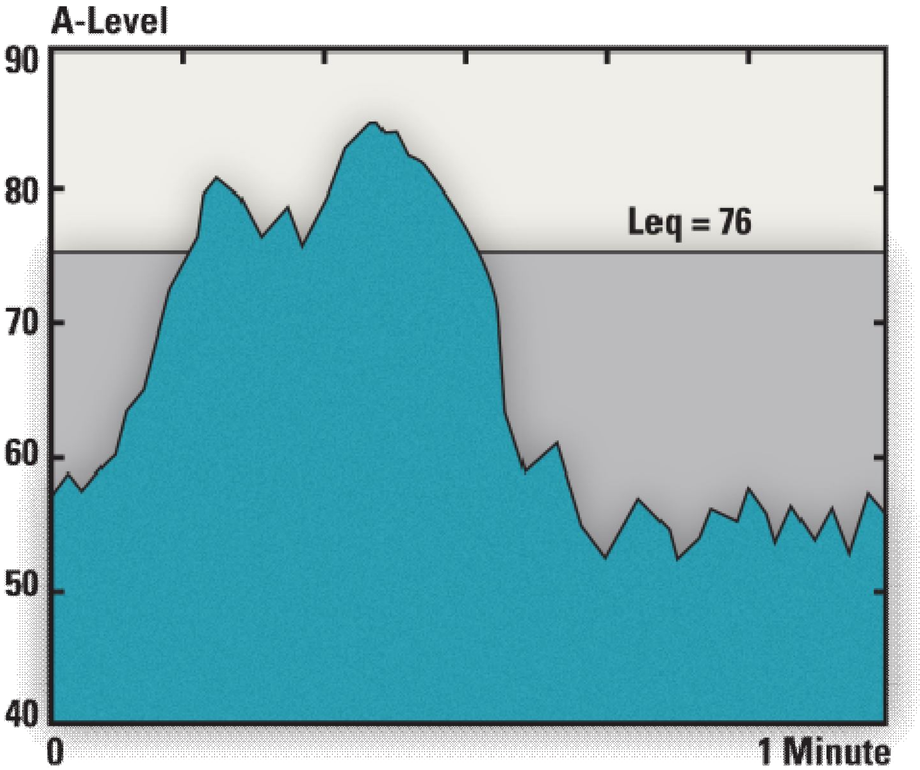
Noise control works on a source-path-receiver model. Noise can be reduced at the source (using mufflers, quieter engines, electric motors), along the path of propagation (distance, barriers), or at the receiver (enclosures, better windows, earplugs).

In the case of RC aircraft, the noise source is elevated and moving, so an enclosure or a property-line noise barrier is typically not an option. Good luck getting the neighbors to wear earplugs because you want to fly!

The available options usually fall into a few categories:

- Limits on aircraft type (electric powered versus glow powered, or a ban on turbines).
- Restricted hours for the field (typically not after 9 p.m. or before 10 a.m.).
- Noise limits on the aircraft (requiring mufflers or baffles, or a limit on engine size).

Although there is no handy library or compilation of sound data for RC aircraft, my experience shows that the typical sound levels for various types of RC aircraft, at a reference distance of 100 feet, are:



Leq 66-75
Leq 68-70
Leq 66-68
Leq 56-58
Leq 68-71
Leq 58-60

The Leq value shown is for approximately 3 to 5 minutes of a given flight. Lmax is the highest momentary level that was observed during a high-speed pass or a takeoff. It is complicated to extrapolate a five-minute Leq out during an entire hour, as is often required when assessing compliance with a local noise ordinance.

That calculation is well beyond a simple explanation. A 5-minute Leq taken during a flight will be higher than the same sounds averaged for an hour. If the limit is Leq 60 for an hour, and you measure Leq 65 during each of several 5- to 10-minute flights that hour, the overall average will likely comply.

There were some surprises in this data. Turbine aircraft were expected to be louder than glow engines, but the difference was only 3 to 4 dBA. Some glow-powered propeller airplanes were louder than the smaller turbine airplanes. A level that is 3 decibels higher is not dramatically louder. Jets with turbines rated from P-60 to PT-160 were measured.

The electric helicopters were slightly quieter than the nitro-powered helis (600 to 800 series, or rotor diameters of 600 mm to 800 mm). Most of the noise comes from the rotor disc during aggressive maneuvers, not the engine.

The loudest propeller airplane measured was a 40% scale gas-powered aerobatic model with a 160cc four-stroke gas engine. On average, its noise was Leq 70 throughout the 6-minute routine, but the peak was higher than other airplanes (90 dBA during a high speed pass down the runway). Smaller gas- or glow-powered aircraft were in the 72 to 86 dBA range for their momentary maximum levels, depending on aircraft size and the power setting.

It is important to note that any sound data must include a distance. If someone says, “My airplane makes 92 dBA,” we need to know at what distance.

It makes a huge difference whether that 92 dBA level occurs at 5 feet (glow engine during run-up) or at 500 feet (Boeing 747 during takeoff).

Distance is typically beneficial. Sound dissipates at roughly 6 dB per doubling of the distance, according to the inverse-square law. A level of 90 dBA measured at 100 feet becomes 84 dBA at 200 feet, 78 dBA at 400 feet, and so forth.

Most are surprised to learn that trees and vegetation do not make a big difference in the sound levels at distances. A row of trees around the field will not lower sound levels at a nearby home.

A mature forest that is 100 yards wide will have roughly a 5 dB net noise reduction value compared to an open, grassy field. Five decibels is slightly noticeable, so the benefit gained by a couple of rows of thinly spaced trees is negligible. There can be an out of sight, out of mind psychological benefit, but nothing that sound meters can quantify.

Conclusion

The RC hobby can be noisy, particularly with fuel-powered aircraft. Most clubs realize that they need to be good neighbors and go to reasonable lengths (or sometimes well beyond reasonable) to protect the hobby and keep using their airfields.

If your club or flying field is threatened by community complaints or enforcement action, it is worthwhile to get advice from someone who is competent in noise assessment. These experts are usually listed under acoustical consultants in the telephone book.

Navigating the maze of noise regulations, zoning requirements, permits, and neighborhood opposition without some expert guidance is unwise. It’s similar to representing yourself in court or diagnosing your own illness.[dingbat]

—Earl Mullins, physical engineer
earl@mullinsacoustics.com