Noise Measurement and Regulation of Racetracks.

This short note provides a review of the engineering principles of noise measurement and propagation in open spaces. It was prepared at the request of Philip Burnett to aid the conversation about possibly regulating the noise level associated with dirt bike and racetrack facilities in Cumberland County.

Sound Measurement—the decibel scale.

To begin it is important to understand how sound is measured. Sound level meters report the strength of a sound signal in a logarithmic scale measured in decibels, typically written dB. There are many variations on the decibel scale, but the one that is important in crafting noise regulations is the dBA scale that mimics the audio response of the human ear by giving less weight to low frequency sounds.

The logarithmic nature of the decibel scale makes the mathematics of combining decibel readings tricky and counterintuitive. For example, two sound intensity sources each producing 50 dBA individually will create a sound level of 53 dBA when played together. The increase of 3 dBA corresponds to a doubling in the sound intensity. Similarly, a decrease of 3 dB corresponds to a drop by a factor of two in the sound intensity. This 3 dB value will be important in the discussion of sound propagation across flat ground given below.

How loud is a given decibel level? There are many tables online that relate a decibel (dBA) reading to a sound in the everyday world. The table below summarizes a typical example of such a table. However, a better means of gaining a good understanding of the true meaning of a given sound level is to use a phone app that implements a sound level meter. There is a particularly good version with validated accuracy for the iPhone created by the federal agency National Institute for Occupational Safety and Health (NIOSH). [Search for NIOSH sound level meter in the App store]

Noise	Average decibels (dBA)
Leaves rustling, soft music, whisper	30
Average home noise	40
Normal conversation	60
Office noise, inside of a car at 60 mph	70
Vacuum cleaner	75
Window air conditioner or power lawn mower	80–89 **(sounds above 85 dB are harmful)**
Passing truck at 10 ft. or food blender at 3 ft	90–95
Boom box, ATV, motorcycle	96–100
Chainsaw or leaf blower	106–115
Sports crowd, rock concert, loud symphony	120–129
Stock car races	130
Gun shot, siren at 100 feet	140

Using the NIOSH app in various settings gives a much better intuitive understanding of the relation between everyday sounds and their corresponding dBA value.

The table indicates that sound levels above 85 dBA are potentially harmful to hearing. The NIOSH recommendation is for a maximum 8-hour workday at 85 dBA with unprotected ears. With every 3 dBA increase the exposure time drops by a factor of two. Thus, at 88 dBA the maximum exposure time is 4 hours, 91 dBA 2 hours, etc. However, the regulation of sound levels in residential settings is not as concerned with hearing damage as with the nuisance impact of loud continuous sounds.

How does sound drop off in decibel level over flat ground?

The sound level drops with distance away from the sound source. The sound received from a single source consists of two parts. First, the direct sound that travels through the air in a straight-line path from the source to the listener. Second, sound that is reflected from the ground or walls; diffracted over berms or around barriers; or refracted (bent) by atmospheric conditions. The full treatment is a very complicated and depends on the terrain, but an approximate formula for sound transmission over hard flat ground can be used to estimate how sound level drops off with distance.

The simple rule for the reduction in dBA level with distance over hard flat terrain is that the decibel level drops by 3 dBA as the distance from the source is doubled. This rule is best illustrated by an example. Assume a single dirt bike meets the California standard (described below) and emits a sound level of 96 dBA at 0.5 meters (about 20 inches). At 1 meter the level will drop by 3 dBA to 93 dBA. At 2 meters the level will drop to 90 dBA. The second line in the table below sketches out how the sound level would drop assuming the 3 dbA model with successive doubling distances out to 128 meters (420 feet).

Distance (m)	0.5	1	2	4	8	16	32	64	128
Decibel (dBA) -3dB	96	93	90	87	84	81	78	75	72
Decibel (dBA) -6dB	96	90	84	78	72	66	60	54	48
Decibel (dBA) -4.5dB	96	91.5	87	82.5	78	73.5	69	64.5	60

It is important to emphasize that this method is an approximation. For example, if the flat ground is covered in grass instead of concrete then the reflection from the ground will be diminished and the decibel level will drop more rapidly with distance. If a direct line of sight path between the source and the listener exists, the maximum drop-off with distance (assuming the ground reflects no sound) will be 6 dBA with every doubling of distance. The third row of the table illustrates this drop-off resulting in a much lower 48 dBA at 420 feet. Finally, the last row of the table illustrates a compromise between the two extremes with a 4.5 dBA drop with doubling of distance. This compromise value more useful and realistic for practical estimates.

Specific information about dirt bikes and ATV’s—the California standard.

Because of the specific issue of concern, it is useful to understand the typical decibel level produced by dirt bikes. Measurements of sound level produced by dirt bikes and ATV’s is done using the Society of Automotive Engineers SAE J1287 JUL98 stationary sound test procedure in which the decibel level is measured in a well-defined position 0.5 meters from the vehicle exhaust. California mandates a maximum 96 dBA decibel value using this test for any off-road vehicle produced after 1986 and thus, given the importance of the California market, most stock dirt bikes meet this standard. However, we are not in California and many users modify the exhaust to improve performance. Bikes that exceed 100 dBA are not uncommon.

Dirt bike racing necessarily involves several bikes, thus the sound level produced by a dirt bike track during a race is the result of a number of bikes running simultaneously. If a track has between 4 and 8 bikes running in a race, the resulting combined decibel output (assuming each produces 96 dBA) would be between 105-117 dBA.

Using this range of values and the compromise sound drop-off value of -4.5 dBA per doubled distance a simple calculation can be done to estimate the sound level at difference distances from the track.

Regulating Noise Level: Two examples.

There are many noise regulations that vary across jurisdictions. Most specify either a maximum or average decibel (dBA) reading either at the boundary of a sound producing property or at the nearest noise sensitive area to such a property. The nearest noise sensitive area (NSA) is typically the closest residence, school, church, recreation area.

In crafting a regulation, the question becomes what dBA level is appropriate and reasonable and how/where the noise level is measured. As some guidance I give a couple of examples.

First, I will describe the federal 55 dBA LDN standard. This standard is used in federally regulated infrastructure projects such as airports, electric substations, natural gas compressor stations etc. The standard specifies that the average noise level over a 24-hour period is 55 dBA but with a nighttime 10 dBA penalty from 10:00 pm to 7:00 am. For a facility that runs continuously with the same constant output sound level, the penalty means that the constant sound cannot exceed about 48.7 dBA. The sound is measured at the nearest NSA outside and away from any structures. This standard is fairly stringent but is applied to facilities that produce sound constantly. It would likely be seen as unfair to apply to a racetrack which (hopefully) operates only part of the time.

As an alternative standard example, the state of Maryland has a noise ordinance that mandates a maximum of 65 dBA during the day and 55 dBA during the night (10:00 pm – 7:00 am) at any outdoor location on a property**.** Notably one of the listed applications of the law is to dirt bikes being used too close to a neighbor's property line. The law exempts lawn equipment, chain saws, etc. being used properly for property maintenance.

Worked Example

As an example of the sort of calculation that might guide regulation decisions, consider a track with 4 bikes producing 105 dBA at 0.5 meters. Using the -4.5 dBA drop for every doubled distance, the table below shows that the track would need to be 256 meters (840 feet) from the nearest neighboring property (or residence, depending on how the regulation was written) to meet a 65 dBA standard.

Distance (m)	0.5	1	2	4	8	16	32	64	128	256
Decibel level dBA	105	100.5	96	91.5	87	82.5	78	73.5	69	64.5

This calculation, as I have emphasized, is merely an approximation of what would, in practice, be a very involved process to determine accurately. If berms, trees, and other barriers were erected it might be possible to meet the standard with a shorter distance to a neighboring property. The process of determining what remediation measures might allow a track to meet a certain standard would require the services of an acoustic engineering firm specializing in outdoor sound.

Conclusion

If you have acoustics questions or require any more information, please feel free to contact me via email at William.robertson@mtsu.edu or phone 615 838 7301.

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