United States
Environmental Protection
Agency

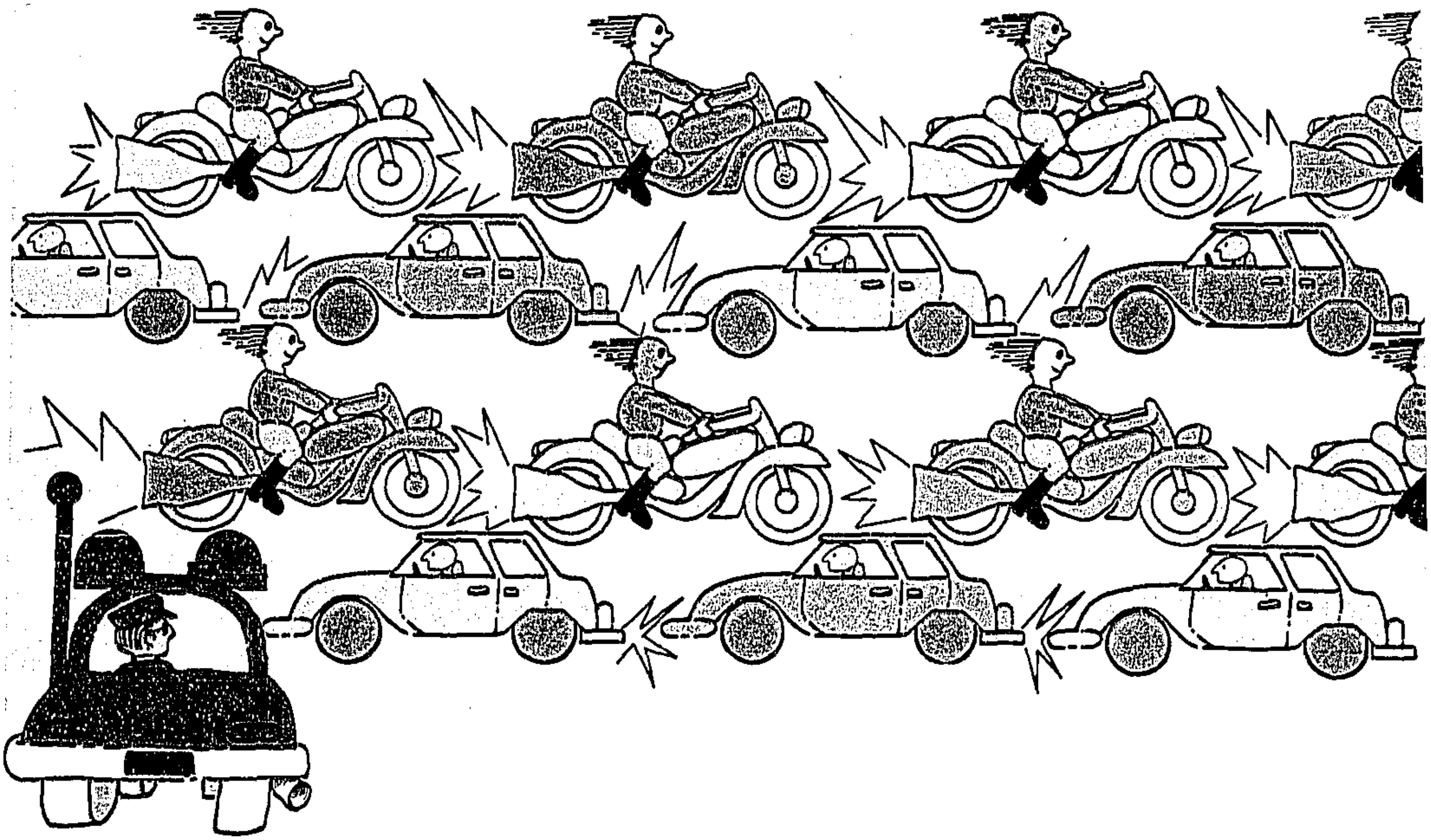
Region V
Noise Program
230 South Dearborn Street
Chicago, Illinois 60604

EPA-905/2-80-00:

N-96-01
II-A-866

EPA

Handbook For Motor Vehicle Noise Enforcement



EPA

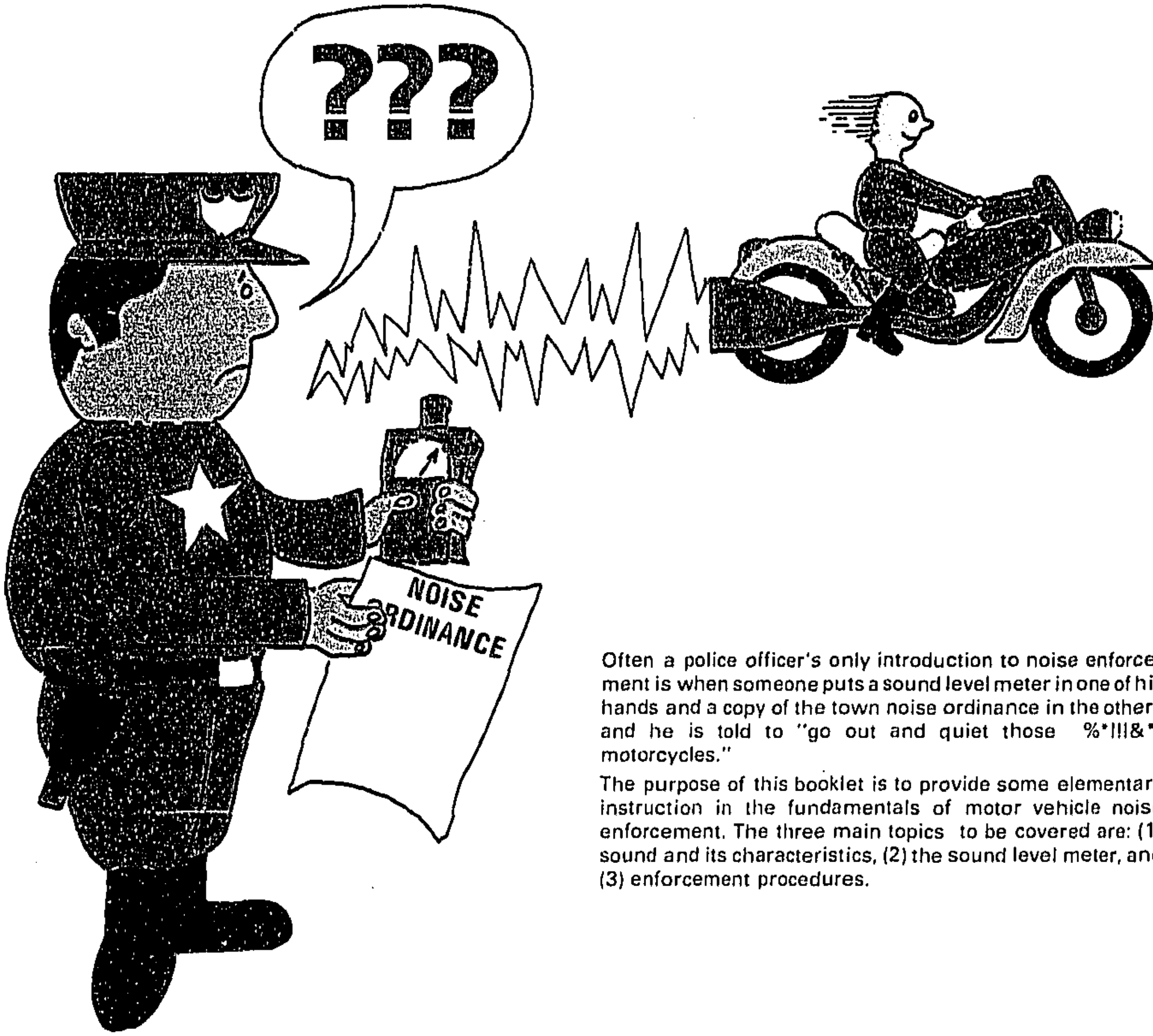
HANDBOOK FOR MOTOR VEHICLE NOISE ENFORCEMENT

NOISE NOISE NOISE

By Gale R. Hruska, Noise Control Specialist
U.S. Environmental Protection Agency
Region V Noise Program
Chicago, Illinois 60604

Illustrations by Robert J. Nagel
U.S. EPA, Region V
Graphic Arts Section

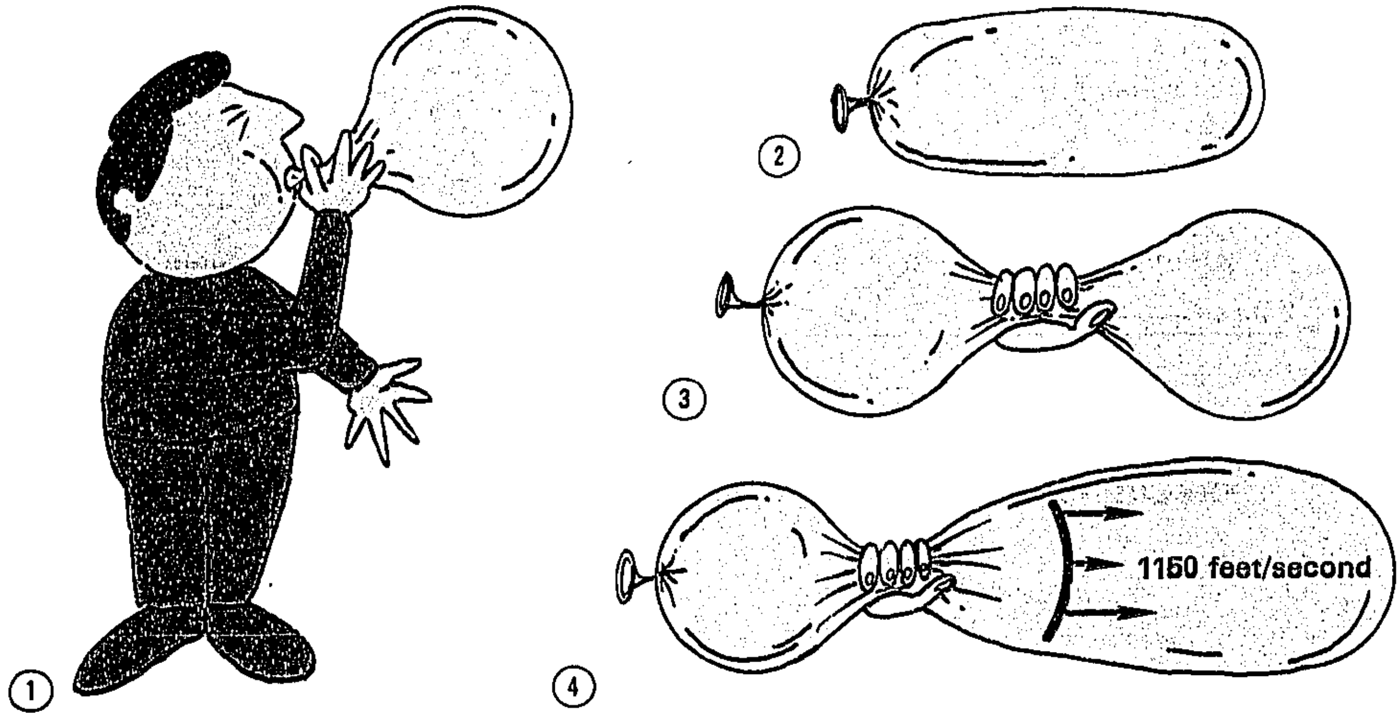
Introduction



Often a police officer's only introduction to noise enforcement is when someone puts a sound level meter in one of his hands and a copy of the town noise ordinance in the other, and he is told to "go out and quiet those %*!!!&*! motorcycles."

The purpose of this booklet is to provide some elementary instruction in the fundamentals of motor vehicle noise enforcement. The three main topics to be covered are: (1) sound and its characteristics, (2) the sound level meter, and (3) enforcement procedures.

Sound Pressure And Wave Motion



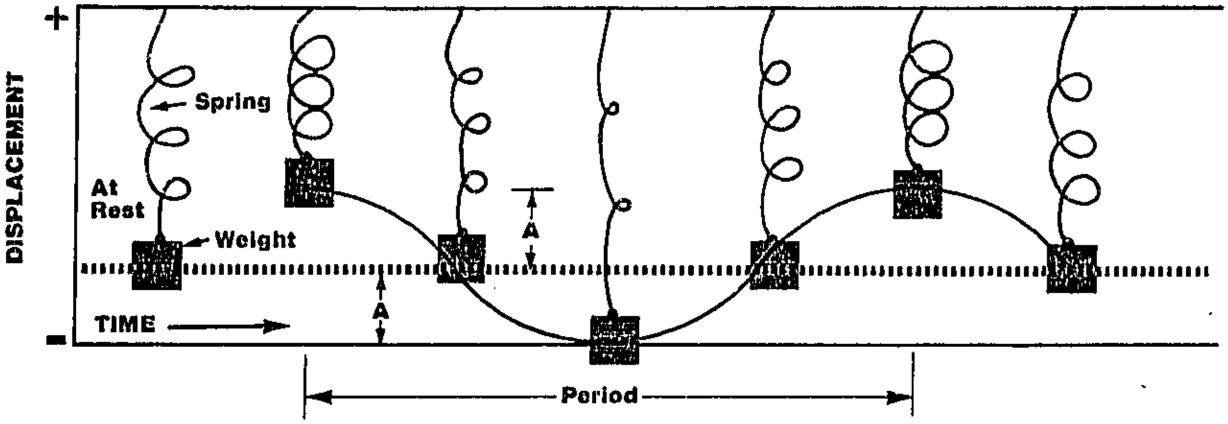
What is sound? Let's use a balloon to find out.

1-2 When one blows up a balloon he uses his lungs to force air into the balloon. This causes the balloon skin to expand into its stretched out shape. The air in the balloon is now under pressure.

3 If we squeeze the balloon in the middle, what happens? The balloon bulges out at the ends and the pressure inside the balloon increases. When the balloon is released it pops back to its original shape at its original pressure.

4 Suppose the balloon were very long and someone squeezed it at one end. What would we observe at the other end? First we would notice that nothing happened for a short period after it was first squeezed, then, just like the small balloon, the pressure would increase. What is happening is that the excess pressure caused by the squeeze is traveling down the tube at a speed of about 1200 feet per second. This excess pressure is commonly termed a sound wave. If the squeeze were released, a decrease in the pressure would travel down the balloon in the same manner. To convince yourself that these actions actually produce sound waves, burst the balloon with a pin.

Periodic Motion - a weight on a spring



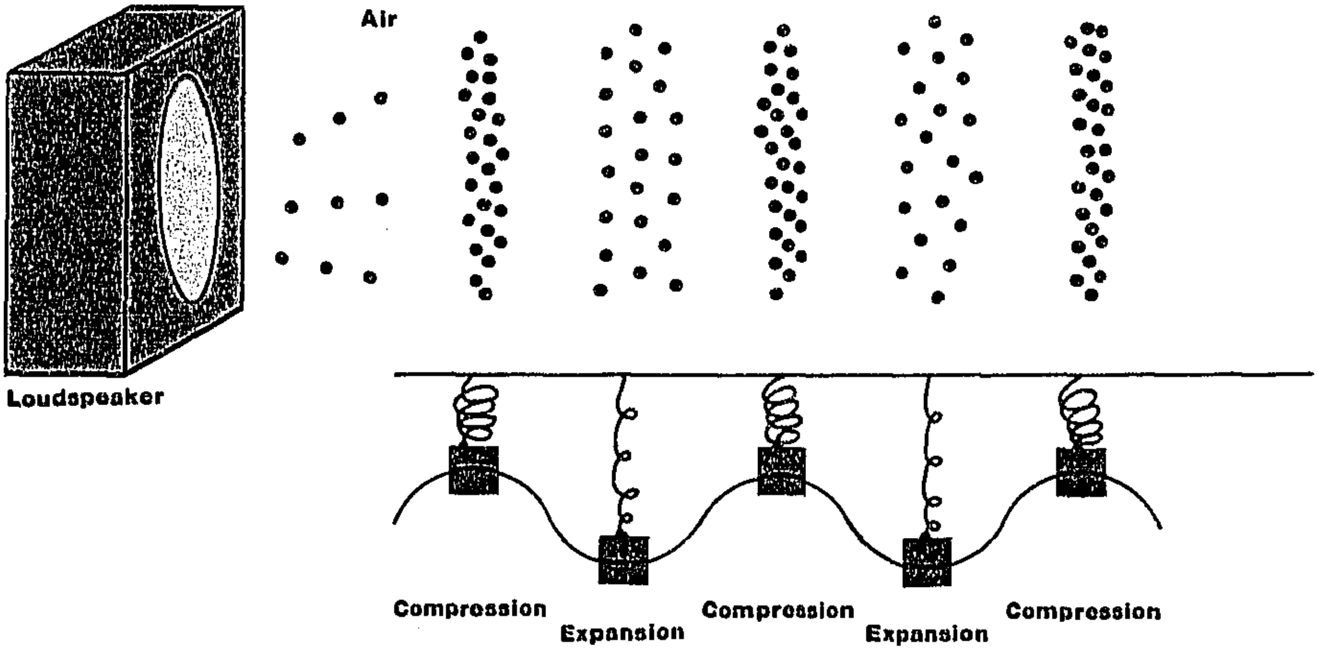
AMPLITUDE (A) - The Maximum Displacement Of The Weight
FREQUENCY - The Number Of Times Per Second The Period Occurs

How do we describe sound? This time let us look at something that appears not to have anything to do with sound at all: a weight hanging from a spring.

If we pull the weight down a distance (A) from the point it naturally hangs, then release it, we see an interesting phenomena. The weight starts returning toward the rest position, and goes through it until it reaches a point as high above the rest position as it was pulled below it. The weight then starts down until it reaches the lowest position, where the process repeats itself again, and again, and again . . .

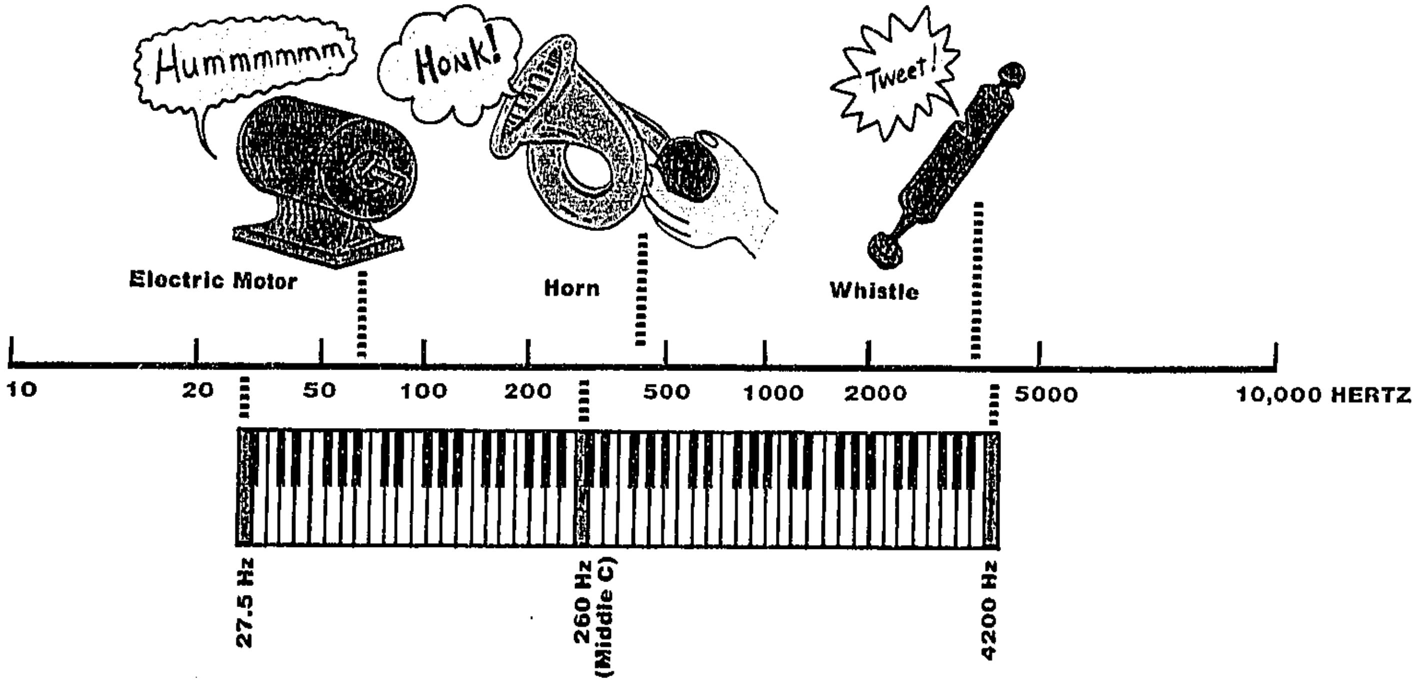
We call the maximum displacement from the "at-rest" position the **AMPLITUDE**, and the time it takes to go through one complete cycle (from down to up to down) the **PERIOD** of the vibration. The number of periods that occur in one second is called the **FREQUENCY**. The units of frequency were once called cycles per second but are now called Hertz. They are abbreviated "Hz".

Sound And Spring



What does the vibration of a spring have to do with sound in air? Let's look at a hi-fi loudspeaker emiting a single tone. As the speaker cone moves forward and backward like the spring, it alternately compresses and expands the air in front of the cone. The compression and expansion then moves out away from the loudspeaker as a sound wave.

Single Frequency Sounds

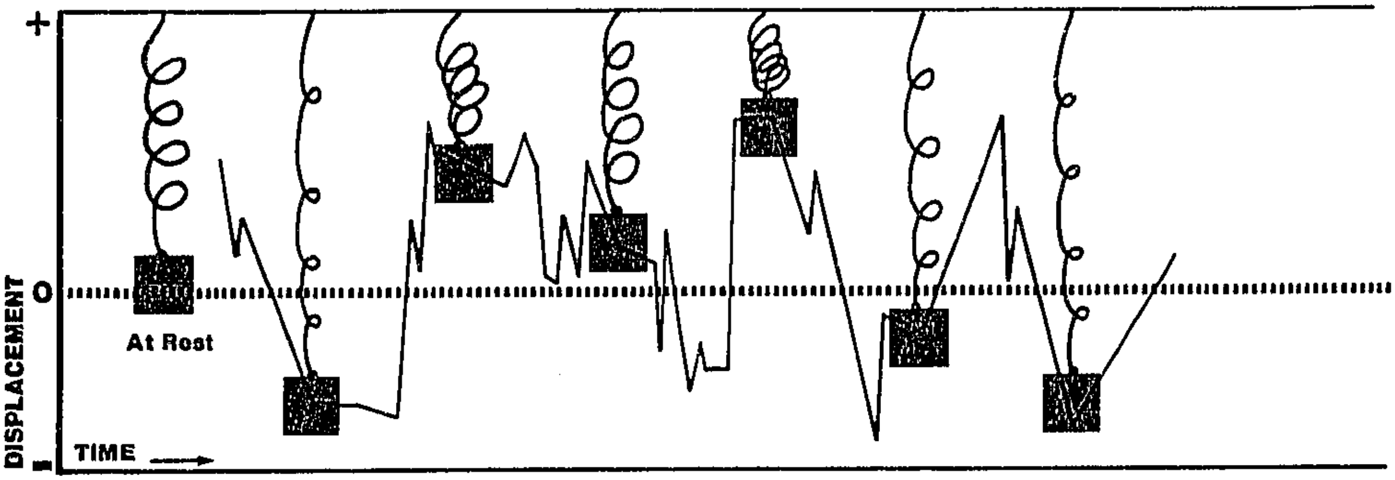


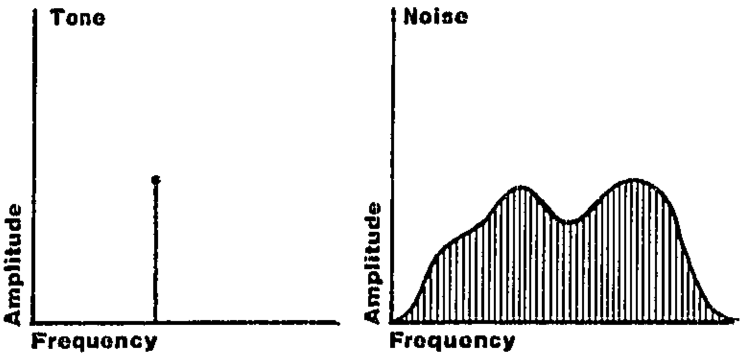
Piano Keyboard

There are a number of common sources of sound that act much like a spring because they cause a single frequency sound to be produced. The keys of a piano are a good example. Pressing the middle C key causes its string to vibrate about 260 times per second. The vibrating string and soundboard cause the air adjacent to it to compress and expand with the same frequency. Just as with the balloon, the changing pressure moves outward as a sound wave.

Other examples of tones are the hum of a motor (60 Hz) and the sound of a police whistle (3500 Hz).

Random Motion - Noise

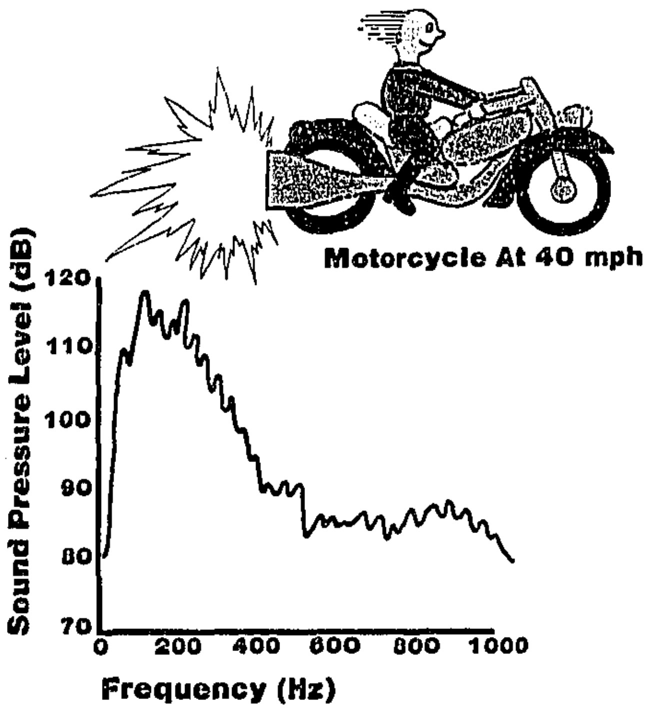


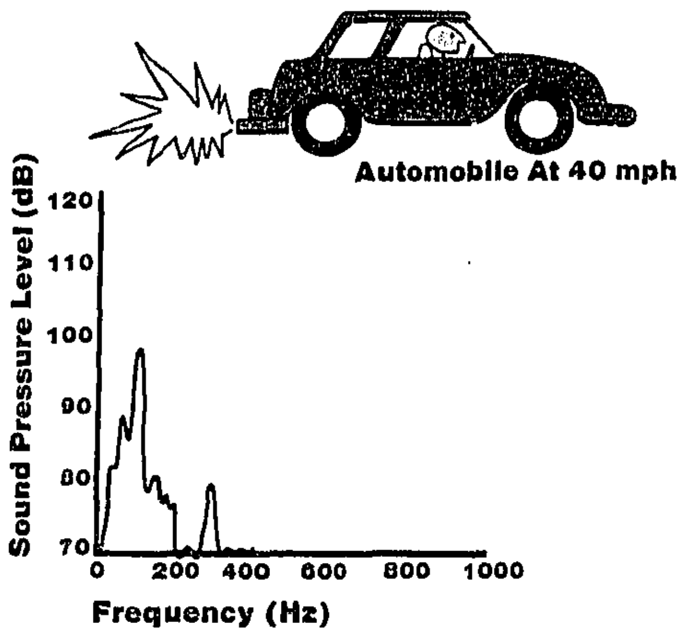


Look at the spring again. Suppose that instead of just pulling the spring down and releasing it, there is an invisible hand which randomly either pulls or pushes on the weight at different times. The way the spring moves might be something like the diagram shows. (Sound can behave in this random manner also - consider rock and roll music.) How do we describe its motion?

Certainly there is no single frequency or amplitude with which to describe the motion as in the previous case. Fortunately noise such as this can be shown to be composed of many single frequency components, each having its own amplitude.

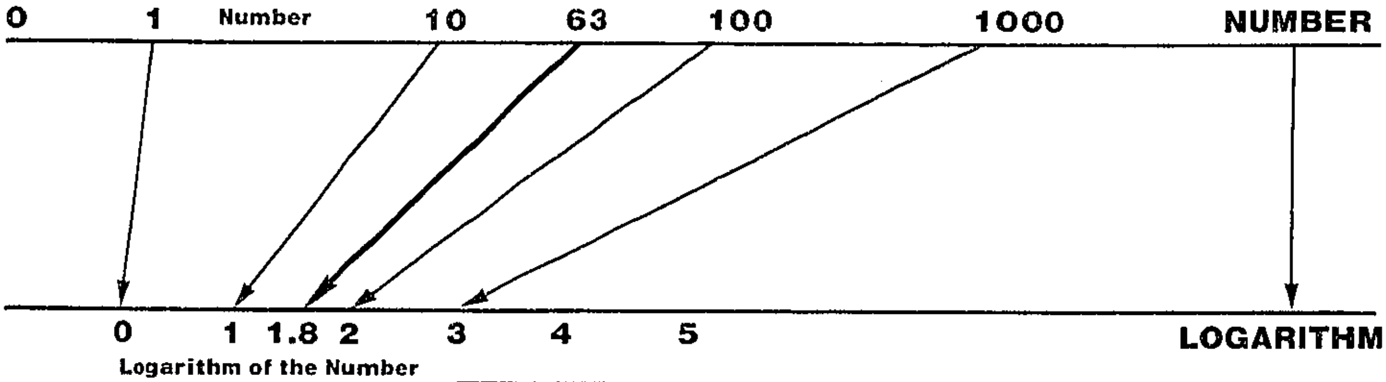
Sound With Many Frequency Components





As an example of sound with many frequency components, let us look at motorcycle and automobile noise. Here we see typical sound pressure components (which are equivalent to amplitudes) for motorcycles and autos. Notice that the levels for motorcycles are greater than for automobiles. They also contain components that are higher in frequency. These are two reasons why motorcycles annoy people more than automobiles.

Logarithms (to the base 10)



RULE	EXAMPLE
1) $\log(a \times b) = \log(a) + \log(b)$	$\log(10 \times 100) = \log(10) + \log(100)$ $= 1 + 2 = 3$ $= \log(1000)$
2) $\log(a/b) = \log(a) - \log(b)$	$\log(1000/100) = \log(1000) - \log(100)$ $= 3 - 2 = 1$ $= \log(10)$

How do we describe the volume of the sounds we hear in everyday life? This can be a problem since the lowest sound pressures the ear can detect are more than a million times less than those that we hear when a jet takes off. To make the numbers manageable we need to consider the concept of the **DECIBEL**. To do this we must first look at logarithms.

Instead of defining logarithms to the base 10 as was done in school, we shall investigate them by examining some of their properties. As we can see from the chart, the logarithm of whole numbers that are powers of ten (1, 10, 100, 1000, ...) are smaller whole numbers such that they indicate the number of zeros that were in the original number (0, 1, 2, 3, ...) As one might guess, a number in between two consecutive powers of ten has its logarithm between the two corresponding consecutive whole numbers. For example, 63 is between 10 and 100, therefore the logarithm of 63 is between 1 and 2 (1.8 to be exact). The values of logarithms are usually found by either looking them up in a table or using a calculator.

Two important properties of logarithms are given in the table. When two logarithms are multiplied together the logarithm of the product is equal to the sum of the logarithms of the individual numbers. When two numbers are divided the logarithm of the quotient is equal to the difference between the logarithms of the individual numbers. Thus we see that the multipying of real numbers is equivelant to adding their logarithms, and division of real numbers is equivelant to subtracting their logarithms.

Sound Pressure Level (SPL) - Decibels

Definition

SPL=20 Log_{10} (Measured Sound Pressure / Reference Pressure)

Reference Pressure (Pref) = 0.00002 Newtons / $(\text{meter})^2$
= 0.00000000294 lb./in^2

Examples

Sound	Sound Pressure	Sound Pressure Level
Whisper	31 × Pref	35 dBA *
Jack Hammer	12,600 × Pref	82 dBA
Jet Take-Off	1,000,000 × Pref	120 dBA

* decibels using A-weighting Network (to be described later)

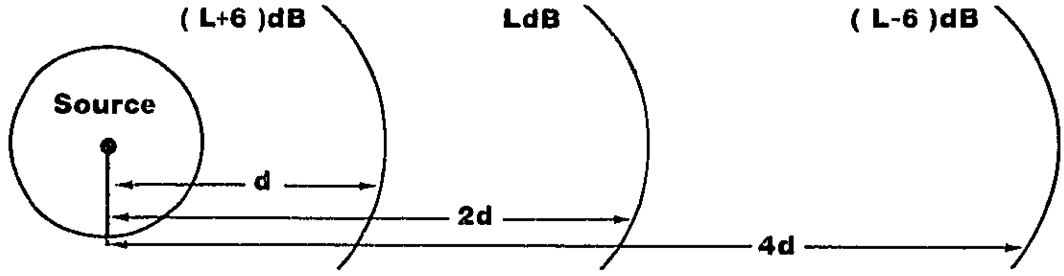
Let's get back to sound. Because the sound levels we encounter in daily life can vary over such a wide range, talking about sound pressure in units such as pounds per square inch would be unweildy. To remedy this situation we define the **SOUND PRESSURE LEVEL (SPL)** as:

SPL=20 × logarithm_{10} (measured sound pressure/reference pressure)

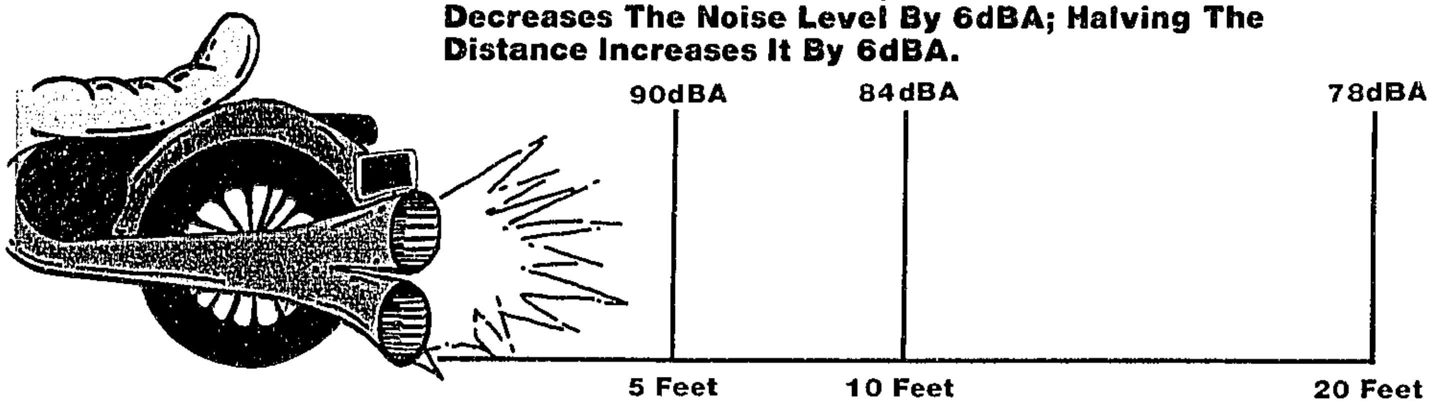
The reference pressure used for environmental noise turns out to be the lowest level sound that a person with normal hearing can detect. The unit of sound pressure level is called the **DECIBEL**. The figure shows the sound levels produced by three common sound sources.

Logarithms (?), decibels (?) - does all of this complicated jargon mean that a police officer will have to have a degree in mathematics ? NO ! All enforcement equipment is calibrated directly in decibels, so no calculations are involved. The police need only know three specific decibel numbers which will help him in enforcing the noise ordinance.

Sound Level And Distance From The Source



RULE OF THUMB: Doubling The Distance From A Source Decreases The Noise Level By 6dBA; Halving The Distance Increases It By 6dBA.



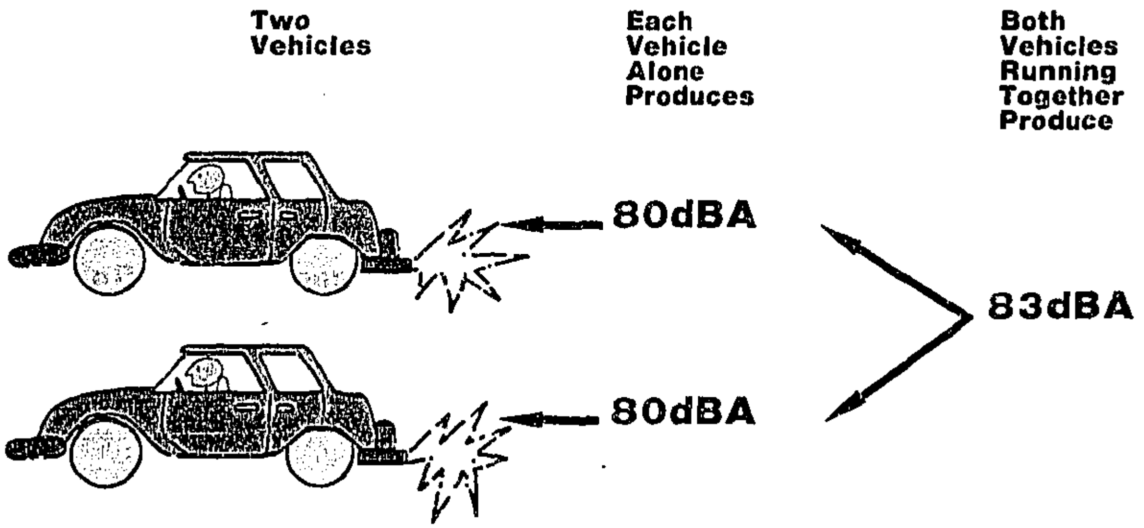
What happens to the sound pressure level as you move toward (or away from) a sound source. Most people know that the noise level increases as you get closer and decreases as you move away. A good rule of thumb to follow is that the noise level decreases by about 6 decibels each time the separation between the source and receiver is doubled; it increases by about 6 decibels each time the distance is halved.

As an example, suppose you measure some motorcycle noise at 84 dBA when you are 10 feet from a vehicle. (The "A" in "dBA" refers to the decibel value measured using a particular weighting network. This concept will be covered when we talk about sound level meters.) What levels would you expect to measure at 5 feet ? At 20 feet ? At 40 feet ? (Answer: 90 dBA, 78dBA, and 72 dBA respectively)

Notice also that the sound pressure level rises at a faster rate as you move closer to the vehicle. It takes only 5 feet to increase the level by 6 dBA (starting at a 10 foot separation), but it takes a 10 foot change for the level to decrease by 6 dBA. The importance of this observation is that the police officer should make sure he is at least as far away from the vehicle as the ordinance requires. It is better to be a little too far than a little too close; less error will result, and what error does occur will favor the violator.

Remember: 6dBA PER DOUBLING OF DISTANCE

Combining Sound Pressure Levels

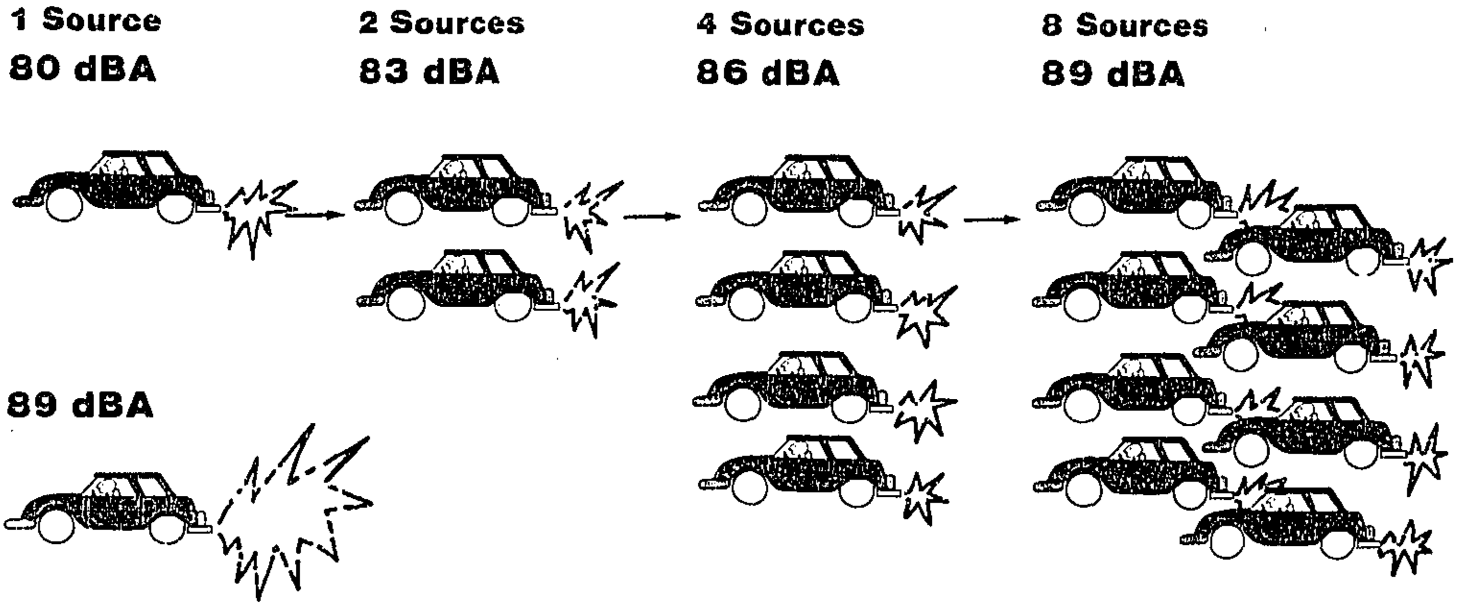


Rule of Thumb: Each time the number of (identical) noise sources is doubled the SPL is increased by 3dBA. Each time the number is halved, the SPL is decreased by 3dBA.

Suppose we have two identical automobiles, each alone producing 80 dBA noise levels. What sound pressure levels do we measure if we run them at the same time? One might naively reason that two times eighty dBA is 160 dBA. Unfortunately this answer is wrong; we cannot add decibels directly to get the overall effect. The correct answer is 83 dBA.

The correct answer is obtained by using the following rule of thumb: Each time the number of (identical) noise sources is doubled, the sound pressure level increases by 3dBA; each time the number is halved, the sound pressure level is decreased by 3dBA.

Comparison Of Noise Levels

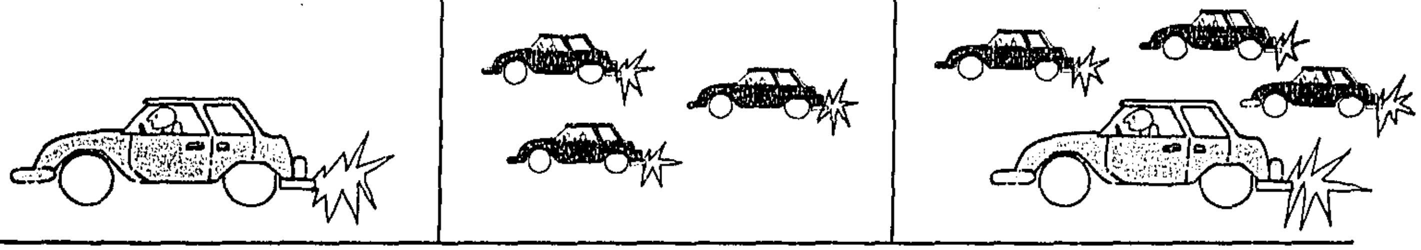


How does the 3dBA rule help the police officer ? Consider this example. Suppose your noise ordinance has an 80 dBA noise limit. You cite a violator for causing an 89 dBA noise level and the case comes to court. The judge asks you how loud 89dBA is. Knowing this rule of thumb you are able to tell him that 89dBA is the same noise level that would be produced by 8 vehicles, each one producing the maximum allowable limit of 80dBA. Cased closed!

Remember: 3dBA FOR EACH DOUBLING OF IDENTICAL SOURCES.

Effects Of Additional Noise Sources

Violator Level	Ambient Level (all other noises)	Ambient & Violator Level
90 dBA	80 dBA	90.4 dBA



RULE OF THUMB: Violators Shall Not Be Given A Citation For A Noise Violation Unless The Level Measured When The Violation Occurs Is At Least 10dBA Above The Ambient Noise Level.

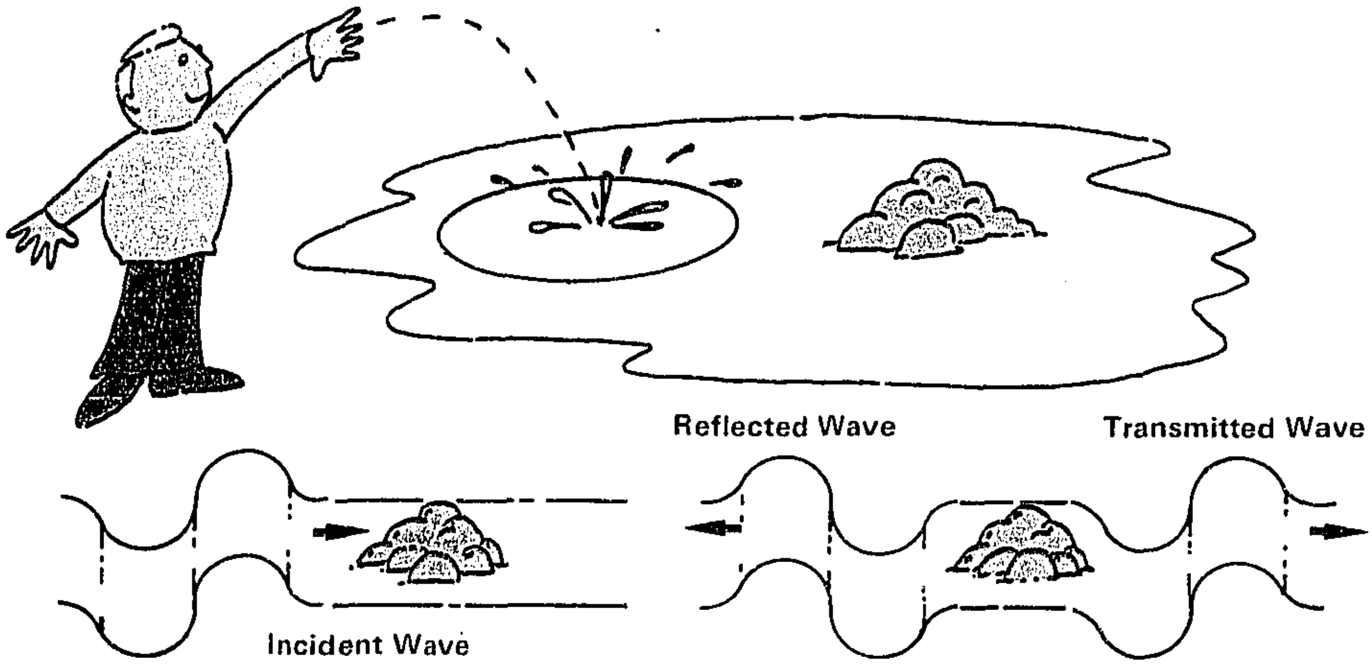
A third rule of thumb to remember involves the contribution to the overall level of all of the other vehicles and noise sources present at the time a violator is cited. This extraneous noise is called the AMBIENT LEVEL. A violator might ask;"There were a lot of other cars on the road when you caught me, so how do you know that they didn't cause the reading to be too high ?" The rule that applies here is: a violator shall not be cited unless the level measured when the violation occurs is at least 10 dBA above the ambient noise level immediately before the violation.

If the above condition is satisfied, then the additional noise caused by all the other sources producing noise will add less than 0.4dBA to the level produced by the violator.

The rule also implies that if there are several noisy vehicles traveling together and you can't separate the noise made by each separately, you will have to let them all go free and hope to catch them singley some other time.

Remember: THIS AMBIENT LEVEL MUST BE AT LEAST 10dBA BELOW THE LEVEL MEASURED WHEN THE VIOLATOR PASSES BY

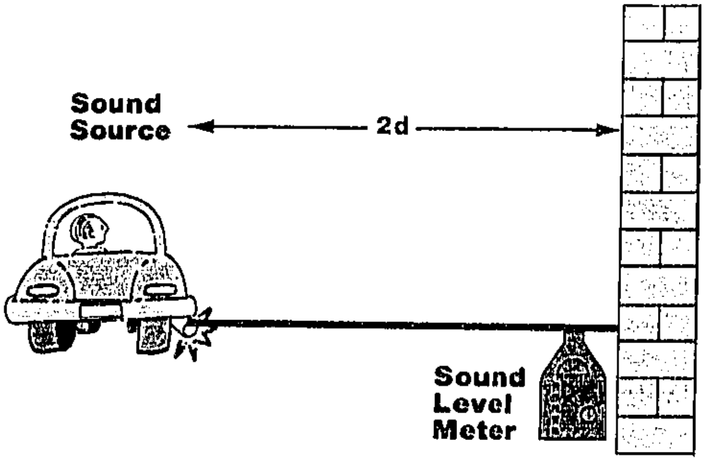
Reflection Of Waves



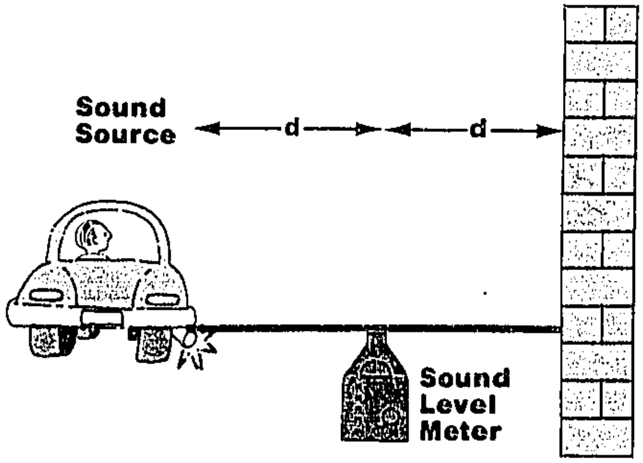
The final rule to remember deals with the reflection of sound from large objects. Let us look at what happens when a water wave encounters an obstacle.

Throw a stone into a pond. This wave acts very much like a sound wave as it travels outward in an everwidening circle. If the water wave encounters an obstacle, you see part of the wave reflected back in the direction it came from. When we throw stones into the pond one after another we see some of the incoming waves interacting with the reflected waves. If we were to make measurements of the wave heights (which would be equivalent to the sound pressure in air) we would find that the height at a point close to the rock would be quite different than if this obstacle were not there. A similiar phenomena occurs in air when large objects are situated near a point where measurements are being taken.

Errors Caused By Reflecting Objects - The Infinite Wall



3dBA Error



Approximately 1/2 dBA Error

RULE OF THUMB: Keep At Least As Far From Any Reflecting Object As You Are From The Vehicle Being Measured.

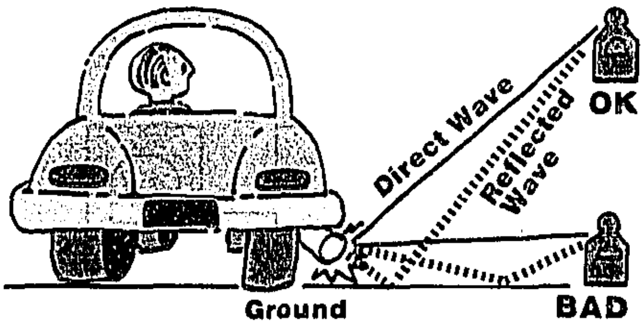
Look at what happens when we make measurements near a large wall. If we put the sound level meter right next to the wall, the value we read will be approximately 3dBA greater than if the wall were not there. However, if we move the wall back until it is the same distance from the SLM as the SLM is from the sound source, we find that the reflected wave will now only cause about 0.5 dBA error. Thus we have a rule of thumb: when making measurements keep at least as far away from any large reflecting objects as you are from the vehicle being measured.

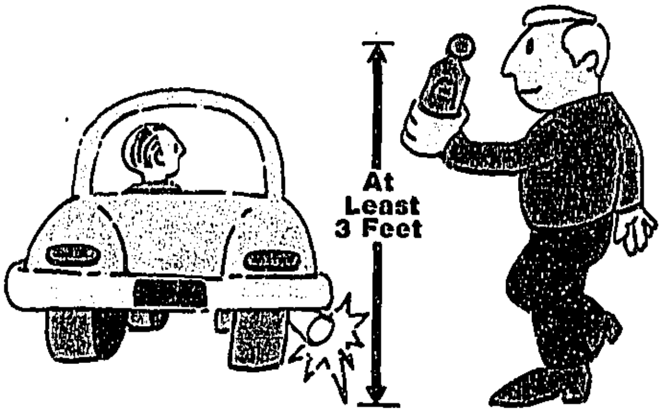
How large is a "large object"? It depends on the frequency of the sound. For automobile noise anything larger than your body can be considered as a large object.

When a SLM is mounted above a patrol car window it will measure some of the reflected from the patrol car itself. Since we are "stuck" with the position of the SLM, we will have to give a little extra leeway to the enforcement sound levels. The exact amount will be discussed later.

Remember: KEEP AT LEAST AS FAR FROM ANY LARGE REFLECTING OBJECTS AS YOU ARE FROM THE VEHICLE YOU ARE MEASURING

Reflection Of Sound - The Ground Reflection

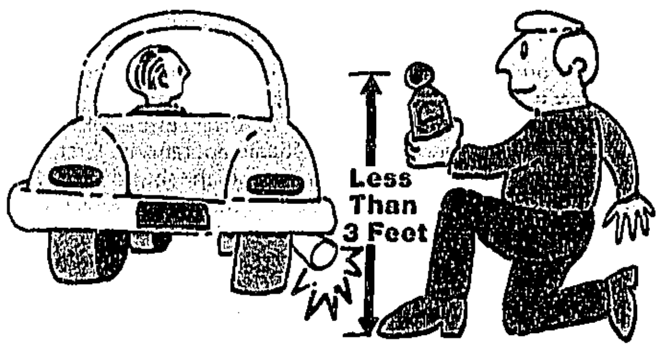




RIGHT

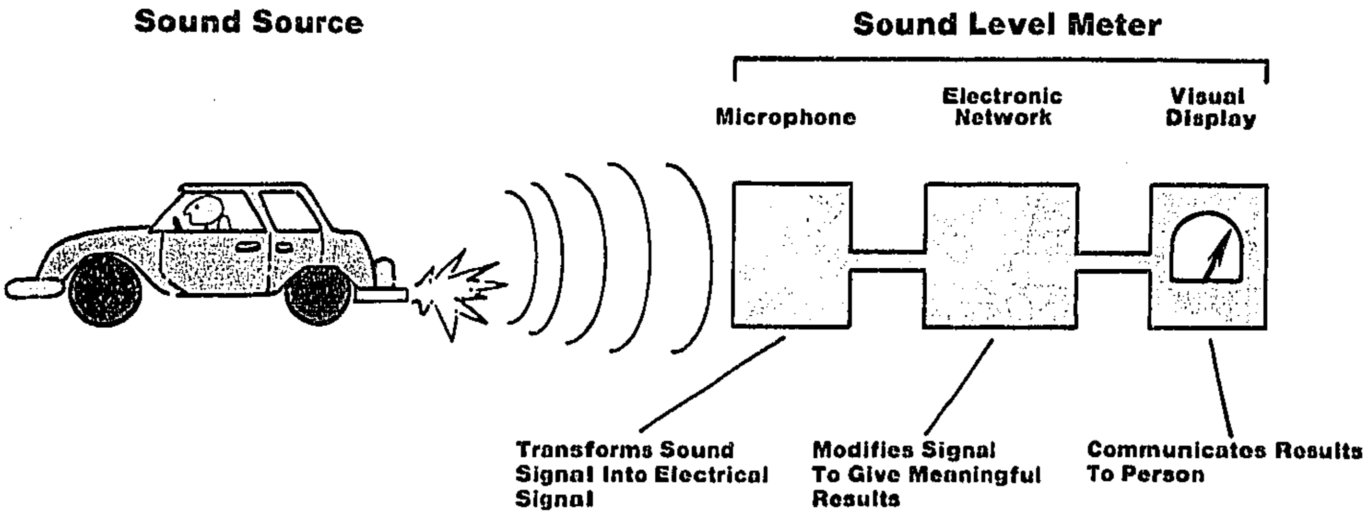
RULE OF THUMB: Measurements Should Be made At Least Three Feet Above The Ground.

When considering sound reflection you may ask, " What about the reflection from the ground ?"
The noise level limit stated in an ordinance takes into account the fact that the noise heard by the receiver consists of sound that is reflected from the ground to the receiver as well as the direct wave. Normally there should be no concern; the exception is when the SLM is close to the ground. In this situation sound from the exhaust pipe, which is also close to the ground, travels close to the ground along the whole path. The result is that the sound waves become distorted producing unexpected results. Therefore a good rule to remember is:
ALL MEASUREMENTS SHALL BE MADE WITH THE MICROPHONE AT LEAST THREE FEET ABOVE THE GROUND.



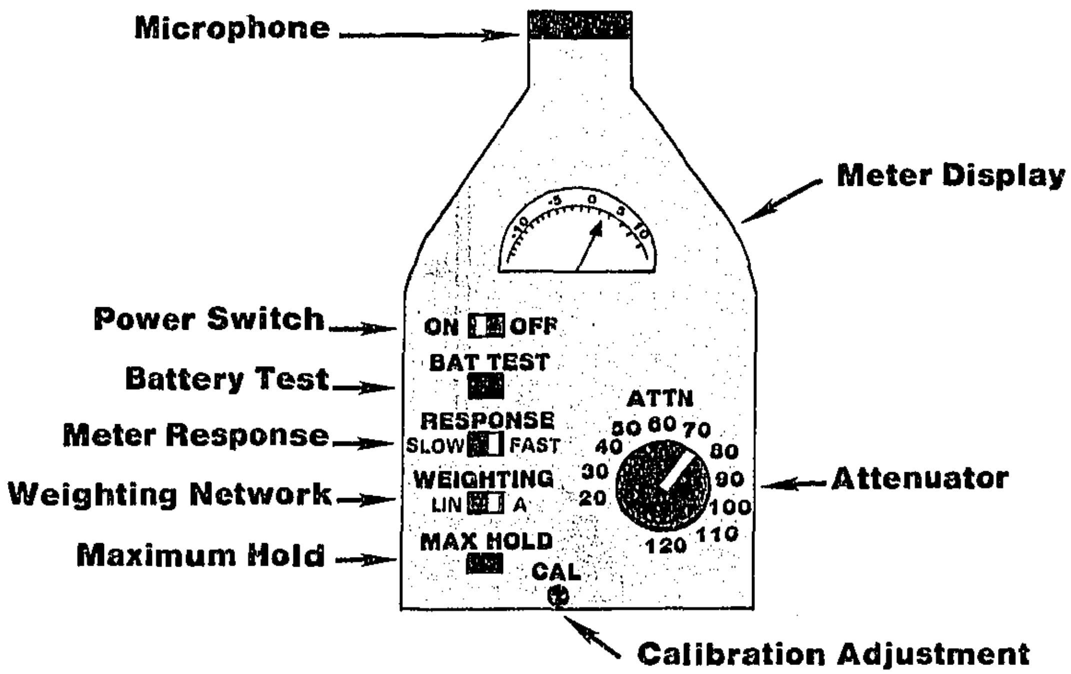
WRONG

The Sound Level Meter - Introduction



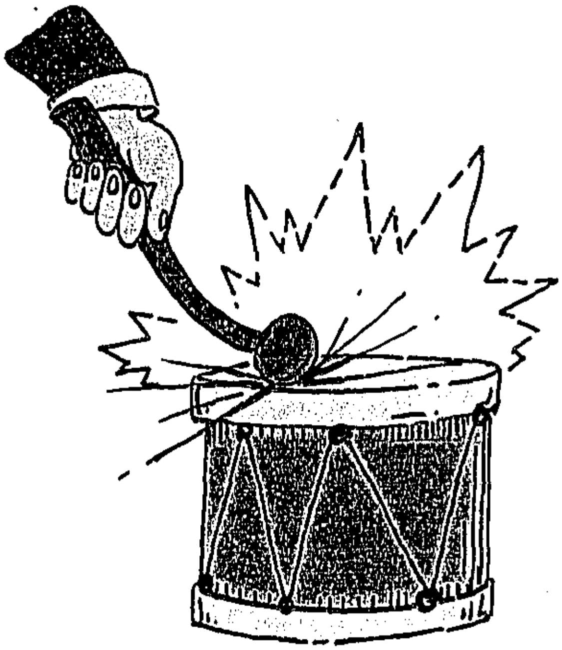
Now that you know all about how sound behaves, it is time to learn how it is measured. The most common device used in noise ordinance enforcement is the SOUND LEVEL METER (SLM). This device performs three basic operations. First it uses a microphone to convert the energy in the sound into an electrical signal. An electronic network then conditions the signal to provide meaningful results. That's all that you will probably need to know about how the SLM physically operates. More important to the enforcement officer is that he must know how to use the instrument correctly. This is what we will concentrate on.

Sound Level Meter Features

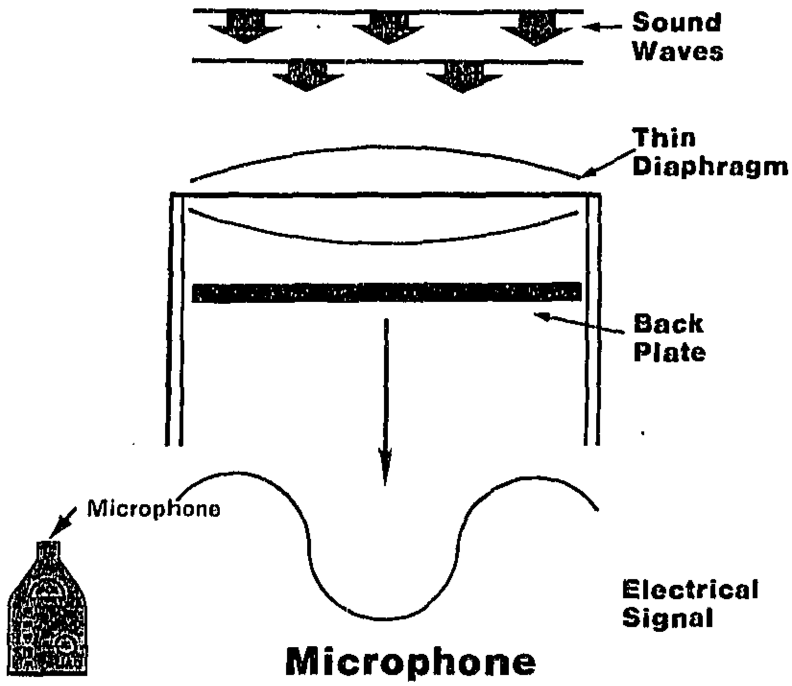


This illustration depicts a sound level meter having features found on many SLMs used in motor vehicle enforcement. Your particular SLM may not have some of the features, and others of them may be incorporated into the instrument so that no switch is necessary. You may also have some special features not discussed here.

The Microphone - Principles of Operation



Drum

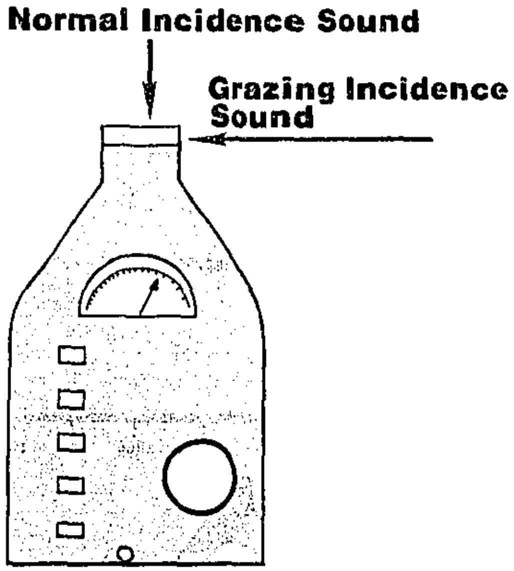


Microphone

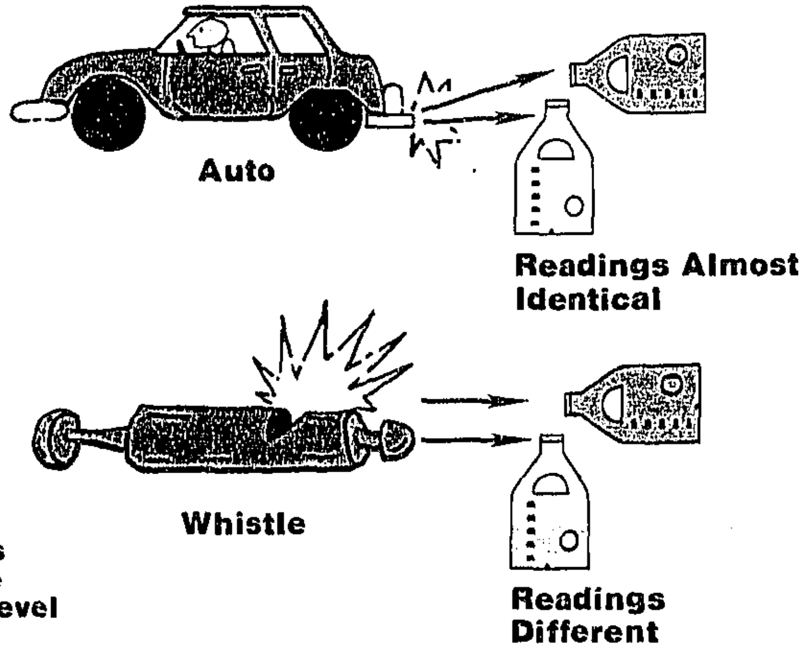
An important part of the SLM is the MICROPHONE. The microphone works like a drum in reverse. When you hit a drum the drumhead vibrates causing the air in front of it to alternately compress and expand. As you know from the previous discussion, this causes a sound wave to be propagated outward toward your ear.

When a sound wave hits a microphone it causes the diaphragm (which is usually a metal foil only a few thousandths of an inch thick tightly stretched over the front of the housing) to vibrate like the drumhead. The diaphragm also happens to be part of an electrical circuit; its vibration produces electrical signals in the SLM circuitry which are proportional to the sound pressure causing the vibration.

Sound Level Meter Directivity



RULE: Always follow Manufacturer's recommendations with regard to the preferred orientation of the Sound Level Meter.

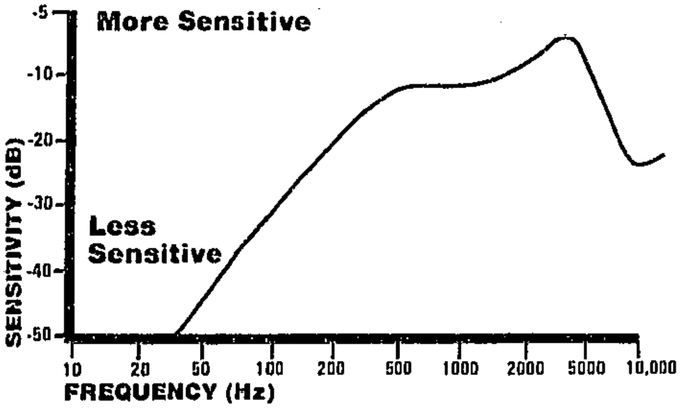


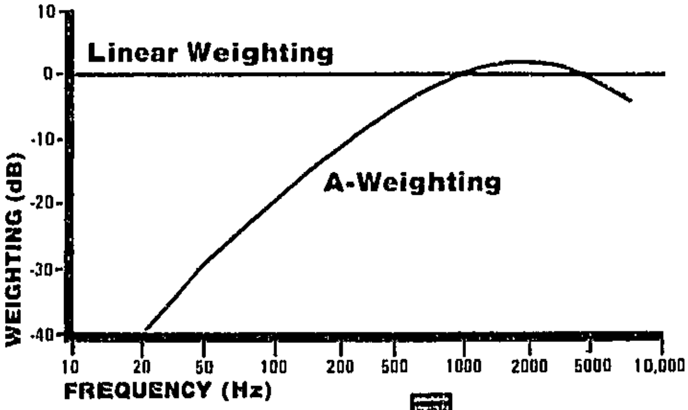
An important question to answer is " How should I hold the SLM ?" Should the microphone be pointed at the noise source (normal incidence) or should the face of the microphone be oriented at some other angle such as at a right angle to the sound wave (grazing incidence)? The rule here is to follow the manufacturer's recommendations as stated in the operator's manual. For most (but not all) SLM's the preferred direction is at grazing incidence.

For low frequency sounds such as those produced by automobile exhaust systems, the readings at the two orientations will vary hardly at all. However, if you try measuring the sound level of a high frequency source such as a siren or a whistle, the sound level measured will depend very much on the angle at which the sound hits the microphone.

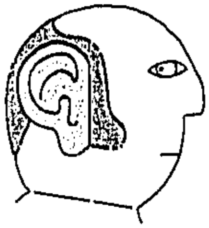
Here is an experiment you should try. Place your SLM off to the side of the patrol car and then change the orientation of the microphone while the car is idling. See what changes you can detect in the reading as the microphone is pointed in different directions (while keeping the distance from the tailpipe the same of course).

Sound Level Meter Weighting And The Sensitivity Of The Ear

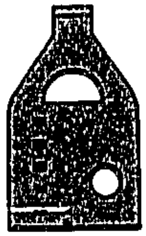




The Ear



The Sound Level Meter



Let us consider the switches on the SLM. The use of two of them, the "on-off" switch and the "battery-test" switch, are self explanatory.

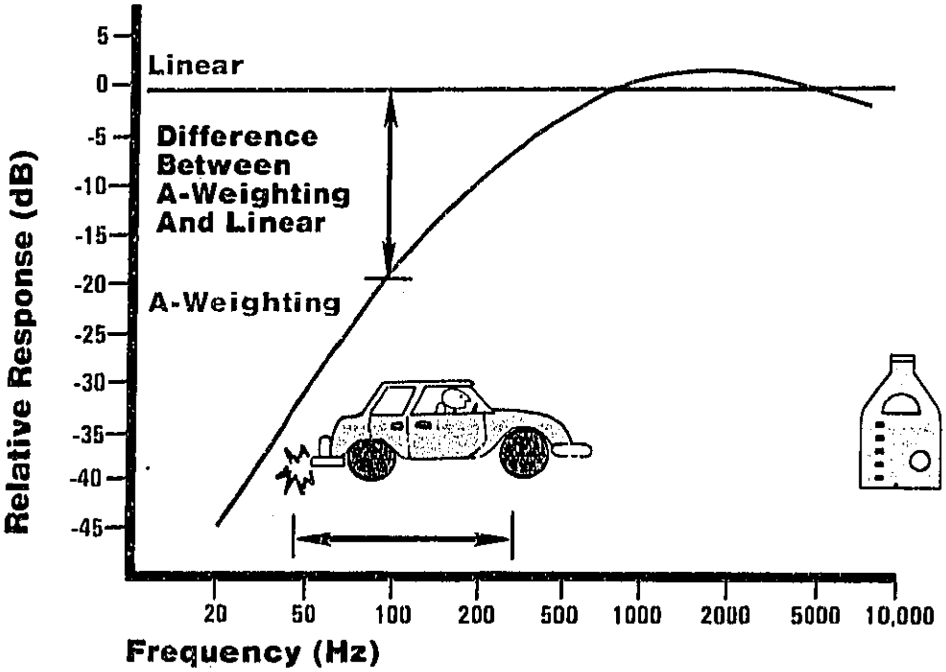
Consider the "weighting" switch. Some SLM's give you a choice of A,B,C,D, and linear settings. Which one should you use? The answer is, "The one your ordinance says to use". Virtually all motor vehicle noise ordinances today use A-weighting network, so A-weighting is most likely the one you'll be interested in.

What is an A-weighting network? Consider the ear. The graph on the left side shows that the ear is not equally sensitive to sounds of all frequencies. For example, people are much more sensitive (and therefore much more annoyed) by noise having significant high frequency components than they are by lower frequency sound. This is why a siren is designed to have such a high pitch. The A-weighting network shown by the second graph virtually duplicates the ear's sensitivity by descriminating against low frequency noise. At 100 Hz the network subtracts 20 dB from the incoming signal before sending it through the rest of the SLM. At 1000 Hz nothing is subtracted.

The linear weighting network considers all frequencies equally important and does nothing to alter the signal. It is used in situations such as when low frequency noise causes building vibrations. The B,C,and D networks are not commonly used in enforcement situations.

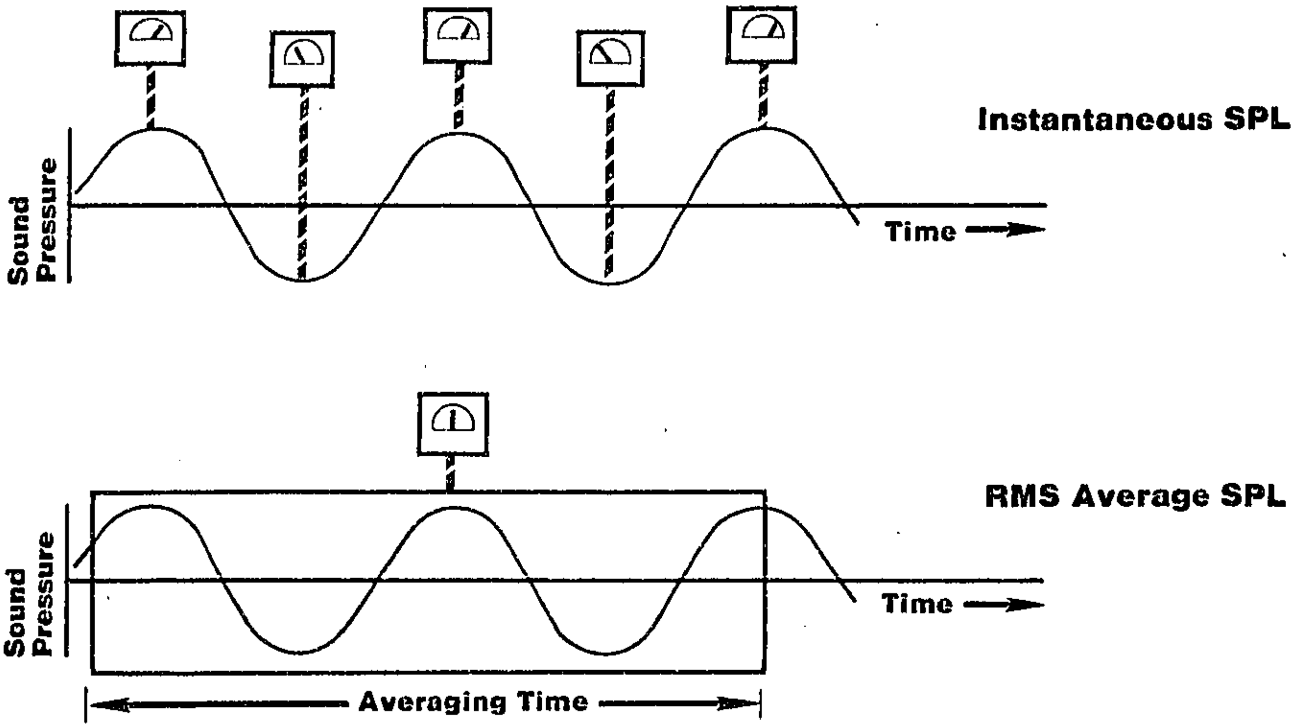
Errors Caused By Using The Wrong Weighting Network

Example: The Automobile



Here we see the difference between the A-weighting and the linear networks and why it is vitally important that the switch is set correctly. Most automobile noise occurs in the frequency range between 50 and 250 Hz. If the weighting switch is incorrectly set to "linear" instead of "A" you might be reading vehicle noise levels that are about 20 dBA too high! Try this yourself using your patrol car as a source. A wrong weighting switch setting should be suspected when every car that passes you turns out to be a violator. If you discover that the SLM was set on the wrong weighting scale you should not hesitate to throw away any citations that might have been written.

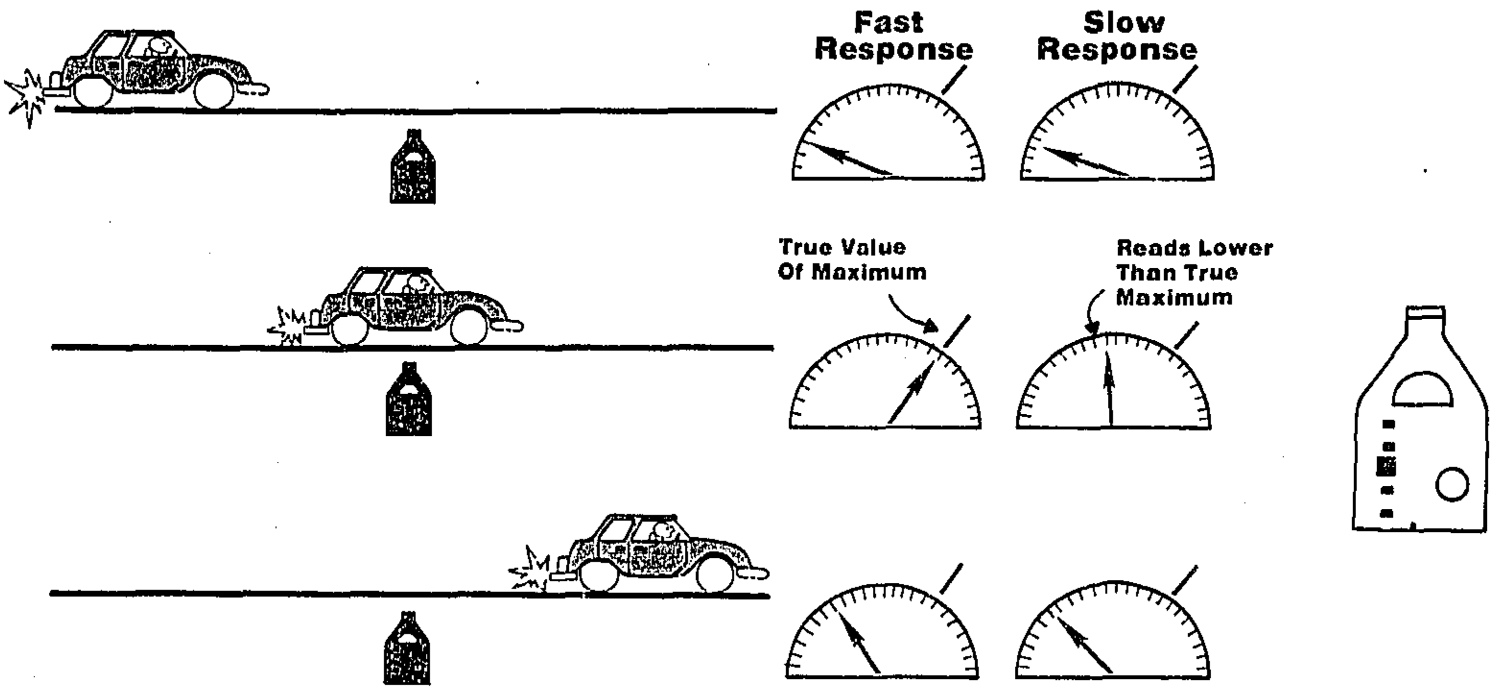
Instantaneous And RMS Average Sound Pressure Levels



Another setting on the SLM is "meter response". If the SLM responded to instantaneous sound pressure what would happen? Looking at a 1000 Hz tone, the meter pointer would rise and fall 1000 times per second as it followed the sound pressure. All we would see is a blur.

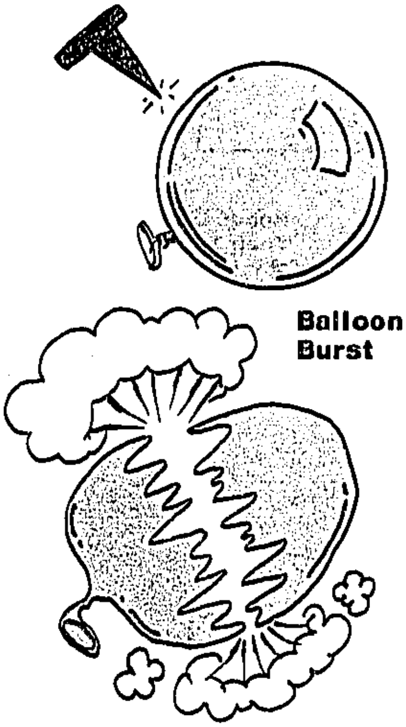
In a real sound level meter the instrument displays an "average" sound pressure level by smoothing out the pointer motion. The technical term for the way the averaging is done is "RMS averaging". The "fast" and "slow" positions determine over what length of time the averaging occurs.

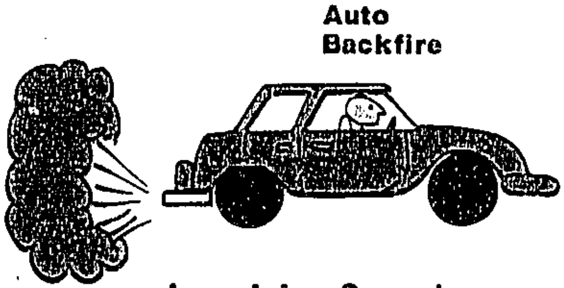
Meter Response - Vehicle Pass-By



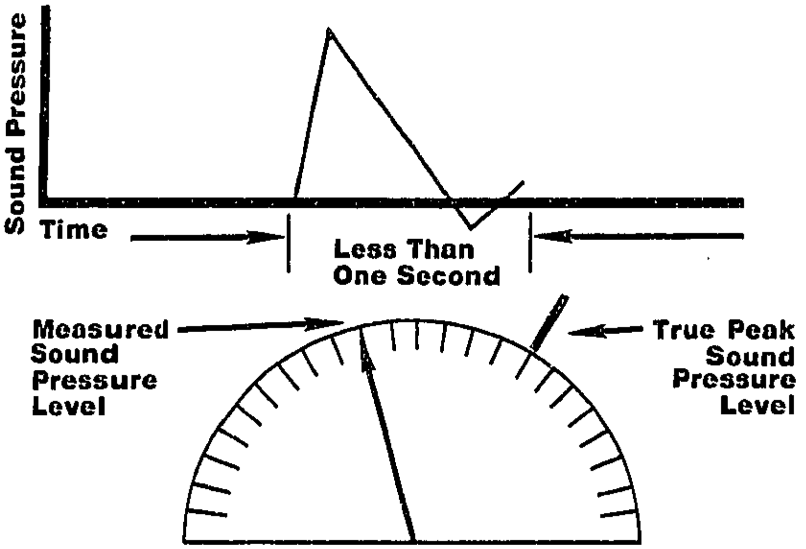
How does the meter response affect the SLM reading during a typical vehicle pass-by? As the vehicle approaches the microphone, the pointer moves up with the increasing noise level. As the vehicle moves away from the observer, the pointer moves down in response to the decreasing noise level. The enforcement officer notes the maximum level reached by the pointer. This procedure works reasonably well with the "fast" setting. If we are in the "slow" response mode and the vehicle is traveling fast, the pointer may never reach the true maximum level before it starts decreasing. The slow response is used when we measure more or less stationary sources that do not change greatly in level over short periods of time.

The important points to be made are that (1) fast response is preferred for motor vehicle enforcement since it best corresponds to the true maximum noise level that a violator causes, and (2) the level that is measured with the slow response will either be less or equal to that measured with the fast response. Thus if you are citing a violator and discover that the SLM is set for a slow response, give the ticket out. The true level was at least as great as what you read on the meter.





Impulsive Sounds

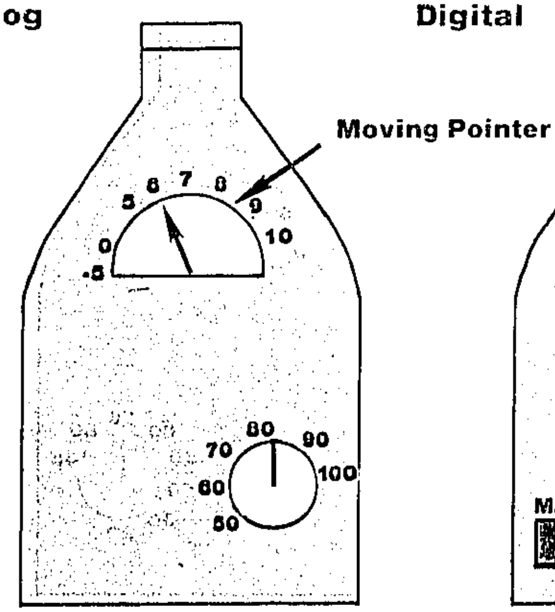


RULE: The sound level meter will always read less than the true maximum value for an impulse noise.

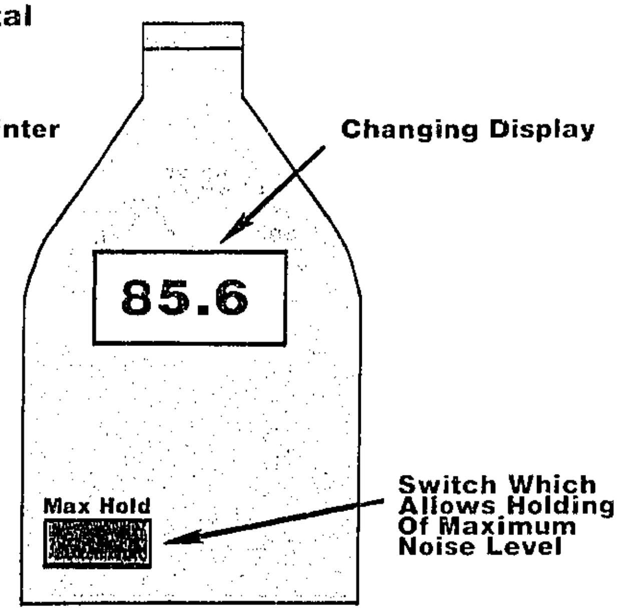
This is a good time to discuss impulsive sounds, such as a balloon bursting, a gun firing, or a automobile backfiring. These sounds are characterized by a very rapid increase in the sound level and only a slightly longer time for the level to decrease back to the ambient level. Are SLM's able to measure these sounds? The answer is "not very well". As with the vehicle pass-by, the duration of the sound is too short to allow the SLM to reach the true level, even on the fast response. It will always read less. You can still issue a citation in this situation because the level you are reading is less than the true maximum level that is occuring. In other words, the violator is causing a greater amount of noise than you are actually citing him for.

Sound Level Meter Displays

Analog



Digital

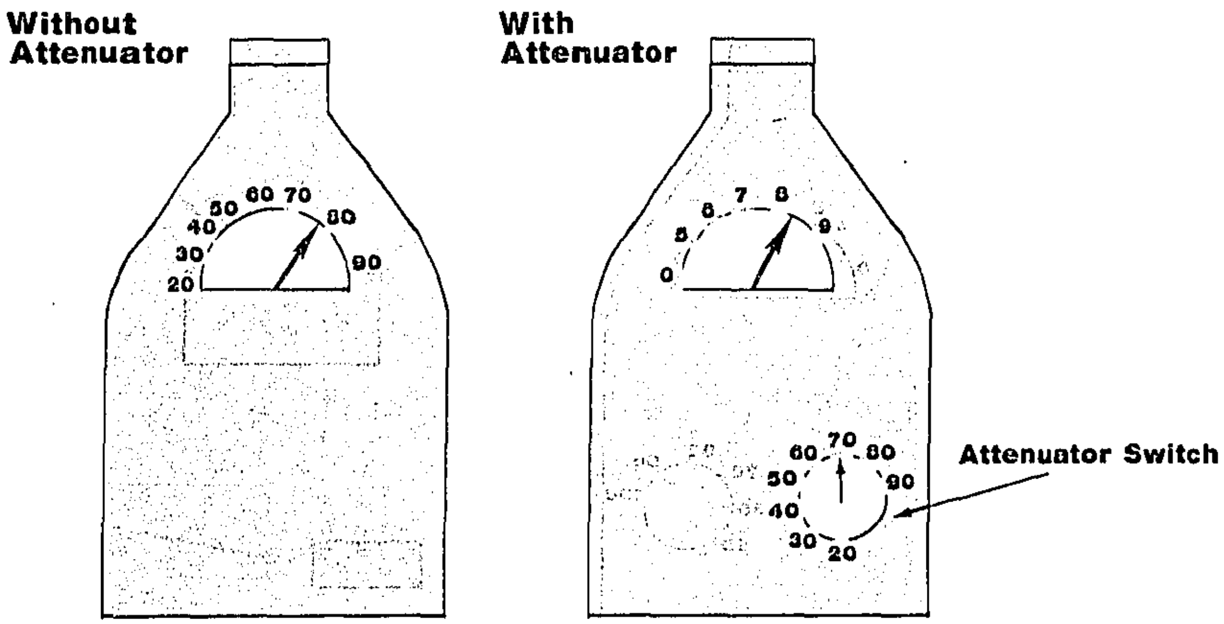


Two types of SLM display are available on SLM's today - digital and analog. Each has its own advantages and disadvantages.

The analog display consists of a pointer which moves across a scale corresponding to the sound level being measured. This type of display allows one to keep tab on the ambient level. Its primary disadvantage is that you have to watch it continuously in order to obtain the maximum level.

The digital display presents the levels directly in decimal numbers and doesn't require one to read scales. Most digital displays update their readings five or more times a second, which makes it hard to read the numbers. Thus a necessity with the digital display is a maximum hold option which displays the maximum value the SLM has measured during the time in which you were interested in.

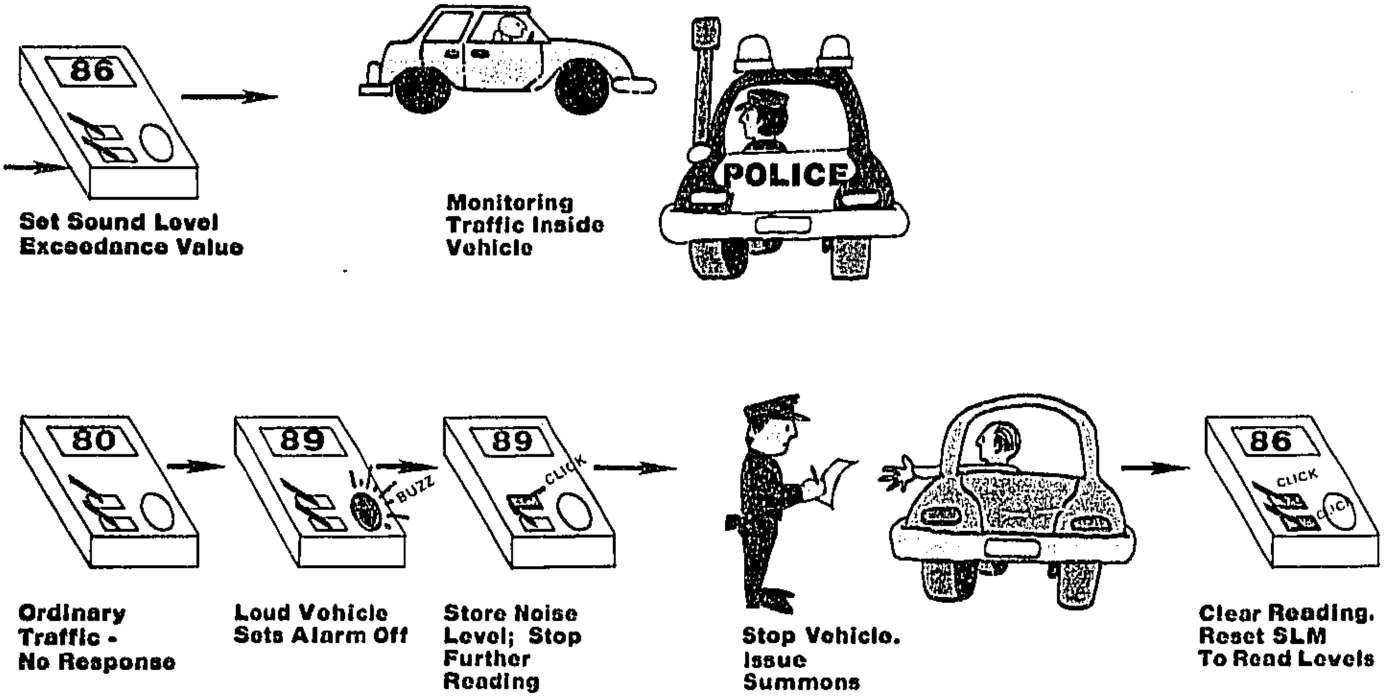
The Attenuator - Expanded Scales



A switch found only on analog SLMs is the attenuator. This switch changes the range of the SLM measurements. Without an attenuator the display might have to cover perhaps 70dBA on one scale. Because of the large range, accurate readings would not be possible.

The attenuator allows the same scale to measure only 10 dBA. Then instead of being able to read the levels to within 1 dBA, reading to within 0.1 dBA could be possible. The price that is paid for this precision is that one has to manually change the attenuator so that the reading stays on scale. Many measurements have been lost when the readings went off the scale before the attenuator setting was switched. Digital displays do not have attenuators, which is a point in their favor.

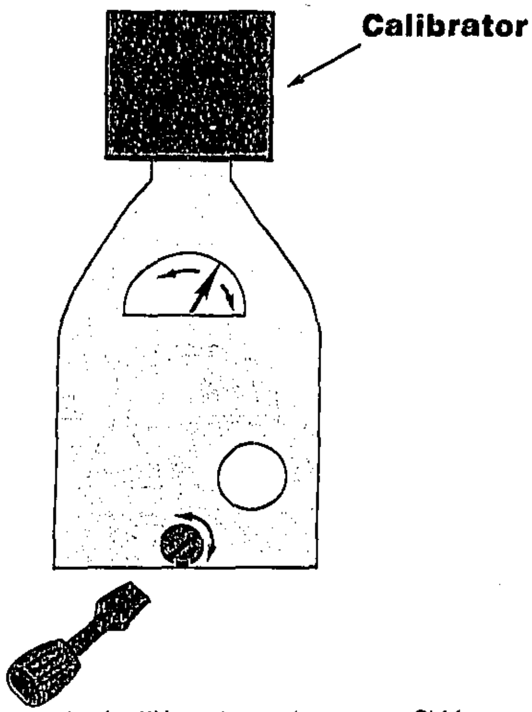
Example Of A Sound Level Meter For Motor Vehicle Noise Enforcement

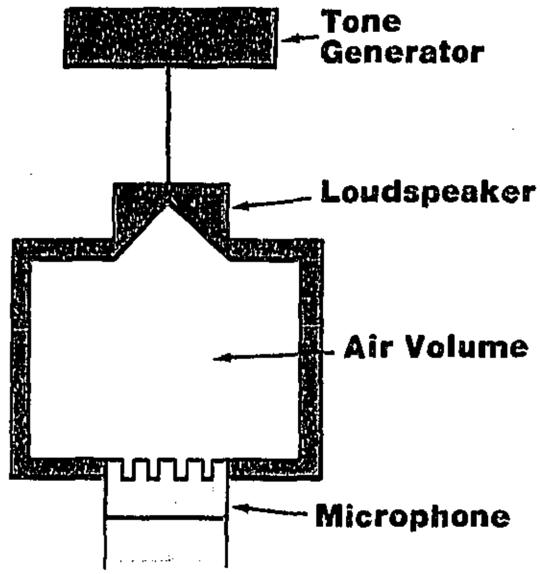


New innovations are appearing in SLMs, making their use easier and more convenient for motor vehicle enforcement. Several SLMs now allow monitoring from inside a patrol car at the same time an officer is doing radar speed enforcement.

One SLM works in the following manner. The officer sets the level that is going to be enforced into the SLM memory. With the microphone mounted outside and above the patrol car window, he monitors his radar or does some other non-noise related task such as eating lunch. As ordinary traffic passes by nothing happens. When the noise enforcement level is exceeded an audible alarm is triggered. The officer then throws a switch to store the maximum level that occured and to stop any new loud levels from being recorded. He chases the violator and issues him a summons. The officer can even show the violator the SLM reading that caused the violation.

Sound Level Meter Calibrator



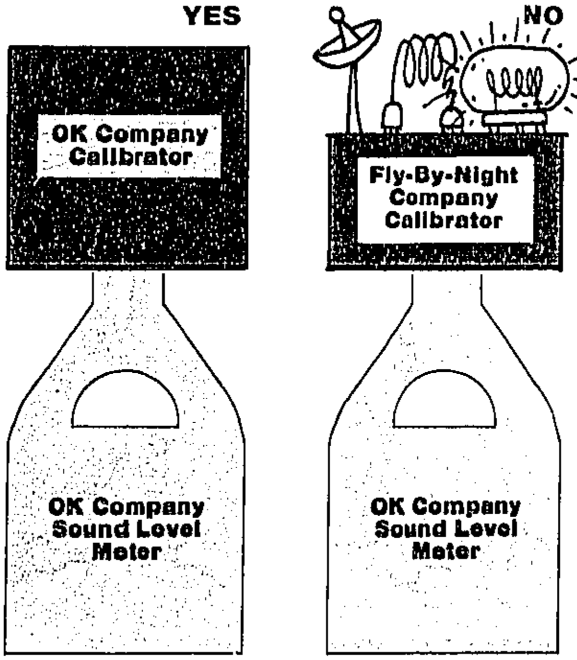


An often asked question is, "How do you know your SLM was reading correctly ?" In order not to be embarassed you should calibrate the SLM ahead of time using, not to anyones surprise, a calibrator.

A calibrator consists of a small cavity at one end of which a small loudspeaker is mounted. At the other end of the cavity there is a hole in which the SLM microphone can be inserted. When the calibrator is turned on, the loudspeaker produces a tone of known frequency and sound pressure level. To calibrate the SLM, the SLM calibration screw is turned until the SLM reads the same sound pressure level that the manufacturer states the calibrator produces.

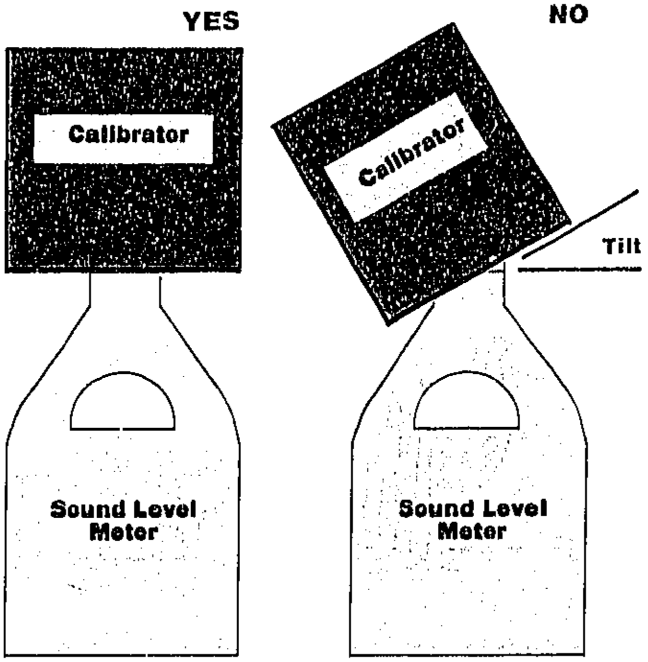
This is the most convenient check of SLM operation. If the SLM can be calibrated with the calibrator you can be almost certain that it is operating correctly. However it is recommended that both calibrator and SLM be returned to the manufacturer or to a calibration laboratory every year or two for a complete check.

Sound Level Meter Calibrator Use



RULE
Use only calibrators approved by the manufacturer.

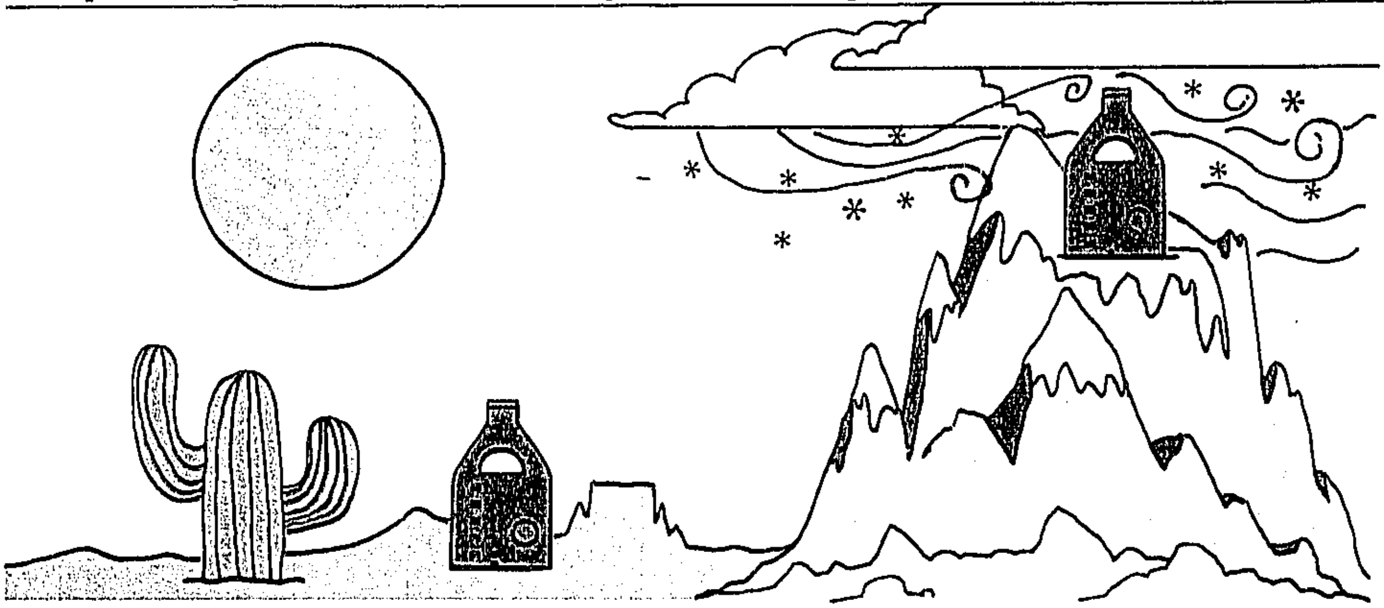
There are two basic rules to follow when calibrating a SLM. First, use only a calibrator that is approved for your particular SLM. One company's calibrator does not necessarily produce the correct sound pressure when used with a different company's SLM. Secondly, be sure that the SLM



RULE
Make sure the calibrator is correctly coupled to the sound level meter.

and the calibrator are correctly coupled. If the calibrator is not inserted correctly, the air volume connecting the loudspeaker and microphone may be too large and cause the sound level in the cavity to be lower than the correct value.

Temperature, Barometric Pressure, and Humidity

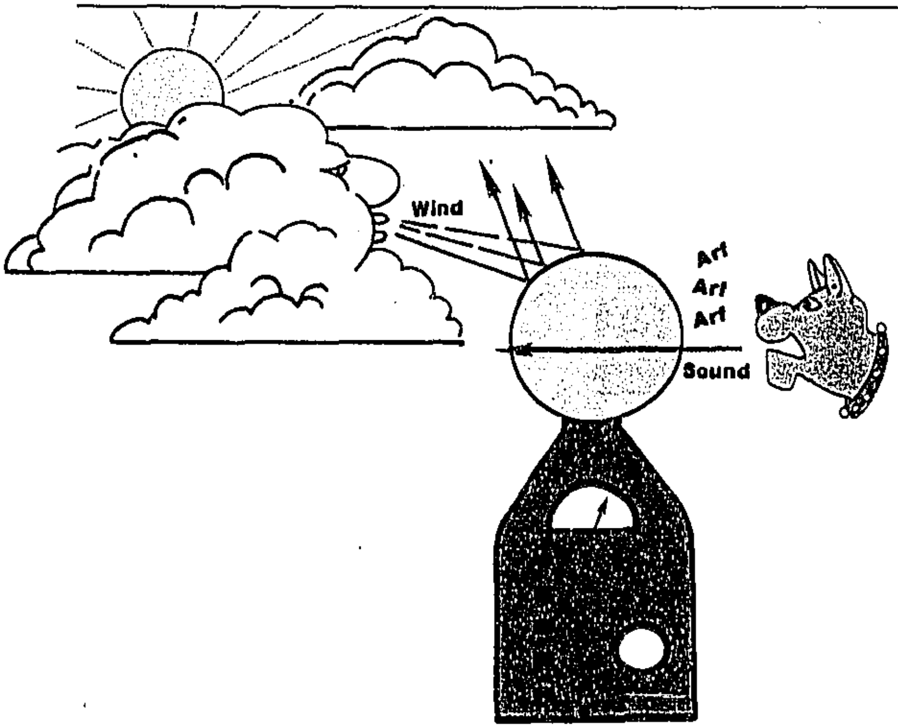


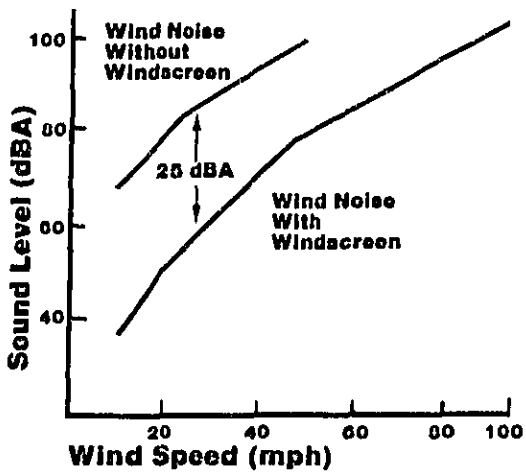
Except under extreme conditions, Temperature, Barometric Pressure, and Humidity have little effect on the accuracy of the SLM AS LONG AS IT IS CALIBRATED UNDER THE SAME CONDITIONS IT IS USED IN.

How do the temperature, barometric pressure, and humidity affect the SLM operation and accuracy? As long as the SLM is used under the same conditions as it was calibrated at, and these conditions are within the manufacturer's specifications, no significant errors are to be expected. However, if conditions do change between calibration and use, significant errors can result.

The above statement implies that you should not calibrate the SLM in Death Valley and then take it up to the top of Mt. Whitney to make measurements and expect accuracy. Similarly in a more common situation, you should not calibrate the SLM in your nice warm patrol car and then use it outside in the damp cold. Bring the SLM and calibrator outside and let them reach the same conditions as the environment; then proceed with the calibration.

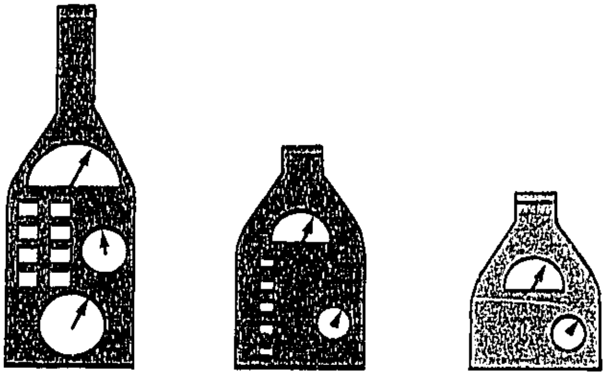
Wind Effects And The Windscreen





Does wind affect SLM accuracy? Yes! For example, a 25 mph breeze blowing across a typical SLM microphone can cause readings of 80dBA. It is for this reason we place a plastic foam ball called a windscreen over the microphone. The windscreen attenuates the noise caused by wind by approximately 25 dBA, yet it does not noticeably affect the level caused by noise. The windscreen also protects the microphone from rain, dirt, birds, etc; it should normally be used at all times.

Sound Level Meter Classification (ANSI)



TYPE	1	2	3
Designation	Precision	General Purpose	Survey
Estimated overall field accuracy	1dBA	3dBA	5dBA
Cost	Expensive	Modest	Cheap
Suitabilty for motor vehicle enforcement	Over-engineered for most community problems involving vehicle noise	Adequate for motor vehicle noise and most other community problems	Not sufficiently accurate

How accurate are sound level measurements ? To answer this question we refer to the American National Standard Institute (ANSI) which has set (voluntary) standards for three types of sound level meters. This chart demonstrates some of the characteristics of those SLMs that meet ANSI specifications. When buying a SLM you should make sure that the manufacturer certifies that the SLM meets the specifications of the type which you are interested in.

The SLM type most commonly used in motor vehicle enforcement is Type 2. We see that when used for motor vehicle enforcement the estimated accuracy is 3dBA. In other words, if all of the procedures recommended in the manual are followed, it is extremely unlikely that the reading will be in error by more than 3dBA.

In order to take into account such possible errors, we suggest that actual enforcement of the noise ordinance begin at sound levels greater than 3 dBA above the legal limit. This is similiar to enforcing a 25 mph speed limit only when the violator exceeds 35 mph; a margin of error is allowed. If the SLM microphone is mounted on a patrol car, you should allow another 2 dBA leeway and enforce the ordinance 5 dBA above the legal limit.

Noise Violation Form (Sample)

NOISE VIOLATION FORM

Date ____________________
Officer ____________________
Equipment: Sound Level Meter __________ Calibrator __________

Procedure

Set meter response to "Fast" __________
Set meter to A-weighting __________
Check calibrator battery: Before __________ After __________
Check sound level meter battery: Before __________ After __________
Calibrate sound level meter: Before __________ After __________
Attach windscreen __________
Describe weather ____________________
Ambient Noise Level __________ dBA

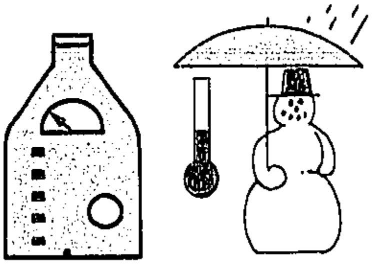
Noise Violation

Time __________
Violator's Name __________ Driver's License Number __________
Vehicle __________ License Plate Number __________
Maximum Measured sound pressure level __________ dBA (Ordinance Limit 80 dBA)
Location:

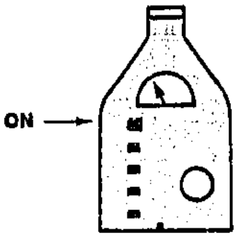
Distance from center of traffic lane ____________________
Distance to nearest large reflecting object ____________________

A strong case can be presented in court if the violation is well documented. This figure illustrates a comprehensive violation form. It is a good idea to include a few words on what in your opinion caused the violation. For example "hole in muffler", "glass packs", "heavy acceleration caused tire squeal" are phrases that can be used. If your noise ordinance has exhaust system regulations in addition to noise limits, you will often be able to cite a violator under both provisions. This can be especially effective when you come up before the judge.

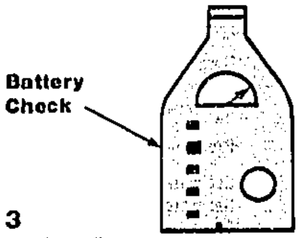
Enforcement Procedure Using The Sound Level Meter (SLM)



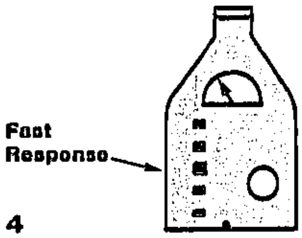
1
Allow the SLM to come to the same temperature as the surroundings. Do not make measurements when it is raining or snowing, or when the temperature is lower than the manufacturer's recommendation.



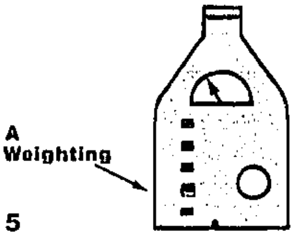
2
Turn the SLM on. Let it warm up for 30 seconds.



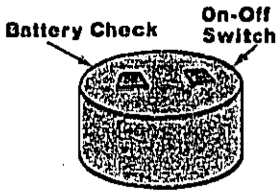
3
Check the Battery.



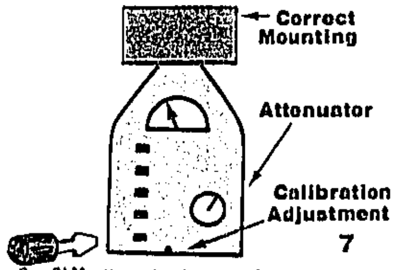
4
Set SLM to fast response.



5
Set SLM to A-weighting.



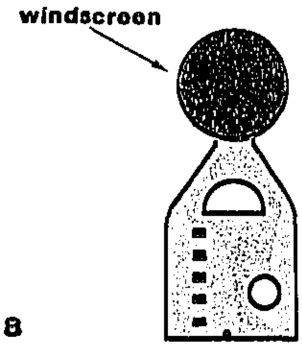
6
Turn on calibrator. Check Battery.



7
Set SLM attenuator to correct range. Make sure calibrator is mounted correctly. Adjust SLM to give correct reading.

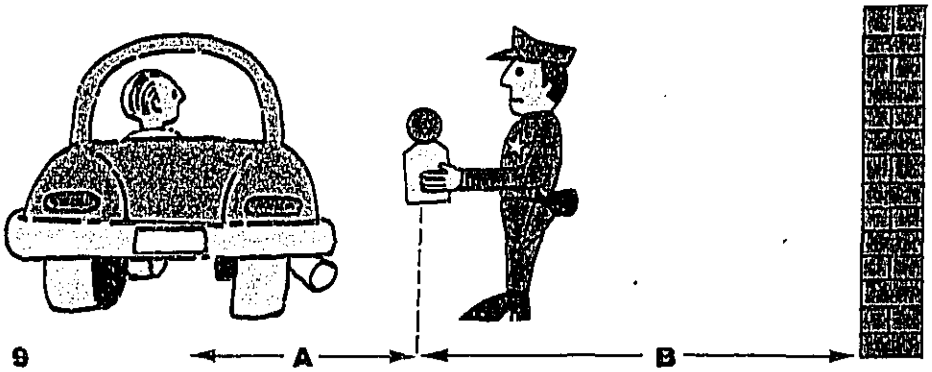
The following four pages illustrates a procedure for making motor vehicle noise enforcement. It's simple, isn't it ?

Enforcement Prodedure Using The Sound Level Meter (continued)



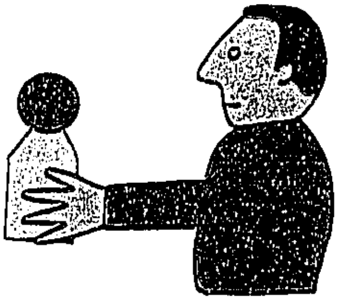
8

Attach windscreen



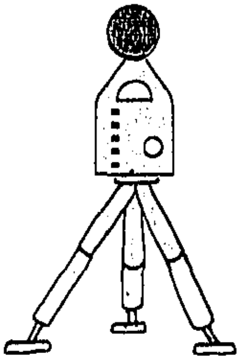
9

Measure the correct distance from the SLM measurement point to the traffic lane (A) and the distance to the nearest large reflecting object (B). Make sure that (B) is greater than (A).



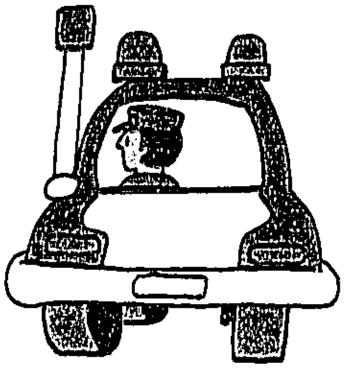
10

The SLM may be held at arms length, or



11

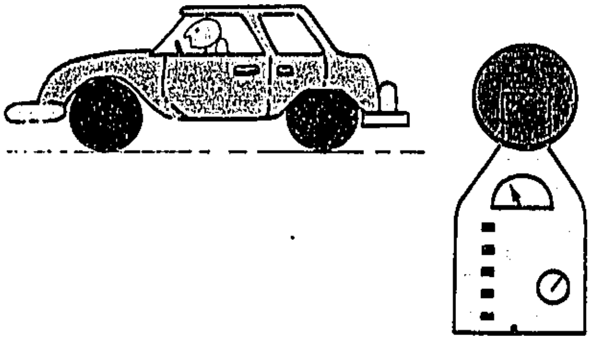
The SLM may be attached to a tripod, or



12

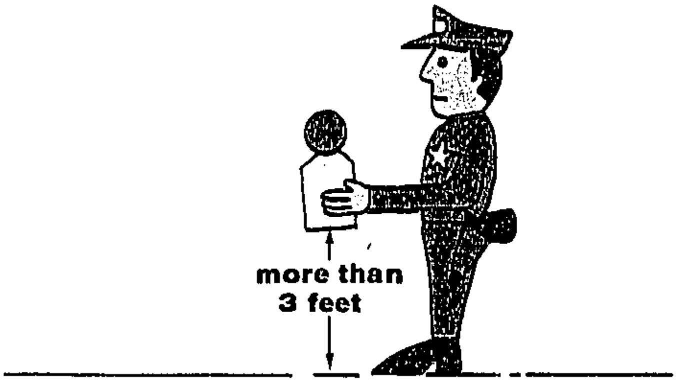
The SLM microphone may be mounted on a boom on a patrol car.

Enforcement Procedure Using The Sound Level Meter (continued)



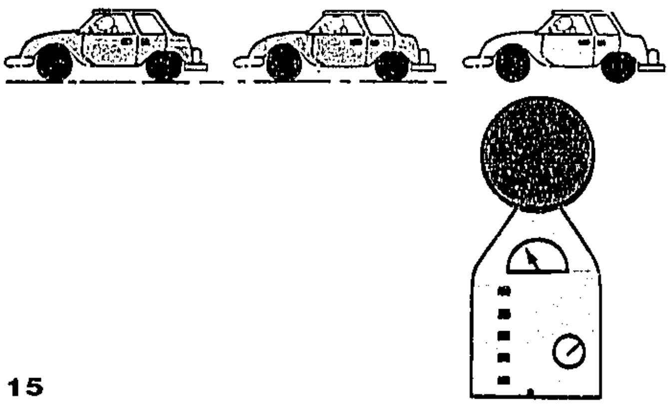
13

Orient the SLM according to the manufacturer's instructions so as to give a uniform frequency response. For most SLMs, this occurs when the microphone diaphragm is parallel to the ground.



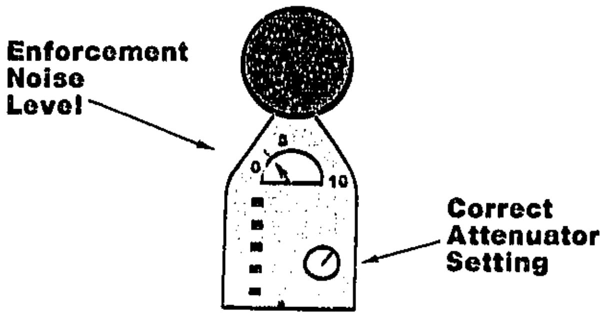
14

Make sure the SLM microphone is at least 3 feet above ground.



15

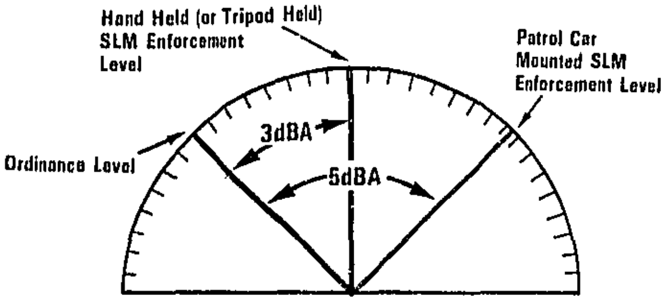
Measure the noise levels that occur under normal traffic conditions. These ambient levels should be at least 10 dBA less than the level to be enforced.



16

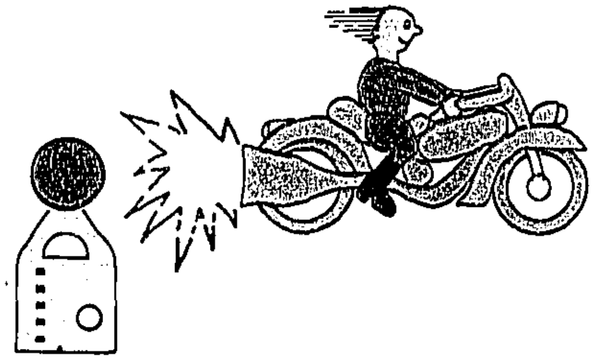
If the SLM has a manual attenuator set it so that enforcement level noise will register on the meter face.

Enforcement Procedure Using The Sound Level Meter (continued)



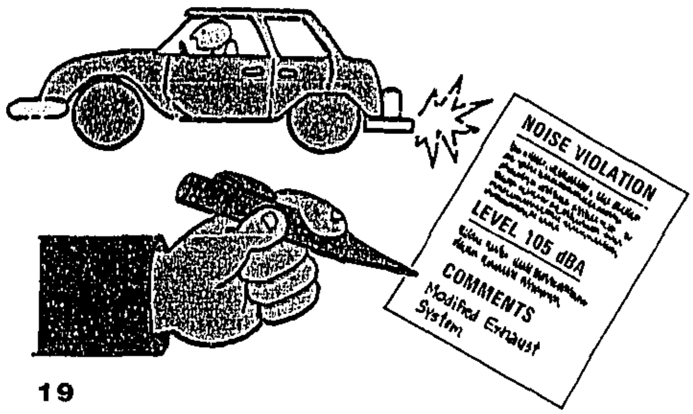
17

Enforcement levels are 3dBA above the ordinance limits for handheld SLMs, and 5dBA above the limits for patrol car mounted SLMs. This leeway will take into account all common sources of error.



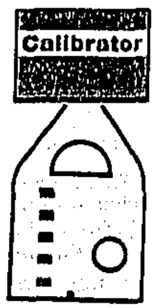
18

The noise level for which a violator is cited will be the maximum value observed.



19

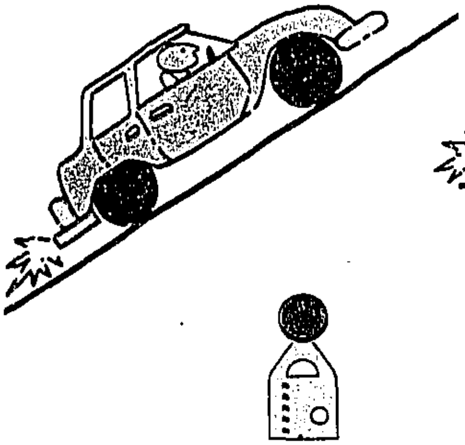
Record all pertinent information on a noise violation form, including comments on the reason the vehicle made so much noise. This is a necessity if the case comes to court.



20

Recalibrate SLM after giving a citation to insure that SLM was functioning correctly when violation was measured.

Three "Don'ts" in Noise Enforcement

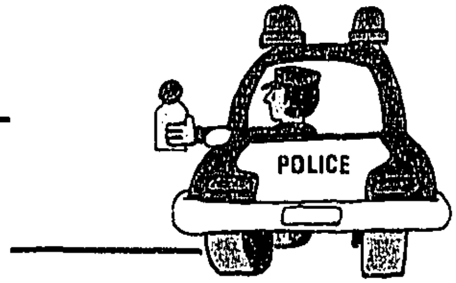


1

Don't enforce the motor vehicle noise ordinance on grades exceeding 5%.

2

Don't make measurements when the pavements are wet.



3

Don't use a hand held SLM by sticking one's arm out of a vehicle window.

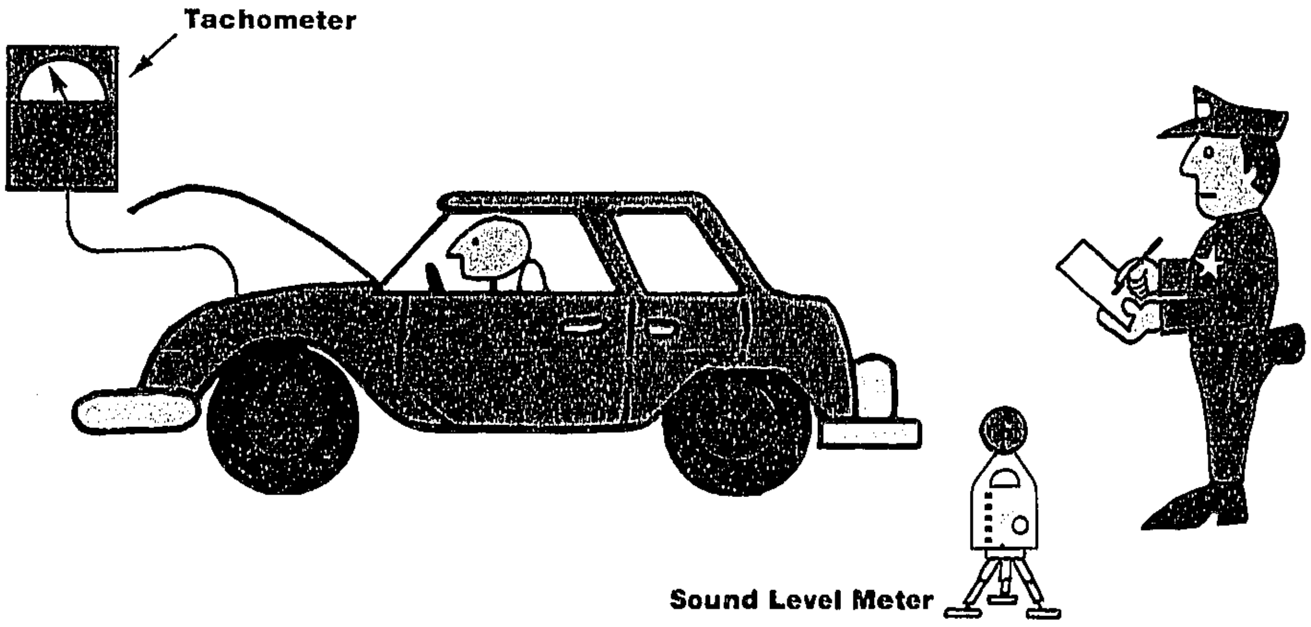
The following three "don'ts" also apply to motor vehicle measurements:

(1) Don't enforce the noise ordinance on steep grades. Although you will catch more violators, it is not fair to borderline vehicles that are forced to run at higher than normal engine speeds just to make it up the hill.

(2) Don't make measurements when the pavements are wet. Under these conditions tire noise becomes an important factor in the total noise produced. The motorist does not have much control over this type of noise.

(3) Don't be lazy and make noise measurements by sticking the SLM out of the patrol car window with your hand. Because of reflections from the car body and the effect of the open window, you will leave open the possibility of unaccounted errors.

Stationary Testing Of Motor Vehicle Exhaust Systems

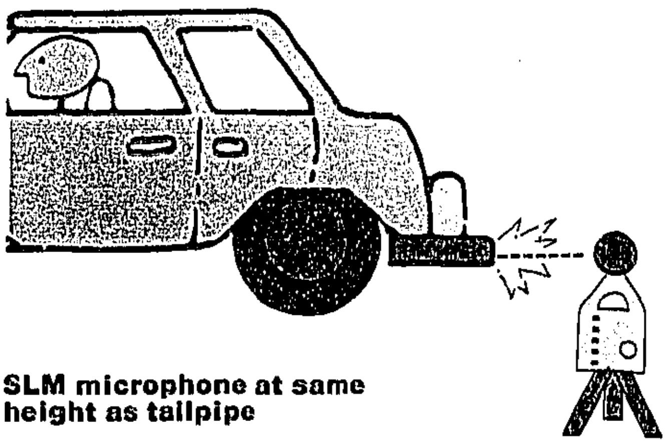


Now that you have ticketed the violator, what happens next? The violator can go to court, pay the fine and then go on his merry way. However, there are communities that feel the main purpose of the motor vehicle ordinance is to quiet the town and not just to collect fines. In this situation the judge may say, "Get your vehicle into good shape, let the police department test it, and if it passes I will throw out the ticket." Now your problem begins; how would you test the vehicle?

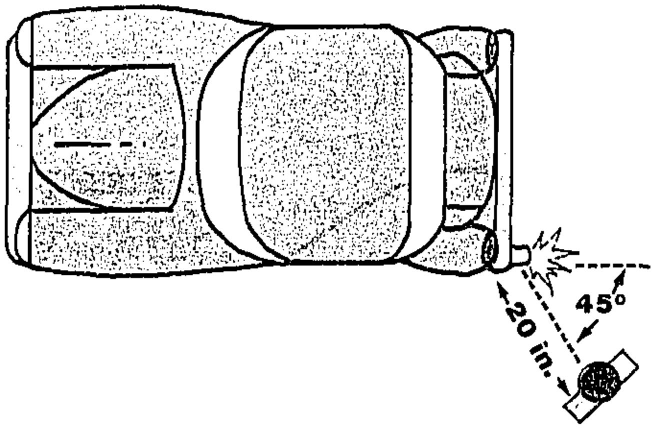
A simple method of exhaust system testing utilizes a stationary test which can be performed in a very short time. The only equipment needed is your sound level meter, a small tripod, and an inductive tachometer. Since the test is stationary, it can be administered in any parking lot.

This type of testing can be put to use in a public relations program by offering "free" tests to any person wants to check his vehicle for noisiness.

Positioning Of Sound Level Meter - Stationary Test



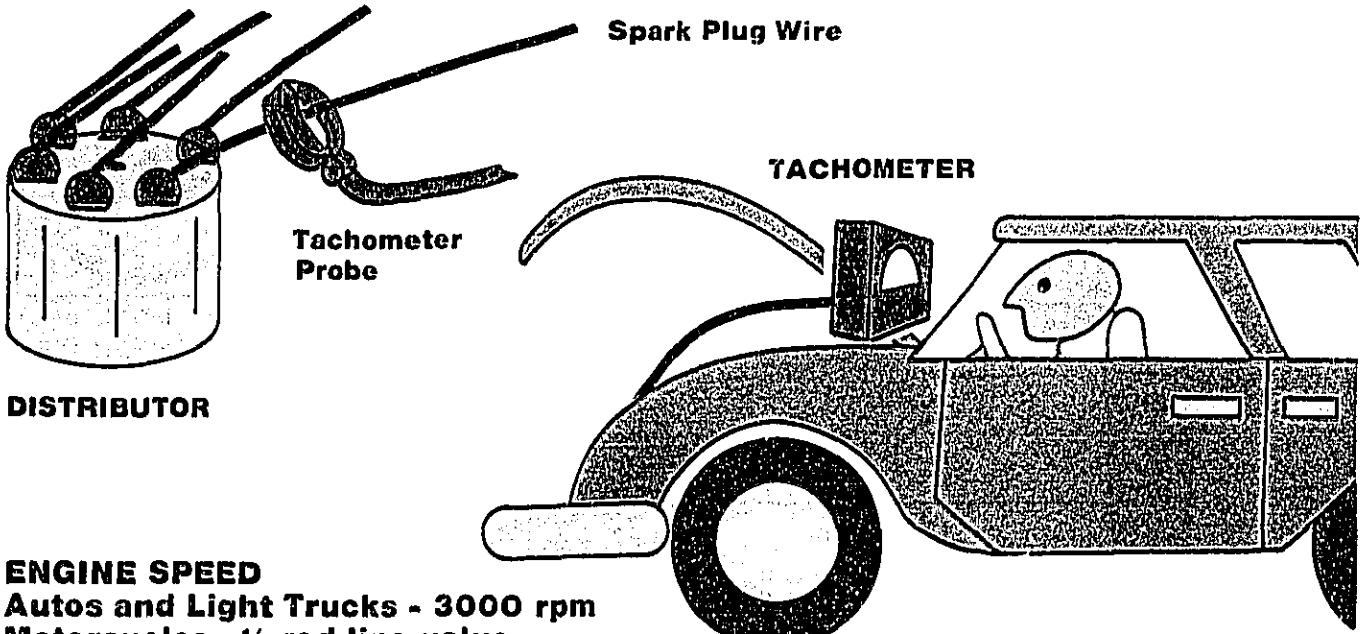
SLM microphone at same height as tailpipe



SLM at 45° angle to tailpipe exhaust axis and 20 inches from outlet

To administer the stationary test set your SLM up on a small tripod with the microphone at approximately the same height as the tailpipe. (This will save you from breathing the exhaust fumes.) Position the SLM at a 45 degree angle from the exhaust flow of the tailpipe and 20 inches from outlet of the tailpipe.

Stationary Test

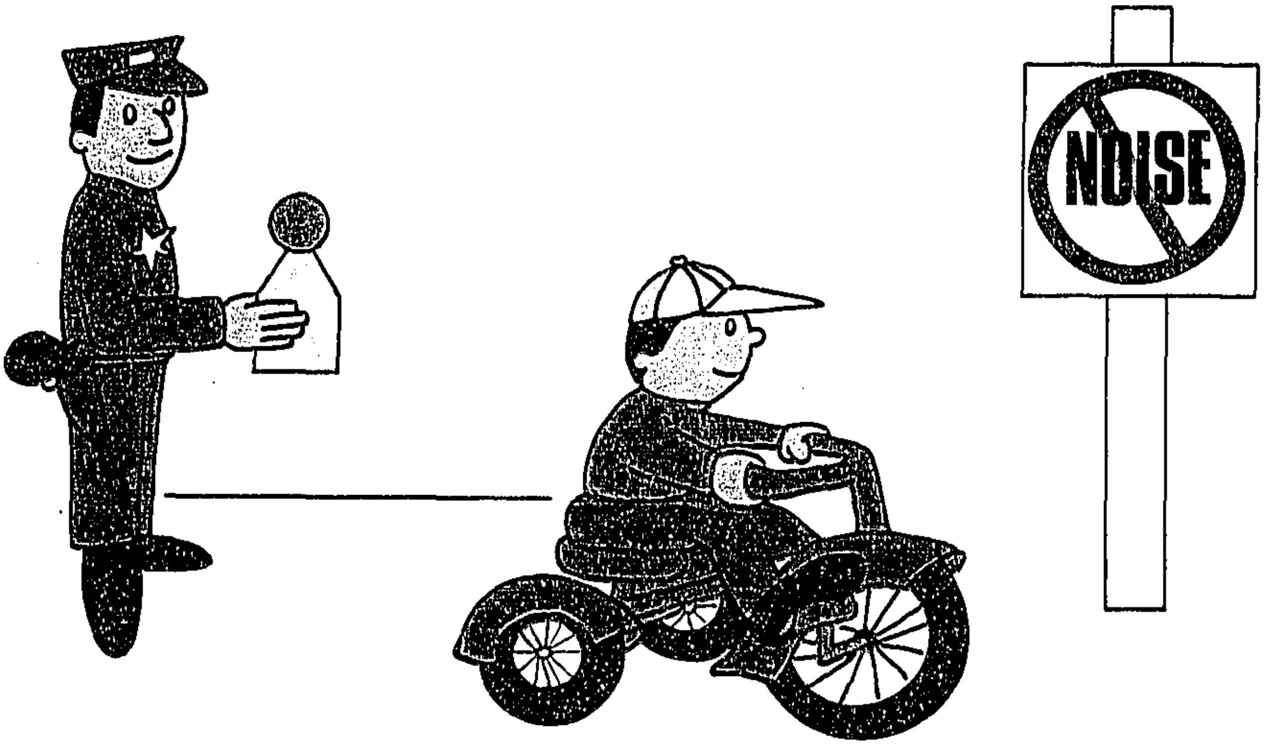


ENGINE SPEED
Autos and Light Trucks - 3000 rpm
Motorcycles - ½ red line value

Now place the tachometer probe around one of the spark plug wires. Letting the driver see the meter face, ask him to place the vehicle in neutral and then slowly step on the accelerator until the tachometer reads 3000 rpm. For motorcycles, which have their own tachometers, you will ask the driver to run the vehicle up to 1/2 the red line value.

Based upon the noise level limits in almost all ordinances, a measured value of 95 dBA or less will insure that the vehicle, if driven reasonably, will not have any reason to worry about causing a violation.

Effective Vehicle Enforcement And A Quieter Community



Now you know everything about making noise measurements. (Would you believe almost everything ?)The most important part of the noise program only begins at this point.

To have an effective program the city should combine a vigorous public awareness program together with visible enforcement. Noise enforcement street signs are a particularly good tool for public awareness. For a full sized paper copy of a sign that has found wide acceptance write to U.S. Environmental Protection Agency, Region V Noise Program 5AHWM, 230 S. Dearborn Street, Chicago, Illinois 60604, (312) 353-2202.

After the above program has been in effect for a while, you can expect the environment to be significantly quieter and the time needed to be spent monitoring for violations can be relaxed.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1980 654-110

United States
Environmental Protection
Agency

Region V
Noise Program, 5AHWM
230 South Dearborn Street
Chicago, Illinois 60604

Official Business
Penalty for Private Use
$300

Postage and
Fees Paid
Environmental
Protection
Agency
EPA 335

U.S. EPA Region V, Graphic Arts 1980.