

TRAFFIC NOISE-TECHNIQUES FOR
MEASUREMENT AND CONTROL

by

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Introduction

Ten years ago, the idea of a civil engineer specializing in a field called noise abatement would have been absurd. Since the big ecological push began in the late 1960's, however, many new disciplines have developed. One of these new disciplines is noise pollution abatement. The Environmental Engineer who works in this area is faced with a problem that is not as technically difficult as most engineering specialties, but he does have another obstacle that can be even more difficult to hurdle; and that is communicating his conception of the problem and his ideas for solution to those who have the power to act. This could be: Convincing the public that a severe noise problem exists, convincing a judge and jury that an abusive action has occurred, or convincing a governing body that new laws are needed.

One drawback that the Noise Abatement Engineer must contend with is educating others in regard to the terminology, causes and effects of noise. Therefore, I will take a few minutes and explain some of the basics, because I doubt that this group of Highway Engineers has taken any courses in traffic noise and its control.

Most experts, when speaking on general terms, agree that the most important effects of too much noise are impaired hearing, interference with speech communication, distraction from mental and skilled manual ability, interference with sleep, and general feelings of annoyance. These are the effects that have been documented over and over again. This is ample proof that they exist. More and more evidence is continuously being introduced, however, that says noise is a major contributing factor in ulcers, fatigue, panic and even heart attacks.

In 1971, a team of University of Louisville psychologists conducted a study aimed at determining the most common annoyances of the urban American adult. In each category of age and gender, noise was listed among the top five annoyances. In adults aged forty years and older, noise was the number one offender. The average total of all types of adults gave noise as the one thing that was most annoying. Unnecessary phone calls and bad drivers were second and third.

The actual loudness of a sound or noise that is perceived in an ear is caused by fluctuations in the atmospheric pressure.

The typical atmospheric pressure near sea level is approximately one million dynes per square centimeter, or one bar. These small fluctuations in the atmospheric pressure are called sound pressures, and these sound pressures are very small when compared to the atmospheric pressure. For example, a large truck will exert a sound pressure not greater than 0.0002 bars, or 200 microbars. This same truck, however, will produce a change in sound pressure which is a million times the change that is barely audible to a sensitive human ear.

To ease the handling of this wide range of numbers, it is customary to deal with sound pressure levels rather than sound pressures. The usual unit of sound pressure level is the decibel, which is abbreviated db, and is dimensionless. The sound pressure level in decibels corresponding to a given sound pressure p , is defined as being equal to twenty times the base ten logarithm of the ratio p to p_0 , where p_0 , the reference pressure, is 0.0002 dynes per square centimeter. This sound pressure is approximately the threshold of hearing for a healthy, young adult ear at a frequency of one thousand cycles per second. The zero levels of decibels corresponds to the reference pressure.

When doing noise research, it is not only important to know the intensity of the sound in question, but also its frequency. The reason for this is that different frequencies of sound affect humans to different degrees. Also, the frequency of a noise gives a clue as to its origin. To meet this desire for collecting sound with a specific frequency range, nearly all sound level meters have built-in response versus frequency weighting curves. These response curves have been standardized in both the United States and Europe. The C curve discriminates against no frequency range, meaning it is an all-pass situation; while the A and B curves discriminate against low frequency sounds, with the A curve being more discriminatory. The purpose for this discrimination is to approximate the response of the human ear. Most researchers feel that the A curve gives the better approximation in the working range of sound pressure levels, and this is the reason traffic noise measurements are taken in decibels on the A weighting curve, or db(A).

The next slide gives examples of different sound pressure levels for different typical sounds:

140	Jet takeoff
130	50 HP siren
120	Thunderclap

110	Riveting hammer
100	Electric furnace
90	Diesel truck
80	Inside sports car (50 mph)
70	Vacuum cleaner
60	Busy street (with no trucks)
50	Normal conversation
40	Low-voiced conversation
30	Whisper
20	Recording studio
10	Rustle of leaves
0	Threshold of hearing

Equipment

Hopefully by this time, you have a basic understanding of the terminology and ramifications of noise pollution. The next step is to discuss what we at the Kentucky Department of Highways are doing with respect to monitoring our highways. This is an important phase of work in Environmental Engineering because one must know not only the present conditions, but also how successful his efforts have been in order to know what future steps need to be taken.

The monitoring equipment we are using was purchased from two sources: The General Radio Company and the B and K Precision Instrument Company. The Division of Research obtained its equipment from B and K, while the Division of Design uses General Radio equipment. It consists of: A sound level meter, calibrator and strip chart, or graphic level recorder. The recorder gives plot of time versus sound level.

Design

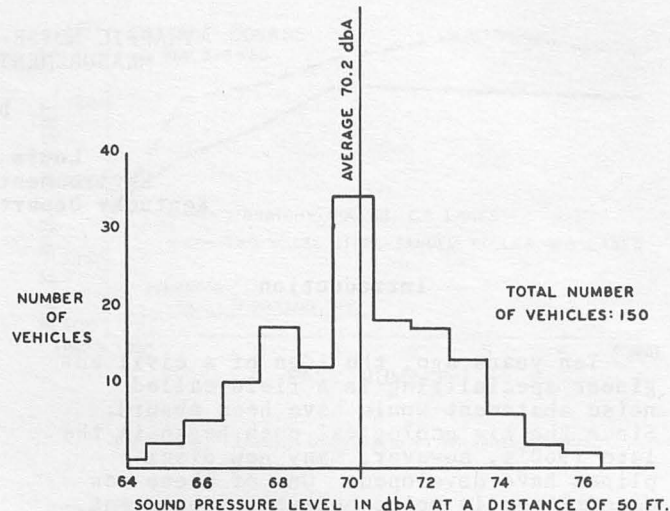
Obviously, there are two major sources of traffic noise pollution: Automobiles and trucks. Motorcycles and buses also contribute, but due to their small number, they are not as significant.

The next slide shows the results of noise level readings taken on 250 automobiles in Kentucky.

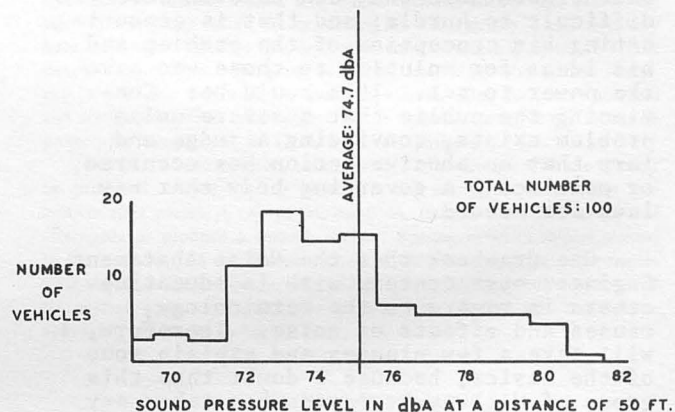
Notice that each graph has definite characteristics of a bell distribution. The great majority of the vehicles traveling less than 35 miles per hour were within the 65-75 db(A) range, and those going greater than 35 were within the 71-81 db(A) range. Also notice that there are no automobiles that emitted sounds very much higher than the average. In both cases, the loudest automobile was only 6 db(A) higher than the average.

This is not the case with the 202 trucks we monitored. Notice that the bell shape has just about disappeared, especially for those trucks traveling less than 35 miles per hour.

The important point to notice about trucks is that there is a small percentage that are grossly higher than average. For trucks going less than 35, two vehicles are around 20 db(A) louder than the average



(a) Noise emission distribution for cars with speeds less than 35 MPH.



(b) Noise emission distribution for cars with speeds greater than 35 MPH.

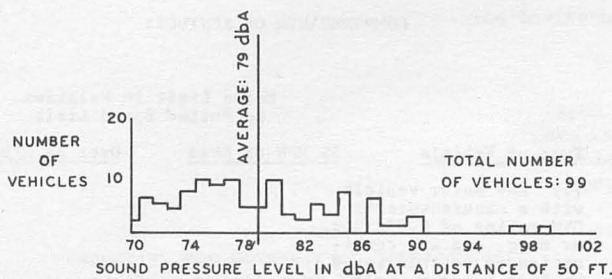
of 79. For those going faster than 35, one truck is 10 db(A) louder than the average.

This is an absurd situation. There is simply no justification for a truck to produce 99 or 100 db(A). If better than 93 percent of the trucks monitored can keep their noise emissions at 90 db(A) or less, all of them should be able to. This is one of the reasons that traffic noise pollution is such a major problem: The truck is ridiculously and dangerously loud.

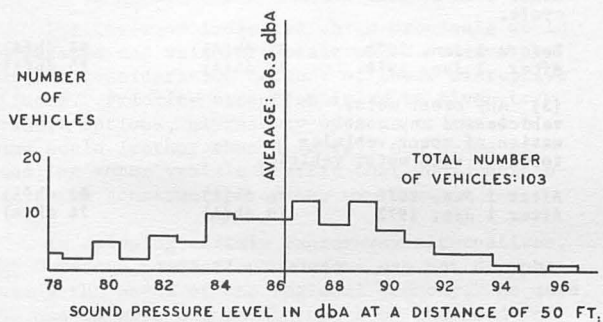
Legislation

Like all environmental disturbances, noise is a multi-faceted problem; but this is not so bad, because it means that more than one approach for solution exists. We have discussed the Civil Engineering solution to traffic noise, but two other approaches are certainly worth mentioning: The mechanical, and the legislative.

First, the mechanical. The two major sources of traffic noise are obviously automobiles and trucks. The dominating



(a) Noise emission distribution for trucks with speeds less than 35 MPH.



(b) Noise emission distribution for trucks with speeds greater than 35 MPH.

factor for automobiles is the extremely large number of vehicles on the road, and for trucks it is the high sound level emissions due primarily to ineffective muffling.

The legislative approach to noise abatement is an area where much potential exists. Lawmakers in all levels of government have been active in passing or at least considering comprehensive anti-noise legislation. The big stumbling block thus far has been a lack of technical information and data on which to base numerical limits for motor vehicles.

As a result, most traditional anti-noise laws define violations in only the most general terms. For example, a law may read: No licensed motor vehicle shall be allowed to make or create loud or excessive noise while being operated upon a public highway. This vague statement gives the police not only authority to enforce, but to also interpret, to make a judgement decision as to what is a violation. The Federal, state and local Constitutions do not give this power to the police, and as a result, the courts have been forced to consider something as elementary as a traffic violation on a constitutional basis. Another problem with this vague-type law is that many police officers do not enforce it at all, except for loud mufflers on hotrods.

Certain cities and states within the country have attempted to deal with the traffic noise problem on an objective rather than subjective basis. Peoria, Illinois, for example, limits sounds emit-

ted from any motor vehicle, measured from the right rear wheel as the vehicle passes the sound level meter. When the distance between the vehicle and the meter is 50 feet, the limit is 85 db(A); when the distance is 25 feet, the limit is 91 db(A), and at 15 feet, 95.5 db(A).

This is an improvement over the subjective type law, but it still leaves much to be desired because it does not consider vehicle speed or whether the vehicle in question is a car or truck. It would be nearly impossible for a stock automobile to reach 85 db(A) at 50 feet, while a large diesel truck pulling a heavy load may have trouble. Nevertheless, Peoria has at least taken a step in the right direction.

One government stands above all others in the area of anti-noise legislation, and that is Chicago, Illinois. Chicago passed a law in 1971 that covers just about every possible type of noise source, including traffic, construction, aircraft, industrial and recreational.

Chicago restricts the sale of any motor vehicle that emits sounds louder than specified limits for its particular date of manufacture. For example, an automobile manufactured between January 1, 1973 and January 1, 1975 cannot be sold if it emits sounds greater than 84 db(A).

The next slide gives the maximum decibel limits for motor vehicles operating on the streets of Chicago, measured at a distance of 50 feet.

CITY OF CHICAGO

RESTRICTIONS BY SPEED FOR OPERATION OF MOTOR VEHICLES WITH MANUFACTURER'S GROSS VOLUME WEIGHT OF 8,000 LB. OR MORE AND ANY COMBINATION OF VEHICLES TOWED BY SAME

DATE	NOISE LIMIT BY db(A) FOR POSTED SPEED LIMITS	
	35 MPH OR LESS	OVER 35 MPH
Before Jan. 1, 1973	88	90
After Jan. 1, 1973	86	90

MOTORCYCLES

Before Jan. 1, 1978	82	86
After Jan. 1, 1978	78	82

ANY OTHER MOTOR VEHICLE AND ANY COMBINATION OF VEHICLES TOWED BY SAME

	NOISE LIMIT BY db(A) FOR POSTED SPEED LIMITS	
	35 MPH OR LESS	OVER 35 MPH
After Jan. 1, 1970	76	82
After Jan. 1, 1978	70	79

DISTANCE: 50 FEET

In the 1972 session of the Kentucky General Assembly, a bill entitled the Noise Pollution Abatement Act was proposed in the House of Representatives. Like the Chicago ordinance, which it was patterned after, this bill dealt with nearly every noise source imaginable.

As far as traffic noise is concerned, the Kentucky bill gave the same limits for the sale of motor vehicles as does the Chicago law. This next slide gives the limits for operation of motor vehicles as they were proposed by the legislators.

COMMONWEALTH OF KENTUCKY

Type of Vehicle	Noise Limit in Relation to Posted Speed Limit	
	35 MPH or Less	Over 35 MPH
(1) Any motor vehicle with a manufacturer's GVW rating of 8,000 lbs. or more, and any combination of vehicle towed by such motor vehicle.		
Before 1 Jan. 1973	84 db(A)	86 db(A)
After 1 Jan. 1973	82 db(A)	84 db(A)
(2) Any motorcycle other than a motor-driven cycle.		
Before 1 Jan. 1978	82 db(A)	84 db(A)
After 1 Jan. 1978	76 db(A)	80 db(A)
(3) Any other motor vehicle and any combination of motor vehicles towed by such motor vehicle.		
After 1 Jan. 1970	76 db(A)	82 db(A)
After 1 Jan. 1978	70 db(A)	76 db(A)

DISTANCE: 50 FEET

The Highway Department was unable to endorse these strict limits, so we proposed an amendment to raise them. This is how the limits appeared in the final bill that was defeated in a floor vote. Notice that the limits for trucks would have been equal to those in the Chicago law.

Conclusion

In summation, we have examined, although briefly, the major causes and sources of traffic noise pollution. Automobiles, because of their great number, and trucks, because of their ineffective muff-

COMMONWEALTH OF KENTUCKY

Type of Vehicle	Noise Limit in Relation to Posted Speed Limit	
	35 MPH or Less	Over 35 MPH
(1) Any motor vehicle with a manufacturer's GVW rating of 8,000 lbs. or more, and any combination of vehicle towed by such motor vehicle.		
Before 1 Jan. 1973	88 db(A)	90 db(A)
After 1 Jan. 1973	86 db(A)	90 db(A)
(2) Any motorcycle other than a motor-driven cycle.		
Before 1 Jan. 1978	82 db(A)	84 db(A)
After 1 Jan. 1978	76 db(A)	80 db(A)
(3) Any other motor vehicle and any combination of motor vehicles towed by such motor vehicle.		
After 1 Jan. 1970	76 db(A)	82 db(A)
After 1 Jan. 1978	70 db(A)	76 db(A)

DISTANCE: 50 FEET

fling, cause highway planners and designers to consider noise as a major parameter when placing a road. Unfortunately, it has not always been so. It is a shame that the vast majority of urban streets and highways were constructed before the environment became such a prime consideration.

However, there is no sense in dwelling in the past; we as highway engineers have had our successes as well as failures. It is time to decide exactly what are our attitudes and procedures toward the environment, and implement them. The Kentucky Department of Highways is in the process of determining these attitudes and procedures, in hopes of doing it's share in the reduction of noise generated from its products.

Bibliography

1. S. Anderson, P. Cameron, J. Devlin and R. Weiss, "Urban America's Most Common Annoyances", presented at the Rocky Mountain Psychological Association Convention, May 12, 1971, Denver, Colorado.
2. C. M. Harris, Handbook of Noise Control New York, McGraw-Hill Publishing Company, 1957.