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National Tire & Battery
Facility Noise
Euless, Texas

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Executive Summary

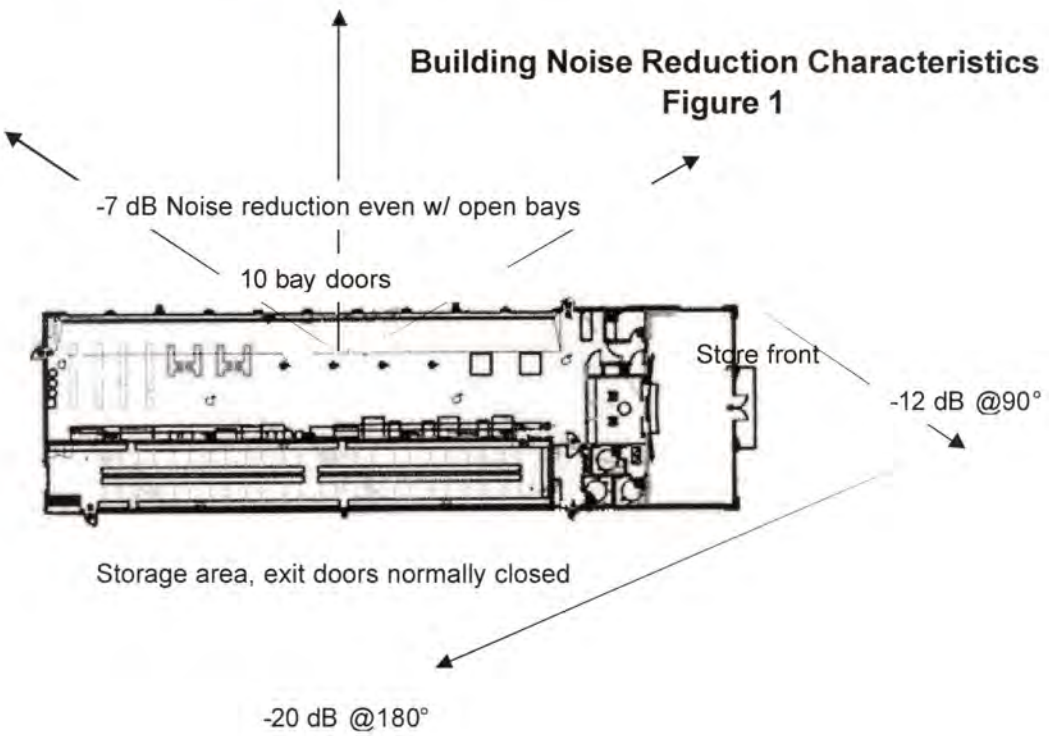
A noise measurement effort at the same store configuration as the Euless application and is specifically intended to measure directly the average noise of tire changing activity over a 15 minutes regulatory duration. This effort changed in focus to measure the level of individual events because the background noise although moderate, was too high not to overwhelming influence the result, and the individual events too low to dominant the measure.

The calculation of the 15 minute average from individual events is straight forward.

Building Design & Orientation

There are several noise reduction features that are inherent in the building design. The tire removal and installation produces several individual noise events inside the building. There is a noise reduction that occurs when the sound travels out the front, even if all the doors are open. Sound has a physical form in air similar to the water vibration when a pebble is dropped. This wavefront must negotiate outside through the open doors which have a smaller percentage area than the total wall surface area. This reduction was measured at the Irving store by using a car horn as a steady repeatable source with many frequencies. A measurement was first made inside the bay doors, then just outside and then at an increased distance of 45'. The noise reduction from inside to just outside is 7 dB. Another way to think of this is that a lot of the reverberant noise bouncing inside the building did not make it outside, even through open doors.

Building Noise Reduction Characteristics
Figure 1



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The sound volume reduces another 8 dB from just outside the doors to a 45' distance, which was at the customer lot curb. The storage area on the back side of the building blocks noise from impinging directly on that wall, acting as a buffer. As a result, the sound coming out the front, must bend around two corners either to the side or vertical over the roof. It was necessary to move the car horn outside the building to measure the noise reduction associated with sound making this turn. The sound was not audible at the ends of the building when the car was inside the building. There is a 12 dB noise reduction compared to measuring directly in front of the open doors at a 45' distance. The car horn was never audible on the back side of the building, even with it placed outdoors. The background noise of IH635 at 750' prevented this audibility or measure. The noise reduction is at least 20 dB, simply subtracting the measure in front from the background noise in the back, and likely is more.

Measurement Equipment

The equipment used to measure onsite sound levels were a Type 1 Larson Davis Model 820 sound level meter that provided the AC output signal to a Rion Model SA 77 frequency analyzer. The microphone and signal conditioning is field calibrated with a Quest Model QA20 piston phone. This technique allows direct measurement of individual frequency components for evaluation. The frequency characteristics of traffic noise are fairly constant and predictable. As a result, this measurement technique is useful in capturing individual events with readout observation that the event is distinctly different than background influences.

Individual Noise Events

The reoccurring noise events associated with tire sales are the air wrench used to remove and install wheel lug nuts, the tire stand operation removing and installing the tire from the wheel, and the use of a car horn when exiting the open bay to warn nearby pedestrians. Table 1 provides a list of these events and the associated noise and duration observed at a reference distance, 45' in front of the open bays.

Event	Duration	dBA @45' front	Duration for one vehicle
Air wrench	1 sec each nut	70 dBA	*5 lug nuts * 4 tires*both on and off=40 sec
Tire stand	10 sec each tire	66 dBA	*4 tires*both off and on=80 seconds
Car horn	2 seconds	69 dBA	2 seconds coming out

The noise measures listed are averages. Individual events vary up and down by 1-3 dB. The duration of a single lug nut removal is 1 sec, and 10 seconds for tire removal off the wheel.

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A typical store has 10 bays, but only 6 employees on duty, which limits the number of cars worked on to 6 at one time. A truck normally requires 45 minutes for a set of four tires and a car, 30 minutes. The worst case scenario for the loudest 15 minutes is probably if all 6 employees start at the same time, take the tires off the car and then the tires from the wheel. This produces 20 sec each for 6 cars, or 120 seconds of air wrench activity (lug nuts) and 40 seconds for each car on the tire stand, and 240 seconds total for 6 cars (tire removal off wheels).

15 minute Leq

Leq is an average of all noises over the time period. In this case the ordinance specifies 15 minutes. As a result, any one second event reduces in Leq over the 900 seconds in 15 minutes by 29.5 dB (10*log (1/900)). The accumulative noise of all air wrench activity is 10*log (total number of events) greater than the volume of just one event. The 120 seconds of air wrench activity have an accumulated noise level of 61.3 dBA, [70 dB + 10* log(120) -29.5]. The 80 seconds of removing the tire from the stand has a Leq of 55.5 dBA. These two contributions add together (logarithmically, see attachment) to produce a total of 62.3 dBA at 45' in front of the open bays.

The time average is a common regulatory scheme, recognizing that noise fluctuates up and down. The maximum value limit of +20 dB ensures that any one event is reasonable.

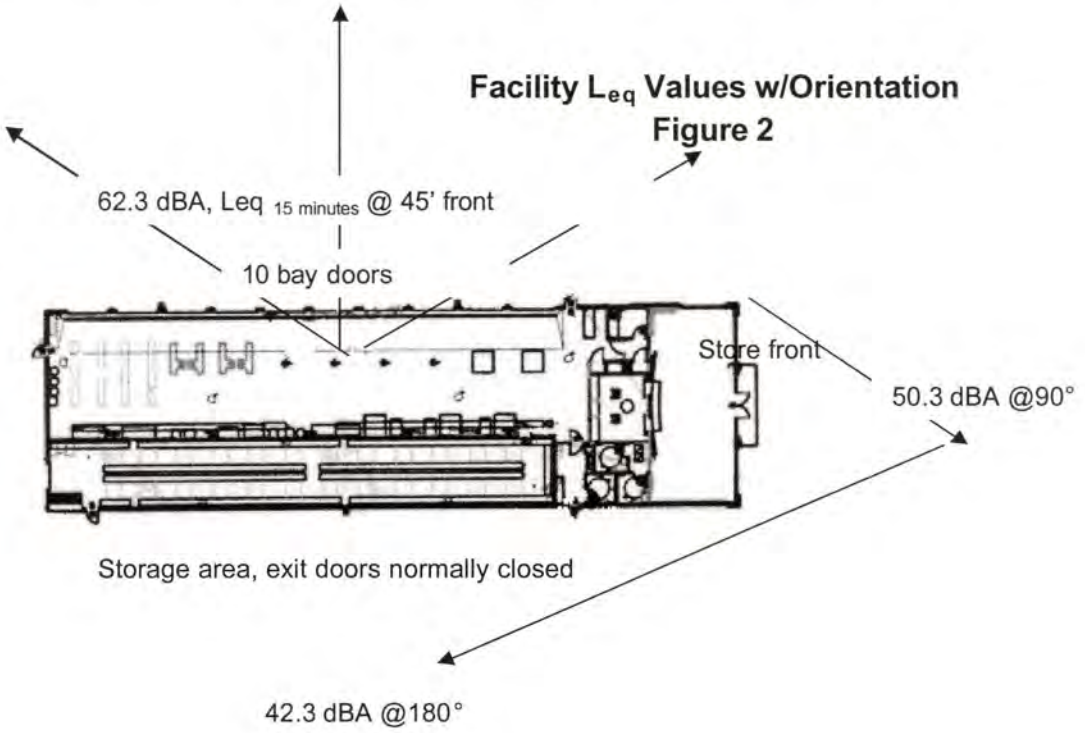

Figure 2 shows the 62.3 dBA at the front and uses the Figure 1 notations to find 50.3 dBA on the end and less than 42.3 dBA on the back side adjacent to residential lots.

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Conclusions

The store visit to Irving did not produce any audible awareness of tire changing activity at the back of the store. The noise was lost in a background noise of 60-66 dBA.

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APPENDIX A
Acoustics Terminology

Taken from "Protective Noise Levels - Condensed Version of EPA Levels Document" EPA Report No. 550/9-79-100, November 1978

ABOUT SOUND

The sound occurs when the air vibrates. The vibration produces alternating bands of relatively dense and sparse particles of air, spreading outward from the source in the same way as ripples do on water after a stone is thrown into it. The result of the movement of the particles is a fluctuation in the normal atmospheric pressure, or sound waves. These waves radiate in all directions from the source and may be reflected and scattered or, like other wave actions, may turn corners. When the source stops vibrating, the sound waves disappear almost instantaneously, and the sound ceases. The ear is extremely sensitive to sound pressure fluctuations, which are converted into auditory sensations.

Sound may be described in terms of three variables:

1. Amplitude (perceived as loudness)
2. Frequency (perceived as pitch)
3. Time pattern

Amplitude

Sound pressure is the amplitude or measure of the difference between atmospheric pressure (with no sound present) and the total pressure (with sound present). Although there are other measures of sound amplitude, sound pressure is the fundamental measure and is the basic ingredient of the various measurement descriptors in the next section, "Measurement of Environmental Noise."

The unit of sound pressure is the decibel dB. The decibel scale is a logarithmic scale, not a linear one, such as the scale of length. The logarithmic scale is used because the range of sound intensities is so great, that it is convenient to compress the scale to encompass all of the sounds that need to be measured. The human ear has an extremely wide range of response to sound amplitude. Sharply painful sound is 10 million times greater in sound pressure than the least audible sound. In decibels, this 10 million to 1 ratio is simplified logarithmically to 140 dB.

Another unusual property of the decibel scale is that the sound pressure levels of two separate sounds are not directly (that is, arithmetically) additive. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (to 73 dB), not a doubling to 140 dB. Furthermore, if two sounds are of different levels, the lower level adds less to the higher as this difference increases. If the difference is as much as 10 dB, the lower level adds almost nothing to the higher level. In other words, adding a 60 decibel sound to a 70 decibel sound only increases the total sound pressure level less than one-half decibel.

Frequency

The rate at which a sound source makes the air vibrate determines frequency. The unit of time is usually one second and the term "Hertz" (after an early investigator of the physics of sound) is used to designate the number of cycles per second.

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The human ear and that of most animals has a wide range of response. Humans can identify sounds with frequencies from about 16 Hz (Hertz) to 20,000 Hz. Because pure tones are relatively rare in real life situations, most sounds consist instead of a complex mixture of many frequencies.

Time Pattern

The temporal nature of sound may be described in terms of its pattern of time and level: continuity, fluctuation, impulsiveness, intermittency. Continuous sounds are produced for relatively long periods at a constant level, such as the noise of a waterfall. Intermittent sounds are those which are produced for short periods, such as the ringing of a telephone or aircraft take-offs and landings. Impulse noises are sounds which are produced in an extremely short span of time, such as a pistol shot or a hand clap. Fluctuating sounds vary in level over time, such as the loudness of traffic sounds at a busy intersection.

MEASUREMENT OF ENVIRONMENTAL NOISE: SOUND DESCRIPTORS

EPA has adopted a system of four "sound descriptors" to summarize how people hear sound and to determine the impact of environmental noise on public health and welfare. These four descriptors are: the A-weighted Sound Level, A-weighted Sound Exposure Level, Equivalent Sound Level, and Day-Night Sound Level. They are related, but each is most useful for a particular type of measurement. The descriptions and some examples of their uses are described below.

A-Weighted Sound Level

One's ability to hear a sound depends greatly on the frequency composition of the sound. People hear sounds most readily, when the predominant sound energy occurs at frequencies between 1000 to 6000 Hertz (cycles per second). Sounds at frequencies above 10,000 Hertz (such as high-pitched hissing) are much more difficult to hear, as are sounds at frequencies below about 100 Hz (such as a low rumble). To measure sound on a scale that approximates the way it is heard by people, more weight must be given to the frequencies that people hear more easily.

A method for weighting the frequency spectrum to mimic the human ear has been sought for years. Many different scales of sound measurement, including A-weighted sound level (and also B, C, D, and E-weighted sound levels) have evolved in this search. A-weighting was recommended by EPA to describe environmental noise because it is convenient to use, accurate for most purposes, and is used extensively throughout the world.

The A-weighting of frequency is also used in the three descriptors discussed below. When used by itself, an A-weighted decibel value denotes either a sound level at a given instant, a maximum level, or a steady-state level. The following three descriptors are used to summarize those levels which vary over time.

Sound Exposure Level

Since the levels of many sounds change from moment to moment, this variation must also be accounted for when measuring environmental noise. One method for measuring the changing magnitude of sound levels is to trace a line on a sheet of moving paper, so that the movement of the pen is proportional to the sound level in decibels. This Figure illustrates such a recording.

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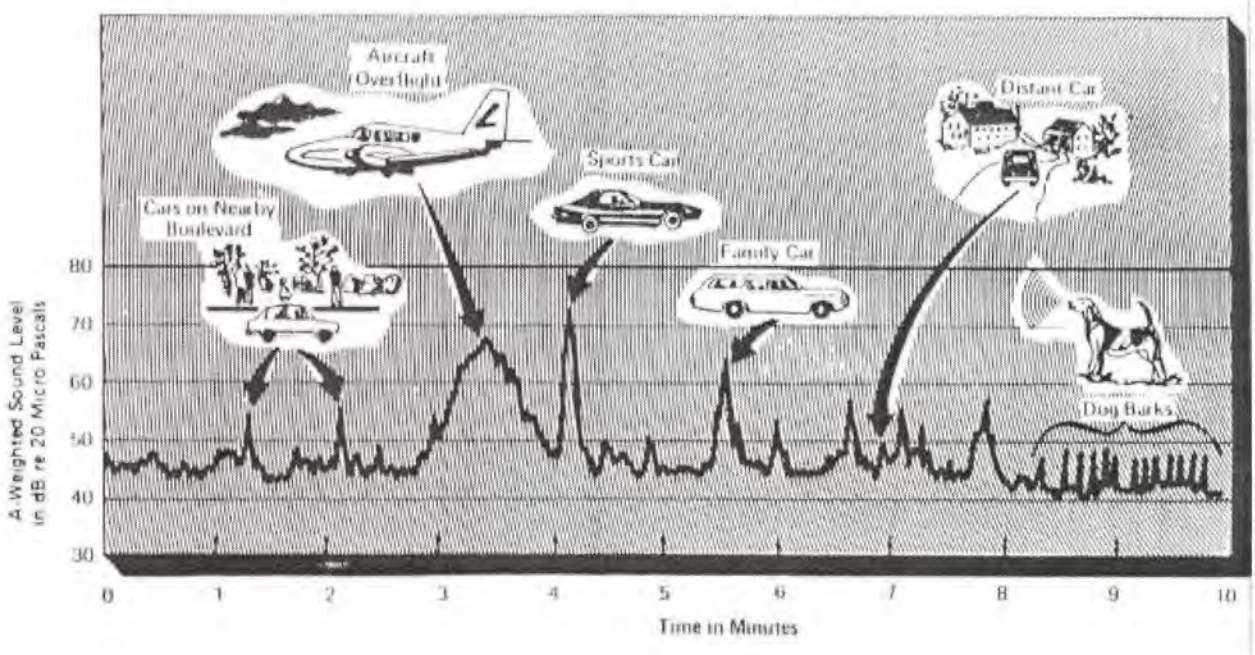
Several features are noteworthy. First, the sound level varies with time over a 30 dB range. Second, the sound appears to be characterized by a fairly steady lower level, and individual events which cause intermittent changes. This fairly constant lower level is often called the background ambient sound level.



Each single event may be partially characterized by its maximum level. It may also be partially characterized by its time pattern. In the example, the sound level of the aircraft is above that of the background ambient level for about a minute, whereas the sound levels from cars are above the background level for much less time.

The duration of sounds with levels that vary from moment to moment is more difficult to characterize. One way is to combine the maximum sound level with the length of time during which the sound level is greater than a certain number of decibels. For example, the number of seconds that the sound rises above the 10 dB down (below maximum) value, determines the sound energy. The total energy of the sound divided by the duration determines the second measurement descriptor, *sound exposure level* (L_S), referred to in the Levels Document as the single event noise exposure level (SENEL). This value represents the total sound energy that is normalized to one second duration.

Equivalent Sound Level (Leq)

Yet another method of quantifying the noise environment is to determine the value of steady-state sound which has the same A-weighted sound energy as that contained in the time-varying sound. This is the third measurement descriptor, termed the Equivalent Sound Level (L_{eq}). The Equivalent Sound Level is a single value of sound level for any desired duration, which includes *all* of the time-varying sound energy in the measurement period. In the Figure, for example, the L_{eq} equals about 58 dB, indicating that the amount of sound energy in all the peaks and valleys in the figure is equivalent to the energy in a continuous sound of 58 dB.

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The major virtue of the Equivalent Sound Level is that it correlates reasonably well with the effects of noise on people, even for wide variations in environmental sound levels and time patterns.

Day-Night Sound Level

The Day-Night Sound Level is the A-weighted equivalent sound level for a 24-hour period with an additional 10 dB weighting imposed on the equivalent sound levels occurring during nighttime hours (10 pm to 7 am). Hence, an environment that has a measured daytime equivalent sound level of 60 dB and a measured nighttime equivalent sound level of 50 dB can be said to have a weighted nighttime sound level of 60 dB (50+10) and an L_{dn} of 60 dB.

Exceedance Levels

The Highway Department often favors controlling noise thresholds. For example, they set permissible thresholds that can not be exceeded 90% of the time. However, the same threshold provides a 10% allowance that has no limiting value. In essence, it allows the louder trucks to operate without noise limit, 10% of the time. This exceedance threshold is L_{10} and the DOT guidelines allow an L_{10}=70 dBA at the property line. In contrast, L_{90} is often used to examine the background or ambient level. This is the lower noise threshold that is exceeded 90% of the time. Other exceedance values range from 1 to 99. The L_1 provides a more reasonable statistical value for the highest maximum values.

Table A1 provides some general reference for common noise sources and their levels in dBA.

Common Noise Source and Their Sound Levels
Table A1

Source	Sound Level (dBA)
Near large jet at takeoff	140
Air raid siren	130
Threshold of pain	120
Thunder of sonic boom	110
Garbage or trailer truck at roadside	100
Power lawn mower at 5'	90
Alarm clock or vacuum cleaner	80
Freeway traffic at 50'	70
Conversational speech	60
Average residence	50
Bedroom	40
Soft whisper at 15'	30
Rustle of leaves	20
Breathing	10
Threshold of hearing	0
Adapted from NBS Handbook 119	

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