Impulsive Noise Measurements with a Conventional Sound Level Meter

A. Behar, Research Engineer
Acoustics Office, Systems Research and Development Branch
Ministry of Transportation and Communications, Ontario

J.M. Riganti, Engineer
División Acústica
Instituto National de Tecnologia Industrial
Buenos Aires, Argentina

1. INTRODUCTION

A continuous noise can be defined by its sound pressure level and its frequency content. If the energy of the noise is also of interest, then the duration must also be taken into account.

The situation is not the same when an impulsive noise has to be evaluated because, besides the characteristics listed above, the peak value and shape of the waveform, as well as its duration, are of interest.

In most industrial environments, high reverberation times cause the shape of the decay of an impulse to be approximately exponential. This fact at first sight offers an attractive possibility for inexpensively deriving the signal time constant, ζ *, as well as the peak level, when using an SLM set first to the "fast" and then to the "slow" response. As can be seen in Figure 1, if we have

$$a_{125} = Ae^{-125/\zeta}$$

and

$$a_{1000} = Ae^{-1000/\zeta}$$

then

$$\zeta = 875/\ln (a_{125}/a_{1000})$$

and

$$A = a_{125}(a_{125}/a_{1000})^{0.143}$$

where A is the peak value, and a_{125} and a_{1000} are the SLM readings for the "fast" and "slow" settings, respectively.

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* ζ is defined as the interval between the time at which the signal reaches its peak value, and the time at which it drops 8.7 dB below this value.

The object of the present study was to find out if it is possible to find the impulse signal's time constant and its peak level by using an inexpensive SLM,such as one built to IEC 123 specification accuracy, and measuring the "fast" and "slow" response readings.

2. EXPERIMENT

A GR 1564 Sound Level Analyzer and GR 1556 B Impact Noise Analyzer were used, their "slow", "fast" and "peak" characteristics having been previously measured according to the method listed in the IEC 123 Recommendation, and also by using an oscilloscope.

The test signals used in the experiment were:

(a) Electrical pulses whose envelope had a rise time of less than 1 ms and decay times of different durations, the modulated signal being a sinusoid of 1 kHz,

(b) The same pulses as for (a), but using modulated pink noise,

(c) Impulsive noises generated by striking two wooden planks against one other. These noises were produced within enclosures of different acoustical characteristics, and picked-up by the SLM under test placed at different distances from the noise source, thus varying the characteristics of the noise at the microphone position.

A modulator was specially designed to be capable of shaping the test signals (a) and (b) in the following way: the envelope always had the same rise time of the order of 0.1 ms, decaying exponentially thereafter. The corresponding time constant could be varied in steps in order to obtain good repeatability. The signal thus obtained was introduced to the SLM under test, as well as to the oscilloscope, the latter being used as a monitoring instrument. An Impact Noise Analyzer (INA) was used to measure the peak levels of the signals as well as their decay times, which were also monitored on an oscilloscope.

Figure 2 shows photographs of the electrical signals (a) and (b). In Figure 2(a) the impulse has a 1 kHz sine content. Figure 2(b) shows the same envelope with pink noise. It can be seen that the second envelope is less regular than the first because of the probabilistic nature of the pink noise.

Figure 3 shows the waveforms corresponding to a real-life impulse obtained within a semi-reverberant acoustical enclosure. It can be easily seen that both the rise and the decay of the signal are quite irregular, due mostly to the changing predominance of the direct and reflected sound waves.

In all cases the following variables were recorded:

(a) "slow" and "fast" readings on the SLM under test, and

(b) "peak" and "time constant" on the INA.

3. RESULTS AND CONCLUSIONS

In order to normalize the results, the difference in reported sound pressure level found between the "peak" and "slow" (P-S) responses, as well as between the "fast" and "slow" (F-S), were evaluated as a function of the time constant. Figure 4 shows a graph of the results obtained by using the electrical 1 kHz signals for the P-S difference together with the calculated regression line. The same procedure was used throughout the experiment, and the correlation coefficients were obtained.

As can be seen from Table 1 where those coefficients are shown, the correlation is quite acceptable in the case of the electrical pulses.

The best results are found using sinusoidal signals. In this case the correlation is almost the same for the "peak" - "slow" and for the "fast" - "slow" values.

For pink noise the results are also good. However, due to its probabilistic nature, the energy contained within each impulse is not the same. Since the integration time of the "slow" response is 8 times longer than that of the "fast" response, the probability of each burst having the same amount of energy is higher for the former. Then since the "peak" level is always the same, and the "slow" is nearly constant while the "fast" is not, the correlation of the difference "P-S" with ζ is better than that for "F-S".

The correlation coefficients corresponding to "real life" noises are not acceptable due to their low values. This result is explained mainly by the fact that the decay of pulses is not exponential, as shown in Figure 3.

Consequently, we are able to conclude that it is impossible to measure accurately the acoustical characteristics of a given impulsive noise by using an SLM which meets the IEC 123 Recommendation. The correlation coefficients are too low to calculate either the peak level or the decay time with acceptable accuracy, except in the rare case of sinusoidal or pink noise pulses having proven exponential decays.

In this study we did not take into account the difficulty of reading the "fast" value due to the ballistic characteristics of the display, because this can be overcome by the use of digital indication devices.

BIBLIOGRAPHY

1. IEC 123 (1961) Recommendations for Sound Level Meters.

TABLE 1. Correlation Coefficients (see text)

TEST SIGNAL	n	r: P-S	r: F-S
Sinusoidal	32	.97	.96
Pink Noise	50	.94	.9
Real-Life Noise	37	.61	.55

n = number of measurements
r = correlation coefficients
P-S = SPL difference recorded between "peak" and "slow" meter response settings
F-S = SPL difference recorded between "fast" and "slow" meter response settings.

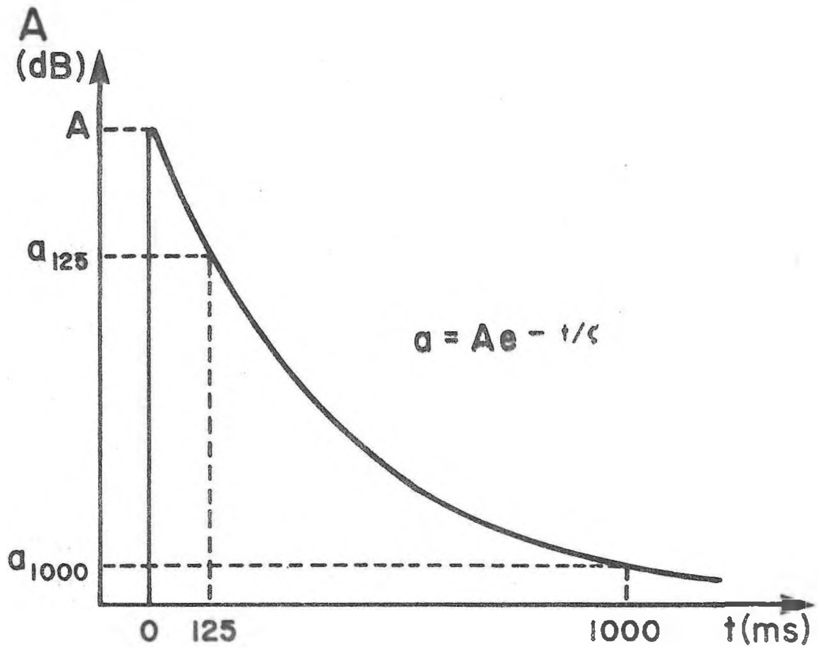
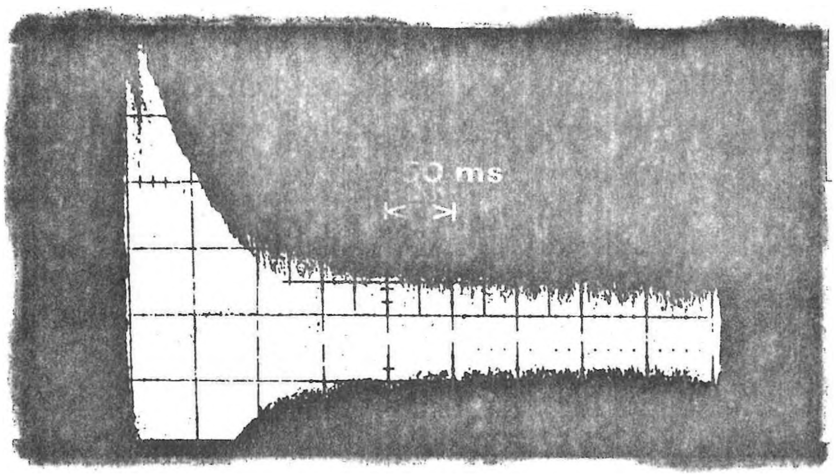
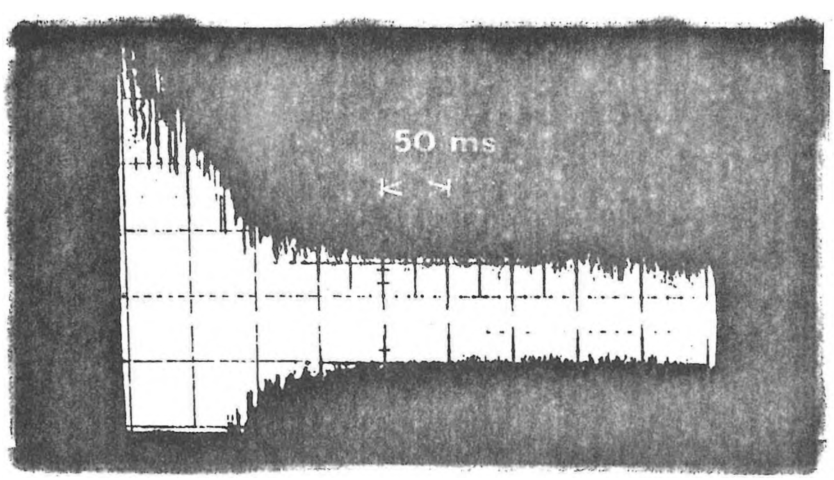


FIGURE 1. Characteristics of an Exponentially Decaying Signal



2(a)

White Noise



2(b)

Pink Noise

FIGURE 2. Oscillographs of the Electrical Test Signals

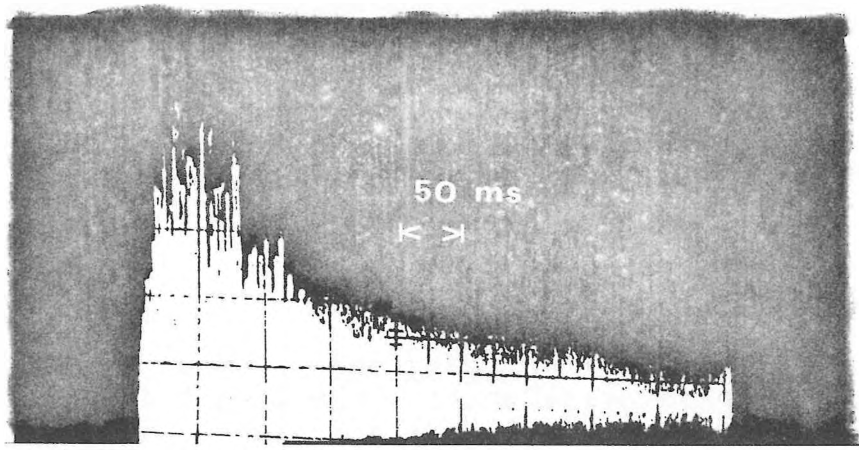


FIGURE 3. Oscillograph of a Real-Life Signal Recorded in a Semi-Reverberant Enclosure

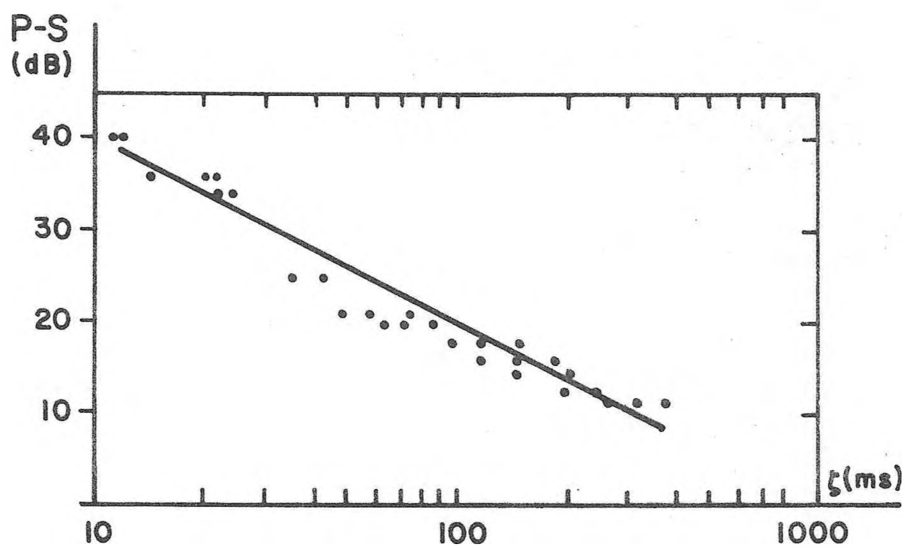


FIGURE 4. SPL Difference Recorded Between "Peak" and "Slow" Meter Response Settings (P-S) as a Function of the Time Constant (ζ) for Modulated 1 kHz Sine Tone

P-S = SPL Difference
ζ = Time Constant