

***Goals of a Noise-Rating System***

An ideal noise-rating system is one that allows measurements by sound level meters or analyzers to be summarized succinctly and yet represent noise exposure in a meaningful way. In our previous discussions on loudness and annoyance, we noted that our response to sound is strongly dependent on the frequency of the sound. Furthermore, we noted that the type of noise (continuous, intermittent, or impulsive) and the time of day that it occurred (night being worse than day) were significant factors in annoyance.

Thus, the ideal system must take frequency into account. It should differentiate between daytime and nighttime noise. And, finally, it must be capable of describing the cumulative noise exposure. A statistical system can satisfy these requirements.

The practical difficulty with a statistical rating system is that it would yield a large set of parameters for each measuring location. A much larger array of numbers would be required to characterize a neighborhood. It is literally impossible for such an array of numbers to be used effectively in enforcement. Thus, considerable effort has been made to define a single number measure of noise exposure. The following paragraphs describe one of the systems now being used.

***The  $L_N$  Concept***

The parameter  $L_N$  is a statistical measure that indicates how frequently a particular sound level is exceeded [12]. If, for example, we write  $L_{30} = 67$  dBA, then we know that 72 dB(A) was exceeded for 30% of the measuring time. A plot of  $L_N$  against  $N$  where  $N = 1\%$ ,  $2\%$ ,  $3\%$ , and so forth, would look like the cumulative distribution curve shown in Figure 15-21.

Allied to the cumulative distribution curve is the probability distribution curve. A plot of this will show how often the noise levels fall into certain class intervals. In Figure 15-22 we can see that 35% of the time the measured noise levels ranged between 65 and 67 dBA; for 15% of the time they ranged between 67 and 69 dBA; and so on. The relationship between this picture and the one for  $L_N$  is really quite simple. By adding the percentages given in successive class intervals from right to left, we can arrive at a corresponding  $L_N$ , where  $N$  is the sum of the percentages and  $L$  is the lower limit of the left-most class interval added, thus,  $L_{30}$

$$L(1 + 2 + 12 + 15) = 67 \text{ dBA}$$

FIGURE 15-21

Cumulative distribution curve.

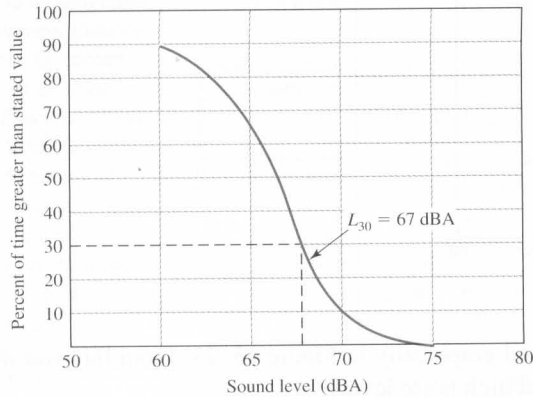
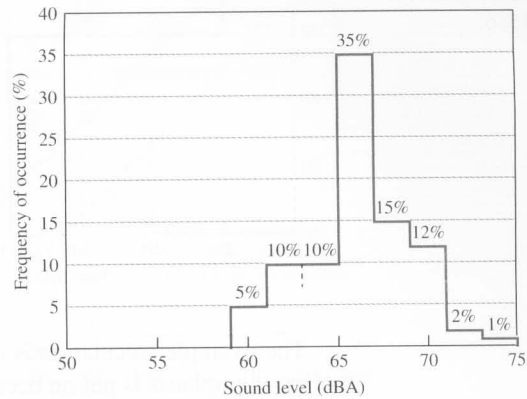


FIGURE 15-22

Probability distribution plot.



### The $L_{eq}$ Concept

The equivalent continuous equal energy level ( $L_{eq}$ ) can be applied to any fluctuating noise level [12]. It is that constant noise level that, over a given time, expends the same amount of energy as the fluctuating level over the same period. It is expressed as follows.

$$L_{eq} = 10 \log \frac{1}{t} \int_0^t 10^{L(t)/10} dt \quad (15-14)$$

where  $t$  = the time over which  $L_{eq}$  is determined

$L(t)$  = the time varying noise level in dBA

Generally speaking, there is no well-defined relationship between  $L(t)$  and time, so a series of discrete samples of  $L(t)$  have to be taken. This modifies the expression to

$$L_{eq} = 10 \log \sum_{i=1}^{i=n} 10^{L_i/10} t_i \quad (15-15)$$

where  $n$  = the total number of samples taken

$L_i$  = the noise level in dBA of the  $i$ th sample

$t_i$  = fraction of total sample time

### EXAMPLE 15-6

Consider the case where a noise level of 90 dBA exists for 10 min and is followed by a reduced noise level of 70 dBA for 30 min. What is the equivalent continuous equal energy level for the 40-min period? Assume a 5-min sampling interval.

**Solution** If the sampling interval is 5 min, then the total number of samples ( $n$ ) is 8, and the fraction of total sample time ( $t_i$ ) for each sample is  $1/8 = 0.125$ . With these preliminary calculations, we may now compute the sum.

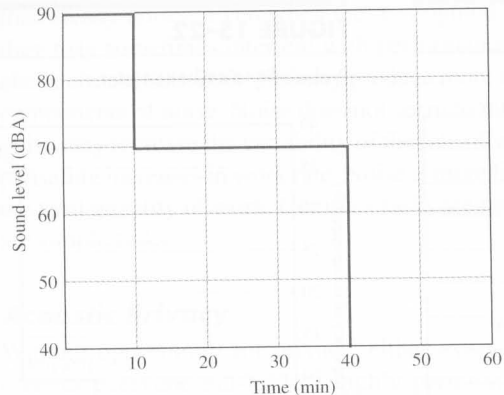
$$\begin{aligned} \sum_{i=1}^2 &= (10^{90/10})(0.250) + (10^{70/10})(0.750) \\ &= (2.50 \times 10^8) + (7.50 \times 10^6) = 2.58 \times 10^8 \end{aligned}$$

And finally, we take the log to find

$$L_{eq} = 10 \log(2.58 \times 10^8) = 84.11, \text{ or } 84 \text{ dBA}$$

**FIGURE 15-23**

Graphical illustration of  $L_{eq}$  computation given in Example 15-6.



The example calculation is depicted graphically in Figure 15-23. From this you may note that great emphasis is put on occasional high noise levels.

The equivalent noise level was introduced in 1965 in Germany as a rating specifically to evaluate the effect of aircraft noise on the neighbors of airports [13]. It was almost immediately recognized in Austria as appropriate for evaluating the effect of street traffic noise in dwellings and schoolrooms. It has been embodied in the national test standards of Germany for rating the subjective effects of fluctuating noises of all kinds, such as from street and road traffic, rail traffic, canal and river ship traffic, aircraft, industrial operations (including the noise from individual machines), sports stadiums, playgrounds, and the like.