APPENDICES

APPENDIX A—GLOSSARY

A-weighting: *A measurement scale that approximates the "loudness" of tones relative to a 40-dB sound pressure level, 1,000-Hz reference tone. A-weighting is said to best fit the frequency response of the human ear: when a sound dosimeter is set to A-weighting, it responds to the frequency components of sound much like your ear responds. A-weighting has the added advantage of being correlated with annoyance measures and is most responsive to the mid-frequencies, 500 Hz to 4,000 Hz.*

B-weighting: *B-weighting is similar to A-weighting but with less attenuation. B-weighting was an attempt to approximate human perception of loudness for moderately high sound pressure levels. It is now outdated and no longer used.*

C-weighting: *A measurement scale that approximates the "loudness" of tones relative to a 90-dB sound pressure level, 1,000-Hz reference tone. C-weighting has the added advantage of providing a relatively "flat" measurement scale that includes very low frequencies.*

Criterion level: *The continuous equivalent 8-hour A-weighted sound level (as dBA) that constitutes 100% of an allowable noise exposure (dose)—in other words, the permissible exposure limit. For OSHA purposes, this is 90 dB, averaged over 8 hours on the A scale of a standard dosimeter set on slow response.*

Dose (%): *Related to the criterion level, a dose reading of 100% is the maximum allowable exposure to accumulated noise. For OSHA, 100% dose occurs for an average sound level of 90 dB over an 8-hour period (or an equivalent exposure). If a TWA reading is used rather than the average sound level, the time period is no longer explicitly needed. A TWA of 90 dB is the equivalent of 100% dose. The dose doubles every time the TWA increases by the exchange rate. Table A–1 shows the relationship between dose and the corresponding 8-hour TWA exposure.*

> *Example: OSHA uses an exchange rate of 5 dB. Suppose the TWA is 100 dB for an 8-hour exposure. The dose doubles for each 5-dB increase over the criterion level of 90 dB. The resulting dose is therefore 400%. With an 8-hour TWA of 80 dB, the dose would halve for each 5 dB below the criterion level. The resulting dose would be 25%. When taking noise samples of duration shorter than the full workday, dose is an easy number to work with because it is linear with respect to time.*

> *Example: If a 0.5-hour screening sample results in 9% dose and the workday is 7.5 hours long, the estimated dose for the full workday would be 135% (7.5 ÷ 0.5 × 9%). This is computed making the assumption that the sampled noise will continue at the same levels for the full 7.5-hour workday. While short-term dose measurements cannot be used to support a citation, they can be effectively used as a screening tool to determine whether full-shift sampling is warranted.*

> *Example: A worker is employed in a high noise area for half an hour each day, and the remainder of the 8-hour workday is spent in a quiet office area. If the worker is exposed to 93 dBA for half an hour, the dosimeter will read 10%. Because no additional dose will be accumulated while working in the quiet office area, the equivalent 8-hour TWA will be 73.4 dBA, as shown in Table A–1.*

Table A–1. Conversion Between Percent Noise Dose and 8-Hour TWA Sound Level

Dose (% Noise Exposure)	8-Hour TWA (dBA)
10	*73.4*
25	*80*
50	*85*
75	*87.9*
100	*90*
150	*92.9*
200	*95*
300	*97.9*
400	*100*
500	*101.6*
600	*102.9*
800	*105*
1000	*106.6*
1600	*110*
3200	*115*
6400	*120*

** When measured with a 5-dB exchange rate and a 90-dBA PEL.*

*** Additional data points are provided in Table A–1 in Appendix A, Section II of the noise standard (29 CFR 1910.95), particularly in the 80–999% dose range.*

Exceedence level: *The level exceeded by the measured noise level for an identified fraction of time. Exceedence levels may be calculated for many time fractions over the course of a shift and are typically expressed with percentages (L%). For example, an L40 equal to 73 dB would mean that for 40% of the run time, the decibel level was higher than 73 dB.*

Exchange rate (or doubling rate): *The increase or decrease in decibels corresponding to twice (or half) the noise dose. For example, if the exchange rate is 5 dB, 90 dB produces twice the noise dose that 85 dB produces (assuming that duration is constant). The OSHA exchange rate is 5 dB (see Table D-2 of the construction noise standard, 29 CFR 1926.52, and Tables G-16 and G-16a of the general industry noise standard, 29 CFR 1910.95).*

Only instruments using a 5-dB exchange rate may be used for OSHA compliance measurements. CSHOs should be aware that the following organizations use noise dosimeters with a 3-dB exchange rate: NIOSH, EPA, ACGIH, and most foreign governments. The U.S. Department of Defense (DOD) previously used a 4-dB exchange rate; however, all branches (except the U.S. Navy) now have adopted the 3-dB exchange rate.

Hertz (Hz): *Unit of vibration frequency, numerically equal to cycles per second.*

Impact noise (or impulsive noise): *Impact noise is created by the impact of one surface on another and is of a short duration. Impulsive noise is typically an air noise that has a short duration, such as the shooting of a firearm or the explosion of a firework. The standard states that exposure to impulsive or impact noise should not exceed a* **140-dB** *peak sound pressure level. Impulsive or impact noises are considered to be much more harmful to hearing than*

continuous noises. In construction, most of the 500,000 workers who are exposed to hazardous noise levels are also exposed to impulsive and impact noise sources on worksites. Impulsive and impact noise is typified by a sound that rapidly rises to a sharp peak and then quickly fades. Both are transient noises of brief duration and high intensity. The sound may or may not have a "ringing" quality (such as a striking a hammer on a metal plate or a gunshot in a reverberant room). Impulsive noise can be repetitive or a single event (like a sonic boom); if impulses occur in very rapid succession (such as with some jack hammers), it is not described as impulsive or impact noise.

Intensity of sound: *Intensity of sound is measured in watts per square meter. To calculate the intensity level in decibels, find the ratio of the intensity (I) of sound to the threshold intensity (I_0).*

$$dB = 10\log_{10}\frac{I}{I_0}$$

L_{avg} (or LAVG): *The average sound level measured over the run time of measurement. This becomes a bit confusing when thresholds are used, because the average does not include any sound below the threshold. Sound is measured in the logarithmic scale of decibels, so the average cannot be computed by simply adding the levels and dividing by the number of samples. When averaging decibels, short durations of high levels can significantly contribute to the average level.*

> *Example: Assume the threshold is set to 80 dB and the exchange rate is 5 dB (the settings of OSHA's Hearing Conservation Amendment). Consider taking a 1-hour noise measurement in an office where the A-weighted sound level was typically between 50 dB and 70 dB. If the sound level never exceeded the 80-dB threshold during the 1-hour period, then the LAVG would not indicate any reading at all. If 80 dB was exceeded for only a few seconds due to a telephone ringing near the instrument, then only those seconds will contribute to the LAVG, resulting in a level perhaps around 40 dB (notably lower than the actual levels in the environment).*

LDN: *Representing the day/night sound level, this measurement is a 24-hour average sound level, where 10 dB is added to all of the readings taken between 10 p.m. and 7 a.m. This is primarily used in community noise regulations where there is a 10-dB "penalty" for nighttime noise but is not used to evaluate compliance with OSHA standards, as it is not an occupational issue.*

L_{eq}: *The true equivalent sound level measured over the run time. L_{EQ} is functionally the same as L_{AVG}, except that it is only used when the exchange rate is set to 3 dB and the threshold is zero.*

Linear weighting: *A weighting most commonly found on upper model sound level meters, typically used when performing octave band filtering analysis.*

Max level: *The highest weighted sound level that occurred, also allowing for the response time to which the meter is set. If the meter is set for A-weighting with slow response, the max level is the highest A-weighted sound that occurred when applying the slow response time.*

Noise dosimeter: *A type of sound level meter that measures the dose of noise. This instrument can calculate the daily noise dose based on a full workshift of measurements, or a dose from a shorter sample. The operator can select different noise dose criteria, exchange rates, and thresholds.*

Octave bands: *Sounds that contain energy over a wide range of frequencies are divided into sections called bands, each one octave. A common standard division is in 10 octave bands*

identified by their center frequencies, 31.5; 63; 250; 500; 1,000; 2,000; and 4,000 Hz. For each octave band, the frequency of the lower band limit is one-half the frequency of the upper band limit. This is the most common type of frequency analysis performed for workplace exposure evaluation and control. An alternative frequency band, the one-third octave band, is defined as a frequency band such that the upper band-edge frequency, f_2, is the cube root of two times the lower band frequency, f_1: $f_2 = (2)^{1/3} f_1$. The level of detail provided by one-third octave bands, however, is rarely required for occupational noise evaluation and control.

Peak noise: *The highest instantaneous sound level that a microphone detects. Unlike the max level, the peak is detected independently of the slow or fast response for which the unit is set.*

> *Example: The peak circuitry is very sensitive. Test this by simply blowing across the microphone. You will notice that the peak reading may be 120 dB or greater. When you take a long-term noise sample (such as a typical 8-hour workday sample for OSHA compliance), the peak level is often very high. Because brushing the microphone over a shirt collar or accidentally bumping it can cause such a high reading, the user must be careful not to place too much emphasis on the reading.*

Permissible exposure limit (PEL): *The A-weighted sound level at which exposure for a criterion time, typically 8 hours, accumulates a 100% noise dose. Only sounds 90 dBA and higher are integrated into the PEL (i.e., the threshold level is 90 dBA).*

Receiver: *A person exposed to noise that originates at a noise source. If the receiver is exposed to a hazardous noise level, the exposure can be reduced through various noise-control methods.*

Response: *Instruments that measure time-varying signals are limited in how fast they can respond to changes in the input signal. Sound dosimeters can operate with a wide variety of response times, but the industry has chosen two particular response times to standardize measurements. These are known as the slow and fast response times. OSHA, the Mine Safety and Health Administration, and ACGIH all require the slow response for sound dosimetry. The standardized time constant for the slow response is 1 second.*

Sound level meter: *An instrument that converts sound pressure in air into corresponding electronic signals. The signals may be filtered to correspond to certain sound weightings (e.g., A-weighted scale, C-weighted scale).*

Threshold level: *The A-weighted sound level at which a personal noise dosimeter begins to integrate noise into a measured exposure. For example, if the threshold level on a sound level meter is set at 80 dBA, it will capture and integrate into the computation of dose all noise in the worker's hearing zone that equals or exceeds 80 dBA. Sound levels below this threshold would not be included in the computation of noise dose. Use an 80-dBA threshold for measurements related to hearing conservation programs and a 90-dBA threshold for exposure results related to the need for engineering or administrative controls.*

The hypothetical exposure situations shown in Table A–2 illustrate the relationship between criterion level, threshold, and exchange rate and show the importance of using a dosimeter with an 80-dBA threshold to characterize a worker's noise exposure. For example, an instrument with a 90-dBA threshold will not capture any noise below that level and will thus give a readout of 0%, even if the worker being measured is actually being exposed to 89 dBA for 8 hours (i.e., to 87% of the allowable noise dose over any 8-hour period).

Table A–2. Effect of Threshold Settings on Dosimeter Readout		
Exposure Conditions	**Dosimeter With Threshold Set at 80 dBA (percent of measured dose)**	**Dosimeter With Threshold Set at 90 dBA (percent of measured dose)**
90 dBA for 8 hours	*100.0%*	*100.0%*
89 dBA for 8 hours	*87.0%*	*0.0%*
85 dBA for 8 hours	*50.0%*	*0.0%*
80 dBA for 8 hours	*25.0%*	*0.0%*
79 dBA for 8 hours	*0.0%*	*0.0%*
90 dBA for 4 hours plus 80 dBA for 4 hours	*62.5%*	*50.0%*
90 dBA for 7 hours plus 89 dBA for 1 hour	*98.4%*	*87.5%*
100 dBA for 2 hours plus 89 dBA for 6 hours	*165.3%*	*100.0%*

Assumes 5 dB exchange rate, 90 dBA PEL, ideal threshold activation, and continuous sound levels.

Time-weighted average (TWA): *A constant sound level lasting 8 hours that would result in the equivalent sound energy as the noise that was sampled. TWA always averages the sampled sound over an 8-hour period. This average starts at zero and grows. It is less than the L_{avg} for a duration of less than 8 hours, is exactly equal to the L_{avg} at 8 hours, and grows higher than the L_{avg} after 8 hours.*

> *Example: Think of a TWA as having a large 8-hour container that stores sound energy. If you run a dosimeter for 2 hours, your L_{avg} is the average level for those 2 hours—consider this a smaller 2-hour container filled with sound energy. For TWA, take the 2-hour container and pour that energy into the 8-hour container. The TWA level will be lower. Again, TWA is always based on the 8-hour container. When measuring using OSHA's guidelines, TWA is the proper number to report if the full workshift was measured.*

Type 1/Type 2 (or Class 1 and Class 2): *Two different accuracy specifications for noise measurements. Type 1 measurements are accurate to approximately ±1dB and Type 2 measurements are accurate to approximately ±2dB. The accuracy of the measurements varies, however, depending on the frequency of the sound being measured.*

Z-weighting: *An unweighted measurement scale that does not apply any attenuation or weighting to any frequency. Instead, this scale provides a flat response across the entire spectrum from 10 Hz to 20,000 Hz, making it useful for octave band analysis and evaluating engineering controls.*

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