

## ACOUSTIC

### INFRASOUND AND LOW-FREQUENCY SOUND

These limits represent sound exposures to which it is believed nearly all workers may be repeatedly exposed without adverse effects that do not involve hearing.

Except for impulsive sound with durations of less than 2 seconds, one-third octave band<sup>(1)</sup> levels for frequencies between 1 and 80 Hz should not exceed a sound pressure level (SPL) ceiling limit of 145 dB. In addition, the overall unweighted SPL should not exceed a ceiling limit of 150 dB.

There are no time limits for these exposures. However, application of the TLVs® for Noise and Ultrasound, recommended to prevent noise-induced hearing loss, may provide a reduced acceptable level with time. This reduction will depend upon the amount of attenuation allowed for hearing protection.

An alternative but slightly more constrictive criterion, where the peak SPL measured with the linear or unweighted frequency response of a Sound Level Meter does not exceed 145 dB for nonimpulsive events, may be used. When using this criterion, the measurement instrument should conform to ANSI Standard S1.4 and the linear or unweighted response should extend down to at least 2 Hz.

*Note: Low frequency sounds in the chest resonance range from about 50 Hz to 60 Hz can cause whole-body vibration. Such an effect may cause annoyance and discomfort. The SPL of such sound may need to be reduced to a level where the problem disappears.*

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### References

1. American National Standards Institute: Specification for Octave-Band and Fractional-Octave Band Analog and Digital Filters S1.11-1986 (R1998). ANSI, New York (1998).

## NOISE

These TLVs® refer to sound pressure levels and durations of exposure that represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. Prior to 1979, the medical profession had defined hearing impairment as an average hearing threshold level in excess of 25 decibels (ANSI S3.6-1996)<sup>(1)</sup> at 500, 1000, and 2000 hertz (Hz). The limits that are given here have been established to prevent a hearing loss at higher frequencies, such as 3000 Hz and 4000 Hz. The values should be used as guides in the control of noise exposure and, due to individual susceptibility, should not be regarded as fine lines between safe and dangerous levels.

It should be recognized that the application of the TLVs® for noise will not protect all workers from the adverse effects of noise exposure. The TLVs® should protect the median of the population against a noise-induced hearing loss exceeding 2 dB after 40 years of occupational exposure for the average of 0.5, 1, 2, and 3 kHz. A hearing conservation program with all its elements, including audiometric testing, is necessary when workers are exposed to noise at or above the TLVs®.

### Continuous or Intermittent Noise

The sound pressure level should be determined by a sound level meter or dosimeter conforming, as a minimum, to the requirements of the American National Standards Institute (ANSI) Specification for Sound Level Meters, S1.4-1983, Type S2A,<sup>(2)</sup> or ANSI S1.25-1991 Specification for Personal Noise Dosimeters.<sup>(3)</sup> The measurement device should be set to use the A-weighted network with slow meter response. The duration of exposure should not exceed that shown in Table 1. These values apply to total duration of exposure per working day regardless of whether this is one continuous exposure or a number of short-term exposures.

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered rather than the individual effect of each. If the sum of the following fractions:

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n}$$

exceeds unity, then the mixed exposure should be considered to exceed the TLV®.  $C_1$  indicates the total duration of exposure at a specific noise level, and  $T_1$  indicates the total duration of exposure permitted at that level. All on-the-job noise exposures of 80 dBA or greater should be used in the above calculations. With sound level meters, this formula should be used for sounds with steady levels of at least 3 seconds. For sounds in which this condition is not met, a dosimeter or an integrating sound level meter must be used. The TLV® is exceeded when the dose is more than 100% as indicated on a dosimeter set with a 3 dB exchange rate and an 8-hour criteria level of 85 dBA.

The TLV® is exceeded on an integrating sound level meter when the average sound level exceeds the values of Table 1.

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### Impulsive or Impact Noise

By using the instrumentation specified by ANSI S1.4,<sup>(2)</sup> S1.25,<sup>(3)</sup> or IEC 804,<sup>(4)</sup> impulsive or impact noise is automatically included in the noise measurement. The only requirement is a measurement range between 80 and 140 dBA and the pulse range must be at least 63 dB. No exposures of an unprotected ear in excess of a C-weighted peak sound pressure level of 140 dB should be permitted. If instrumentation is not available to measure a C-weighted peak, an unweighted peak measurement below 140 dB may be used to imply that the C-weighted peak is below 140 dB.

**TABLE 1 . TLVs® for Noise<sup>A</sup>**

		Duration per Day	Sound Level dBA <sup>B</sup>
TLV®-PA	Hours	24	80
		16	82
		8	85
		4	88
		2	91
		1	94
	Minutes	30	97
		15	100
		7.50 <sup>C</sup>	103
		3.75 <sup>C</sup>	106
		1.88 <sup>C</sup>	109
		0.94 <sup>C</sup>	112
	Seconds <sup>C</sup>	28.12	115
		14.06	118
		7.03	121
		3.52	124
		1.76	127
		0.88	130
		0.44	133
		0.22	136
		0.11	139

<sup>A</sup> No exposure to continuous, intermittent, or impact noise in excess of a peak C-weighted level of 140 dB.

<sup>B</sup> Sound level in decibels are measured on a sound level meter, conforming as a minimum to the requirements of the American National Standards Institute Specification for Sound Level Meters, S1.4 (1983)<sup>(2)</sup> Type S2A, and set to use the A-weighted network with slow meter response.

<sup>C</sup> Limited by the noise source—not by administrative control. It is also recommended that a dosimeter or integrating sound level meter be used for sounds above 120 dB.

**Notes:**

1. For impulses above a C-weighted peak of 140 dB, hearing protection should be worn. The MIL-STD-1474C<sup>(5)</sup> provides guidance for those situations in which single protection (plugs or muffs) or double protection (both muffs and plugs) should be worn.
2. Exposure to certain chemicals may also result in hearing loss. In settings where there may be exposures to noise and to carbon monoxide, lead, manganese, styrene, toluene, or xylene, periodic audiograms are advised and should be carefully reviewed. Other substances under investigation for ototoxic effects include arsenic, carbon disulfide, mercury, and trichloroethylene.
3. There is evidence to suggest that noise exposure in excess of a C-weighted, 8-hour TWA of 115 dBC or a peak exposure of 155 dBC to the abdomen of pregnant workers beyond the fifth month of pregnancy may cause hearing loss in the fetus.
4. The sum of the fractions of any one day may exceed unity, provided that the sum of the fractions over a 7-day period is 5 or less and no daily fraction is more than 3.
5. Table 1 is based on daily exposures in which there will be time away from the workplace in which to relax and sleep. This time away from the workplace will allow any small change to the worker's hearing to recover. When the worker, for times greater than 24 hours, is restricted to a space or series of spaces that serve as both a workplace and a place to relax and sleep, then the background level of the spaces used for relaxation and sleep should be 70 dBA or below.

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**References**

1. American National Standards Institute: Specification for Audiometers. ANSI S3.6- 1996. ANSI, New York (1996).
2. American National Standards Institute: Specification for Sound Level Meters. ANSI S1.4-1983 (R1997). ANSI, New York (1997).
3. American National Standards Institute: Specification for Personal Noise Dosimeters. ANSI S1.25-1991. ANSI, New York (1991).
4. International Electrotechnical Commission: Integrating-Averaging Sound Level Meters. IEC 804. IEC, New York (1985).
5. U.S. Department of Defense: Noise Limits for Military Materiel (Metric). MIL-STD-1474C. U.S. DOD, Washington, DC (1991).

## ULTRASOUND

These TLVs® represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. Previous TLVs® for the frequencies 10 kilohertz (kHz) to 20 kHz, set to prevent subjective effects, are referenced in a cautionary note to Table 1. The 8-hour TWA values are an extension of the TLV® for Noise, which is an 8-hour TWA of 85 dBA. The ceiling values may be verified by using a sound level meter with slow detection and  $\frac{1}{3}$  octave bands. The TWA values may be verified by using an integrating sound level meter with  $\frac{1}{3}$  octave bands. All instrumentation should have adequate frequency response and should meet the specifications of ANSI S1.4-1983 (R1997)<sup>(1)</sup> and IEC 804.<sup>(2)</sup>

**TABLE 1. TLVs® for Ultrasound**

TLV®-PA	One-third Octave-Band Level <sup>(3)</sup>			
	Mid-Frequency of Third-Octave Band (kHz)	Measured in Air in dB re: 20 µPa; Head in Air		Measured in Water in dB re: 1 µPa; Head in Water
		Ceiling Values	8-Hour TWA	Ceiling Values
	10	105 <sup>A</sup>	88 <sup>A</sup>	167
	12.5	105 <sup>A</sup>	89 <sup>A</sup>	167
	16	105 <sup>A</sup>	92 <sup>A</sup>	167
	20	105 <sup>A</sup>	94 <sup>A</sup>	167
	25	110 <sup>B</sup>	—	172
	31.5	115 <sup>B</sup>	—	177
	40	115 <sup>B</sup>	—	177
	50	115 <sup>B</sup>	—	177
	63	115 <sup>B</sup>	—	177
	80	115 <sup>B</sup>	—	177
	100	115 <sup>B</sup>	—	177

<sup>A</sup> Subjective annoyance and discomfort may occur in some individuals at levels between 75 and 105 dB for the frequencies from 10 kHz to 20 kHz especially if they are tonal in nature. Hearing protection or engineering controls may be needed to prevent subjective effects. Tonal sounds in frequencies below 10 kHz might also need to be reduced to 80 dB.

<sup>B</sup> These values assume that human coupling with water or other substrate exists. These thresholds may be raised by 30 dB when there is no possibility that the ultrasound can couple with the body by touching water or some other medium. [When the ultrasound source directly contacts the body, the values in the table do not apply. The vibration level at the mastoid bone must be used.] Acceleration Values 15 dB above the reference of 1 g rms should be avoided by reduction of exposure or isolation of the body from the coupling source. (g = acceleration due to the force of gravity, 9.80665 meters/second<sup>2</sup>; rms = root-mean-square).

## References

1. American National Standards Institute: Specification for Sound Level Meters. ANSI S1.4-1983 (R1997). ANSI, New York (1997).
2. International Electrotechnical Commission: Integrating-Averaging Sound Level Meters. IEC 804. IEC, New York (1985).
3. American National Standards Institute: Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters S1.11-1986 (R1998). ANSI, New York (1998).