

Updated June 07, 2013

## Potential Health Effects of Noise Exposure

Exposure to noise is a continuing challenge to individual and community health; sources of excess noise include vehicular traffic, aircraft, industry, and countless sources in the home and/or workplace. The potential health impacts associated with exposure include annoyance, sleep disturbance, interference with communication, decreased school performance, increased levels of stress, and modification of social behavior. Chronic exposure to noise is associated with increased risk of hearing impairment, hypertension, and ischemic heart disease.

Table 1. Examples of Long-term Effects Related to Noise Exposure<sup>§</sup>

Effect	Exposure type	Measure*	dB	Location of assessment
Hearing Impairment	Environmental	L <sub>aeq</sub> (24 hr avg)	70	Indoors
	Occupational		75	
Hypertension	Environmental	L <sub>dn</sub> (24 hr avg)	70	Outdoors
	Occupational	L <sub>aeq</sub> (24 hr avg)	<85	Indoors
Ishchemic Heart Disease	Environmental	L <sub>aeq</sub> (24 hr avg)	70	Outdoors
Annoyance	Environmental	L <sub>dn</sub> (24 hr avg)	42 <sup>#</sup>	Outdoors
	Occupational	L <sub>aeq</sub> (24 hr avg)	Industry <85 Office <55	Indoors
Performance	School	L <sub>aeq</sub> (avg during school day)	70	Outdoors
	Occupational		70	
Disturbance of Sleep pattern	Sleep	L <sub>aeq</sub> (overnight avg)	<60	Outdoors
Awakening	Sleep	SEL	55	Indoors
Sleep Quality	Sleep	L <sub>aeq</sub> (overnight avg)	40	Outdoors
Mood Next Day (sleep disturbance)	Sleep	L <sub>aeq</sub> (overnight avg)	<60	Outdoors

<sup>§</sup> The information contained in Table 1 was derived from Passchier-Vermeer and Passchier (2000).

\* Noise levels presented in this table are presented as an equivalent sound level (L<sub>aeq</sub>) measured over a period of time and day-night level (L<sub>dn</sub>) which measures sound level over 24 hours with sound levels during the night. A sound exposure level (SEL) is the equivalent sound level of an event measured over 1 second.

<sup>#</sup> The dB level causing annoyance is approximately 12 dB lower for impulse noise.

The potential risk of adverse health effects associated with exposure to noise is dependent on the duration of exposure (acute or chronic), intensity (decibel level), and sound frequency. Noise-induced hearing loss can result from a one-time exposure to sounds  $\geq 120$  decibels (dB) or exposure to sounds  $\geq 85$  dB over an extended period of time without hearing protection. The louder the sound the smaller amount of time required for damage.

To protect the community from exposure to excess noise, legislation has been enacted at the Federal, state, and local levels to reduce potentially harmful exposures. These efforts have typically focused on the reduction of harmful occupational and residential exposure to noise. Federal regulations governing occupational exposures are shown in the following tables.

Table 2. OSHA Daily Permissible Occupational Noise Level Exposure

Duration per day (hours)	Sound level (dB)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
$\leq 0.25$	115

The standards recommended by the National Institute for Occupational Safety and Health (NIOSH) are similar but slightly lower than the current standards of the Occupational Safety and Health Administration (OSHA); examples of the NIOSH recommendations are shown below. The NIOSH recommendations are also used by the Centers for Disease Control and Prevention (CDC) for recommendations of maximum environmental noise exposure levels.

Table 3. NIOSH Recommended Exposure Limits for Repeated Noise Exposures

Duration per day (hours)	Sound level (dB)
8	85
6	86
4	88
3	89
2	90
1.5	92
1	94
0.5	97
$\leq 0.25$	100

Similar to other communities, the City of Madison has established legislation to decrease the potential exposure to excessive noise. In each of these communities, the common theme of these ordinances is to govern acceptable noise standards for exposures generated from vehicles, construction equipment, industrial and agricultural equipment, and other noises generated at unsafe levels that may impact residential environments.

Examples of noise regulations from various communities are shown in the table below (Table 4). In the sample selected, the common approach is to define unacceptable noise levels as levels that lead to annoyance, disturbance of peace, and potential health impacts of residential areas near the source of exposure; the acceptability of these complaints are typically determined by the first responder at the scene (i.e. law enforcement). Other communities such as the City of Madison, Wisconsin and Minneapolis, MN have standardized this approach by establishing acceptable decibel (dB) levels that can be monitored, evaluated, and reported to determine acceptability. Additional communities including New York City have also included octave band levels into noise ordinances to reduce exposure to noise with potential damaging bandwidths. In this case, as the frequency of the noise increases (measured in Hertz), acceptable dB levels are decreased to prevent acute or chronic injury.

Table 4. Examples of Noise Regulation in Various Communities

Community	Noise Ordinance Regulation*
Dane County, WI	Excessive noise defined as any sound or level that unreasonably disturbs peace, comfort, quiet, or repose of persons in vicinity of sound. Applies to all of Dane County communities without a similar ordinance addressing excessive noise.
Madison, WI	Established time periods and acceptable noise levels for stationary and equipment sources of noise in dB. Residential: 65 dB Commercial, manufacturing, or agriculture: 70 – 75dB Equipment: 70 – 88 dB
Monona, WI	Similar ordinance to Dane County, no dB level established.
Middleton, WI	Established time periods and acceptable noise levels in dB. Amplified sound cannot exceed 60-65 dB. Other levels of unacceptable noise are defined in a similar manner as Dane County.
Milwaukee, WI	Established time periods and acceptable levels of noise in noise rating (NR) numbers established by the International Standards Organization (ISO/TC 43, Secretariat-139, August 1961, Table 1) <sup>#</sup> . The acceptable noise limits range from NR 55 – 65 during established day time hours and 45 – 60 during night hours; the NR number is dependent upon zoning.
Minneapolis, MN	Established time periods and acceptable noise levels in dB. The maximum permitted sound along business district boundaries ranges from 32 – 72 dB and along residence district boundaries 39 – 79 dB; both ranges are dependent upon octave band frequency.
Indianapolis, IN	Similar to Dane County ordinance. Acceptable times are established and noise is deemed excessive if sounds are an annoyance, unsafe, and/or disturbing to the peace.
New York, NY	Addresses noise levels from commercial and residential sources with a special focus on construction, machinery, railroads, subways, and vehicles. This ordinance also includes octave bandwidths (Hz) in addition to established acceptable dB levels in the evaluation of noise complaint assessments.
<p>* The regulatory information was current at the date of writing of this document.  <sup>#</sup> Noise rating (NR) is based upon a mathematical calculation that considers the sound pressure of noise (dB) and the frequency of the sound (hertz) to determine safe levels of sound exposure.</p>	

Please note that the sample of community noise regulations provided in the table above is by no means a comprehensive view of approaches to regulate excessive noise exposure but an example of the variety of potential strategies to address this issue.

Although the current City of Madison noise ordinance does not include octave band restrictions, the acceptable levels are below the current OSHA standards and, with the exception of equipment noise restrictions, are below the more conservative NIOSH and CDC recommendations for occupational and environmental exposures. The level set by the ordinance for residential exposures (65 dB) is below the maximum exposure level of 70 dB recommended by the CDC and the United States Environmental Protection Agency (US EPA) for environmental exposures over a 24 hour period during a lifetime; a level lower than the NIOSH recommendation of 80 dB. However, in occupational settings, strategies to control noise exposure should also include personal protective equipment (as appropriate) to reduce the potential risk of noise-induced hearing loss.

Any subsequent revisions to this legislation should explore the inclusion of bandwidth considerations to further improve the effectiveness of the ordinance.

### **Additional Resources**

The following resources and links provide additional information concerning the potential risk of noise exposure.

Centers for Disease Control and Prevention. (2013). About hearing loss. Available at: <http://www.cdc.gov/healthyyouth/noise/signs.htm>

City of Madison. (2009). Chapter 24 – offenses against peace and quiet. Retrieved on November 17, 2009 from: <http://www.municode.com/Resources/gateway.asp?pid=50000&sid=49>

National Institute for Occupational Safety and Health. (1998). Criteria for a recommended standard – Occupational noise exposure. Available at: <http://www.cdc.gov/niosh/docs/98-126/pdfs/98-126.pdf>

Passchier-Vermeer, W, and Passchier, WF. (2000). Noise exposure and public health. *Environmental Health Perspectives*, 108 (supplement 1), 123-131. Available at: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1637786/pdf/envhper00310-0128.pdf>

United States Environmental Protection Agency. (2013). EPA identifies noise levels affecting health and welfare. Available at: <http://www.epa.gov/history/topics/noise/01.html>

United States Department of Labor, Occupational Safety and Health Administration. (n.d.). Occupational noise exposure – 1910.95. Available at:  
[http://www.osha.gov/pls/oshaweb/owadisp.show\\_document?p\\_table=standards&p\\_id=9735](http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9735)

World Health Organization. (1999). Guidelines for community noise. Available at:  
<http://www.who.int/docstore/peh/noise/guidelines2.html>

World Health Organization (WHO). (2001). Occupational and community noise. Available at:  
[http://www.who.int/peh/Occupational\\_health/OCHweb/OSHPages/OSHDocuments/Factsheets/noise.pdf](http://www.who.int/peh/Occupational_health/OCHweb/OSHPages/OSHDocuments/Factsheets/noise.pdf)

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