

Now Hear This!

What All Environmental Engineers Should Know About

Noise Control



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Noise is an issue that affects almost everyone. And even though environmental engineers are often called on to deal with noise-related problems, most of them receive little or no academic training in noise control. This primer suggests why all environmental engineers should know something about noise control, what they need to know, and where they can find the necessary information.

A SIGNIFICANT ENVIRONMENTAL PROBLEM

The U.S. Clean Air Act identified noise as a "significant" environmental problem (42 USC 1858). The U.S. Environmental Protection Agency (EPA) looked into the effects of noise, noise sources, and methods of control, but has never followed through with a national noise control strategy. As a result, four major federal laws form the basis of noise regulation in the United States: The Housing and Urban Development Act of 1965 (PL 89-117), the Control and Abatement of Aircraft Noise and Sonic Boom Act of 1968 (49 USC 1421-1430), the Noise Control Act of 1972 (42 USC 4901), and the Quiet Communities Act of 1978 (PL 95-609). The lack of a national noise control strategy has led other agencies, including the U.S. Department of Transportation, the Federal Aviation Administration, and the Occupational Safety and Health Administration (OSHA), to develop their own noise control policies.

Noise can be a nuisance, create unsafe working conditions, and potentially lead to lifelong learning disabilities in children. It can also lead to permanent hearing loss, resulting in a negative change in lifestyle. The effects of noise on long-term health are becoming more widely accepted. Certainly, noise needs to be considered a complicating factor when

studying the chronic health effects of air pollution.¹ In addition, some investigators are now assessing hearing effects from exposure to various chemicals.²

The Institute of Environmental Epidemiology suggests that environmental engineers and environmental professionals could productively be involved with many stages of noise management, from identifying the problem to developing mitigation and abatement strategies.³ The role of an environment, health, and safety (EH&S) department is to prevent accidents and minimize exposure to hazardous agents and conditions, including excessive noise. Environmental engineers should understand all aspects of EH&S issues. A frequently understudied area of EH&S is noise, where a lack of understanding of noise regulations and concepts can lead to mistakes in determining when and where hearing protection is and is not required.

Informed environmental engineers should also assist in reducing workers' resistance to hearing protection and promote an understanding that even meeting OSHA's regulations will not protect everyone's hearing. In a study published in 2002, R.R. Davis estimated that 4.1 million U.S. workers were exposed to decibel (dB) levels greater than 85 (85 dB is the determining factor used by OSHA for implementing noise monitoring), but only 41% wore hearing protection.⁴ His study showed no apparent tie between policy and the percentage of workers wearing protection. To firmly establish the need for noise control, D.G. Bull suggests showing the relationship between noise and damage to hearing.⁵ He stresses the need to stimulate the interest of technical staff because they have a major influence on the day-to-day noise emissions in a facility.

The fans, blowers, pumps, and motors associated with pollution control equipment have the potential to generate significant noise. For example, consider a fan for a furnace baghouse that generates high noise levels in an area where office workers frequently traverse. OSHA may insist that workers wear ear plugs when walking in the vicinity of the fan. Since this may not be practical, the fan might be replaced with a quieter unit or enclosed to further reduce noise levels.⁶ Environmental engineers working in industry should be able to assist management in identifying the potential

for conflicts. Considering noise issues during the planning process can eliminate conflicts or the creation of additional problems, as well as potentially lowering costs.

Indoor noise is an issue, but so is outdoor noise. For example, when designing groundwater remediation systems within residential or commercial areas, noise associated with catalytic oxidizers, soil vapor extraction, or air sparging blowers must be considered. Other projects where noise can pose a significant issue include water and wastewater treatment facilities, storm and sanitary sewer pump stations, wind turbines, gas, oil- and coal-fired power facilities, petrochemical facilities, and solid waste transfer stations.

Studies of the effects of transportation noise, particularly its effect on sleep and learning disabilities, have focused on airports and highway noise. Currently, the Hypertension and Exposure to Noise near Airports (HYENA) Consortium is assessing the impacts on cardiovascular health of airport and road traffic noise near six major European airports.⁷

Sometimes the solutions to noise problems are relatively straightforward, such as increasing the sound absorption within a pump station to reduce the interior noise to acceptable levels or ensuring the materials used in construction have sufficient transmission loss to minimize the noise radiated to the nearby receptor. In many cases, a multifaceted approach is necessary to develop a cost-effective solution.

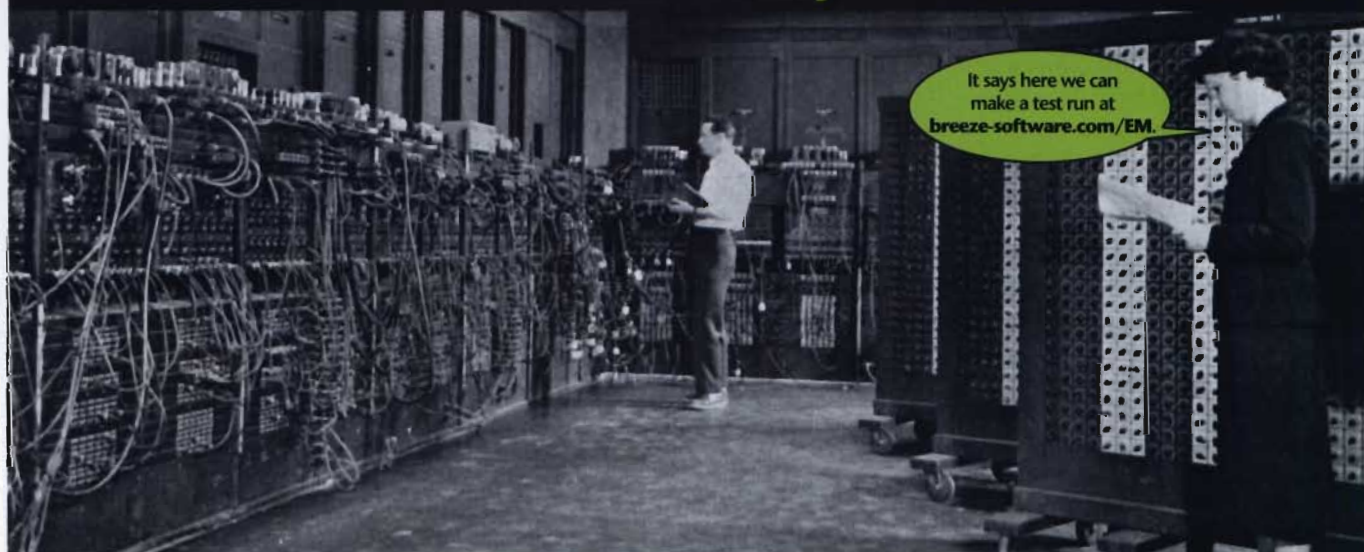
NOISE CONTROL EDUCATION

Most undergraduate engineers are exposed to the basic principles of sound when they take physics. Much of the fundamental research continues to be the province of physicists. Some engineering disciplines, like mechanical engineering, have done a good job in providing graduate students with an introduction to noise control. Penn State University's program is one of the most comprehensive. However, most environmental engineering programs in the United States do not offer students the opportunity to study noise control.⁸

The American Academy of Environmental Engineers lists 41 U.S. universities that currently have accredited undergraduate environmental engineering programs.^{9,10} Few of these programs identified noise as an issue that was presented to students even briefly in the introductory class to environmental engineering. Three programs had a course on noise in their curriculum and several identified noise as an engineering elective taught at the graduate level or in some other department.

Noise and noise control is still not being presented to the majority of environmental engineering students. And even when it is presented, noise control is not raised to the same level of importance as air pollution control, wastewater control, solid and hazardous waste management, and now global warming and sustainability.

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NOISE CONTROL RESOURCES

Text	Primary Topic Areas
<i>Occupational Audiometry: Monitoring and Protecting Hearing at Work</i> ; Maltby, M.; Butterworth-Heinemann, Elsevier: San Diego, 2005	1, 5
<i>Noise & Hearing Conservation Manual, 4th Edition</i> ; E.H. Berger, ed.; American Industrial Hygiene Association: Fairfax, 1986	1, 4, 5
<i>Engineering Noise Control, 3rd Edition</i> ; D.A. Bies.; Spon Press: London, 2003	2, 6, 7, 9
<i>Handbook of Environmental Acoustics</i> ; Cowan, J.P.; Van Nostrand Reinhold: New York, 1994	2, 6
<i>Fundamentals of Physical Acoustics</i> ; Blackstock, D.T.; John Wiley & Sons Inc.: New York, 2000	2
<i>Fundamentals of Noise and Vibration Analysis for Engineers</i> ; Norton, M.P.; Cambridge University Press: Cambridge, 1989	2
<i>Handbook of Acoustical Measurements and Noise Control, 3rd Edition</i> ; C.M. Harris, ed.; McGraw-Hill: New York, 1993	2, 3, 6, 9
<i>Noise Control, Measurement, Analysis, and Control of Sound and Vibration</i> ; Wilson, C.E.; Krieger: Melbourne, 1989	2, 3
<i>Architectural Acoustics</i> ; Long, M.; Academic Press: Burlington, 2006	8
<i>A Practical Guide to Noise and Vibration Control for HVAC Systems</i> ; Schaffer, M.E.; American Society of Heating, Refrigerating, and Air Conditioning Engineers: Atlanta, 2005	8
<i>Noise Control Manual</i> ; D.A. Harris, ed.; Van Nostrand Reinhold: New York, 1991	9
<i>Noise and Vibration Control Engineering: Principles and Application</i> ; L. Beranek; I. Ver, eds.; John Wiley & Sons Inc.: New York, 1992	1-10
<i>The Noise-Vibration Problem Solution Workbook</i> ; Royster, L.H.; Doswell, J.; American Industrial Hygiene Association: Fairfax, 2002	1-8
<i>Fundamentals of Noise and Vibration Analysis for Engineers</i> ; Norton, M.P.; Cambridge University Press: Cambridge, 1989	10
<i>Mechanical and Structural Vibrations</i> ; Ginsbergh, J.H.; John Wiley & Sons Inc.: New York, 2001	10
<i>Theory of Vibrations, 3rd Edition</i> ; Thomson, W.E.; Prentice Hall: Upper Saddle River, 1988	10
<i>Handbook of Noise and Vibration Control</i> ; M.J. Crocker, ed.; John Wiley & Sons Inc., New York, 2007	2, 7, 8, 9, 10
<i>The Noise Manual</i> ; E.H. Berger, ed.; American Industrial Hygiene Association: Fairfax, 2003	1, 2, 3, 4, 5, 6, 8

WHAT YOU NEED TO KNOW

Noise issues should be covered in the first course in environmental engineering. A few of the introductory texts have included this important topic. For example, the introductory text by Mackenzie Davis in *Introduction to Environmental Engineering, 4th Edition* provides a good first learning experience.¹¹ Also, there is a chapter that goes into the basic concepts of noise and its control that includes a number of good example problems.

Whether developing a training course or learning what is needed to solve a specific problem, there are many resources available. For example, the Web site BooksInPrint.com lists 682 books on noise control currently available in English.¹² In addition, the Institute of Noise Control Engineering has an online review of a number of excellent books.¹³

Below we have identified key topics that may be of value as a starting resource in the respective areas of noise and noise control. Select titles to accompany these topics are shown in the sidebar "Noise Control Resources" above.

- 1. Anatomy of the ear and fundamentals of hearing.** Understanding hearing is a good place to begin the study of noise control.
- 2. Overview of sound power and sound levels.** Noise is not only related to the acoustical pressure generated by the source, but subjective indexes.

This goes beyond the basic concepts of sound covered in most physics classes. Basic books in noise control cover these concepts well.

- 3. Measurement and instrumentation.** How noise is measured depends on the objective. If one needs to reduce noise levels by looking at the design of equipment, a detailed sound spectrum is required. In addition to vendor literature, most recent books provide an overview of modern instrumentation.
- 4. Comfort criteria.** Determining how much noise is acceptable requires recognizing the subjective nature of noise, including concepts of loudness, loudness level, speech interference level, and noise criteria.
- 5. Damage risk criteria.** When noise reaches levels high enough to make communications difficult, one needs to be concerned about both the short- and long-term health effects. These issues, hearing conservation programs, and engineering or administrative controls are discussed in various texts as well as the literature.
- 6. Community noise.** The impact of noise sources on the surrounding community raises a number of questions. What is the best way to measure the noise and what metric works best when trying to correlate the measured level with community reaction?

7. Outdoor propagation (point and line sources).

Propagation of sound outdoors determines how sources impact receptors. The environmental engineer involved with this determination needs to know the acoustical power emitted by the source as a function of frequency, as well as the directional nature of the sound. In addition, reduction of the sound at the receptor's location may occur because of the atmosphere, lapse rate, wind direction and speed, and surface adsorption.

8. Room acoustics (small and large enclosures, noise levels indoors).

Predicting noise levels indoors may be required to assess the impact of new equipment or operations within a plant. Understanding when theory works best and its limits is important.

9. Noise control.

Noise Control can take place at the source, at the receiver's location, or in the path between source and receiver. Methods of control include partitions, barriers, lagging, or silencing (e.g., mufflers, lined ducts, resonators).

10. Vibration control.

Vibration control is often the best way to reduce noise at the source and prevent the sound from being transmitted through the structure to other locations.

In addition to books, there are several publications available on noise control:

- *Noise Control Engineering Journal* (probably the most applicable journal for practicing engineers; www.inceusa.org/pubs.asp)
- *Journal of the Acoustical Society of America* (<http://scitation.aip.org/jasa>)
- *Journal of the American Industrial Hygiene Association* (www.aiha.org)
- *Sound and Vibration Control Magazine* (www.sandv.com)
- *Noise News International* (a publication of the Institute of Noise Control Engineering; www.inceusa.org/pubs.asp)

A number of professional organizations have national technical committees that deal with noise issues. In addition to A&WMA, examples include the Institute of Noise Control Engineering, the Acoustical Society of America, the American Society of Refrigeration and Air Conditioning Engineers, the American Society of Mechanical Engineers, the American Society of Automotive Engineers, the American Society of Civil Engineers, and the American Industrial Hygiene Association.

Finally, there are many excellent online resources for information on noise control.^{14,15} This will continue to be an important source of information.

SUMMARY

Environmental engineers are often called on to deal with noise-related problems. Noise affects health and quality of life for all of us. In summary, noise control should be of interest to environmental engineers for the following

key reasons:

1. Understanding the fundamentals is within every engineer's grasp and engineers are already familiar with the operating principles of process equipment (e.g., fans, pumps, motors). This gives them an advantage in designing solutions to noise issues or avoiding problems in the first place.
2. Environmental engineers should have a good understanding of noise-related regulations as they may find themselves working in a health and safety role.
3. Understanding the difference between sound pressure level and sound power level is important for all disciplines that may be specifying equipment. Understanding why 85 dB(A) at 3 feet—although a standard specification—is not appropriate in many cases is one example.
4. Since the regulatory framework is fractured,¹⁶ environmental engineers and planners who may eventually be involved in site selection/project development should have a clear understanding of noise when designing or approving projects.
5. It is more effective both in terms of mitigation and cost to address noise early in the design process rather than as a retrofit. If new engineers aren't exposed to this, they won't know how to identify problems before they arise or how to appropriately solve them after they occur.

Finally, if environmental engineers aren't concerned with noise control, then who should be?

ACKNOWLEDGMENTS

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10. Accreditation Board for Engineering and Technology (ABET Inc.) See www.abet.org.
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