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Standards and Criteria for Noise Control—An Overview*

Kenneth McK. Eldred† presents an overview of standards and criteria for noise control with emphasis on the effects of noise on people. The activity in the voluntary standards system is described briefly and examples are given of the general standards available for noise control application and use. Similarly, the area of federal regulation and information documents pertaining to environmental noise control in the community and the workplace are summarized. Finally, the article provides a summary of recommended criteria for noise control with respect to: speech interference; risk of hearing loss; community reaction to noise; and, requirements in specific spaces.

The phrase, "noise control," implies the control of noise for a purpose. Most often its purpose is to control the noise environment in which people live, work or play. Therefore, the emphasis in this article is on standards and criteria which relate to noise and its control *for people.*

The meanings of the words, "standard" and "criteria," in the language of the noise control engineering profession, differ from that of a federal regulatory body. In the former, "standard" generally means a documented method, procedure or specification which has been generated by one of the standard developing organizations in the voluntary standards system which, in the United States, is coordinated by the American National Standards Institute (ANSI). This meaning will be utilized in this article.

For a federal environmental regulatory body, a standard usually means a set of limit values which shall be adhered to in accordance with their use in a regulation. The standard is normally embodied in a regulation which usually contains specific test procedures and/or references to voluntary standards for additional detail. When such documents are discussed they will be called "federal regulations."

The word, "criteria" is generally utilized in the engineering profession to denote recommended limit values, or relationships, that are utilized in the performance of engineering calculations or design. In the federal lexicon the word criteria is used to describe a set of cause and effect relationships.[1] The engineer's definition will be used here.

Effects of Noise on People

The effects of environmental noise on people may be considered in two broad classes: (1) hearing loss, and (2) speech and other interferences with human activities which may lead to reduced performance, annoyance and stress.

Hearing loss from noise is a reduction in the ability to hear sounds caused by the physiological damage resulting from cumulative exposure over a period of time to excessive levels of environmental noise. Hearing loss interferes with an individual's ability to engage in normal conversation and other activities involving sound.

The other interferences with human activities include effects of noise on: listening to TV and radio, listening to music, sleep, relaxation and thinking, and mental activities and work tasks requiring concentration.

The general relationships between sound levels and their effects on people can be found in the EPA "Criteria" and "Levels" documents, and in their extensive reference lists.[2,3] Additional data of particular significance for industrial noise can be found in the Department of Health Education and Welfare Criteria Document and its references.[4]

Voluntary Standards

There exists a history of standardization in areas pertinent to noise control, including: instrumentation; basic physical measurements; evaluation of the effects of noise on people; acoustical performance of building materials and structural systems; and, measurement of the noise output of various sources, for example—aircraft, trucks, transformers, air-conditioning equipment. This standardization has been accomplished through a

*Received 20 December 1978; revised 12 October 1981
†Ken Eldred Engineering, P.O. Box 1037, Concord, Massachusetts 01742

TABLE 1
EXAMPLES OF VOLUNTARY STANDARDS WHICH ARE OF GENERAL USE IN NOISE CONTROL*

NOMENCLATURE	SHORT TITLE
Criteria	
S3.4-1980	Procedure for Computation of Loudness
S3.5-1969 (R1978)	Calculation of Articulation Index
S3.10 (proposed)	Permissable Noise Exposure for Hearing Conservation
S3.14-1977	Speech Interference Rating of Noise
S3.16 (proposed)	Hearing Conservation Criteria
S3.18-1979	Human Exposure to Whole Body Vibration
S3.19-1974	Measurement of Ear Protectors and Muffs
S3.23-1980	Land Use Planning with Respect to Noise
SAE·ARP865A	Effective Perceived Noise Level
Measurement	
S1.4-1971 (R1976)	Specifications of Sound Level Meters
S1.7-1970 (R1975)	Test Method for Sound Absorption of Acoustical Materials
S1.10-1966 (R1976)	Method for Calibration of Microphones
S1.11-1966 (R1976)	Specification for Octave, ½-Octave and ⅓-Octave Filters
S1.13-1971 (R1976)	Methods for Measurement of Sound Pressures
S1.25-1978	Specification for Personal Noise Dosimeters
S1.26-1978	Calculation of Atmospheric Absorption of Sound
S1.30-1979	Determination of Sound Power Levels
S1.39-1979	Draft Guidelines for Preparation of Standard Procedures for Measurement of Noise Emission
S6.1-1973 (SAE RPS184)	Qualifying a Sound Data Acquisition System
Noise Control Materials and Structures	
ASTM C423-66 (1972)	Reverberation Room Measurement of Sound Absorption
ASTM E90-75	Sound Transmission Loss in Laboratory
ASTM E336-71	Field Measurement of Transmission Loss
ASTM E413-73	Sound Transmission Class
ASTM E492-73	Impact Sound Transmission
ASTM E497-76	Guidelines for Partition Installation

*A large number of additional standards are available, see Refs. 5-8 and contact ANSI and Standards Organization's secretariat for the most current information

consensus process in the voluntary standards system comprised of independent organizations coordinated by ANSI.

There are five organizations that are responsible for the majority of acoutical standards relevant to noise control. They are:

- American National Standards Committee S-1, "Acoustics" (Acoustical Society of America -secretariat): responsible for instrumentation and basic methods for the physical measurement of sound.
- American National Standards Committee S-3, "Bioacoustics" (Acoustical Society of America -secretariat): responsible for instrumentation and basic methods pertaining to the psychological and physiological effects of noise.
- American Standards Committee S-12, "Noise" (Acoustical Society of America - secretariat): responsible for applied methods of measurement, evaluation and control of noise.
- American Society for Testing and Materials (ASTM) Committee E-33: responsible for methods for measuring the noise reduction of materials and building structural systems.
- Society of Automotive Engineers (SAE), Committees on Road Vehicle Sound Level, Off-Road Vehicle Sound Level and Aircraft Noise Measurement: responsible for methods of measuring the noise radiated from vehicles of all types.

In addition, numerous other organizations develop standards related to specific types of classes of sources of noise. For example, the Air Conditioning and Refrigeration Institute, American National Standards Committee S-2, "Mechanical Shock and Vibration," American Society of Heating Ventilating and Air Conditioning Engineers, American Society of Mechanical Engineers, Compressed Air and Gas Institute, Institute of Electrical and Electronic Engineering and the Snowmobile Association, among others, have produced one or more voluntary consensus standards relevant to noise control.

Table 1 presents several examples of voluntary standards which are of general use in noise control engineering. These, and other standards, provide a great deal of useful methodology and information necessary for

TABLE 2
EXAMPLES OF FEDERAL REGULATIONS AND INFORMATION FOR NOISE CONTROL

FEDERAL AGENCY*	DESIGNATION	DATE**	SUBJECT
Regulations			
FAA	14 CFR Part 36	1969-1981	Noise Standards for Aircraft Type Certification
DOL (OSHA)	29 CFR Part 1910, 95	1971-1981	Occupational Noise Exposure
FHWA	23 CFR Part 772	1973-1979	Highway Noise Standards and Procedures
FAA	14 CFR Part 91	1973-1981	Sonic Boom, Noise Operating Limits for Subsonic and Supersonic Aircraft, and Flight Rules
EPA	40 CFR Part 202	1974	Interstate Motor Carriers (in use)
HUD	24 CFR Part 51	1974-1979	Noise Abatement and Control: Criteria and Standards Policy
EPA	40 CFR Part 201	1960-1976	Interstate Rail Carriers (in use and new)
EPA	40 CFR Part 204	1976-1979	Portable Air Compressor (new) and Waste Compactors
EPA	40 CFR Part 205	1976-1981	Medium and Heavy Trucks (new)
EPA	40 CFR Part 211	1979	Product Noise Labeling and Hearing Protector Labeling
FAA	14 CFR Part 150	1981	Interim Airport Noise Compatibility Programs
Other Information			
DOL (OSHA)	Bul 344	1971	Guidelines to DOL Noise Standard[18]
EPA	Senate No. 92-63	1972	Report to the President and Congress on Noise[19]
EPA	Ser 93-8	1973	Report on Aircraft/Airport Noise[20]
EPA	550/9-74-004	1974	Information on Levels . . . to Protect Public Health & Welfare[3]
DOT/FAA	Office of Sec.	1976	Aviation Noise Abatement Policy[21]
FAA	Order 1050.1B	1977	Policy and Procedures for Environmental Impacts[22]
EPA	ONAC	1977	Toward a National Strategy for Noise Control[23]
NRC	CHABA WG 69	1977	Evaluation of Environmental Impact of Noise[24]
FAA	Adv. Circ. 91-53	1978	Noise Abatement Departure Profile for Turbojet Aircraft Over 75,000 lbs.[25]
FAA	Adv. Circ. 36-3A	1980	Estimated Airplane A-Weighted Noise Levels[26]

*DOL-Department of Labor
DOT-Department of Transportation
EPA-Environmental Protection Agency
FAA-Federal Aviation Administration
FHWA-Federal Highway Administration
HUD-Housing and Urban Development
NRC-National Research Council (of the National Academy of Sciences)
**Initial date to most recent amendment

the professional practice of noise control engineering. At the same time, they provide a defined common language for communication of technical facts related to noise control. These standards have been developed by knowledgeable professionals working in the field in a consensus process which is intended to ensure that all parties having a substantial interest have been heard.

A more complete list of standards, including a large number related to the measurement of the noise of specific types of sources, is contained in the report of the ANSI Standards Planning Panel on Noise Abatement and Control and in other publications.[5-8] Many new standards will be developed in the next few years to complete a system of standards for most significant aspects of noise control engineering. These proposed standards writing projects and their interrelation with existing standards and needs are described in a report, developed as a result of a standards workshop held in December, 1977.[9]

Federal Regulations and Related Information

The concerns of the public related to environmental pollution, and its effects on public health and welfare which grew in intensity during the 1960's led to a series of noise regulating actions by local communities and states and by the U.S. Congress. In 1969, Congress gave the FAA (Federal Aviation Administration) authority to regulate noise emission from aircraft.[10] In the same year Congress enacted the National Environmental Policy Act, requiring noise to be considered a factor in environmental impact statements.[11] Also, in 1969, under authority of the Walsh-Healey Act, the Department of Labor promulgated regulations for noise abatement in the workplace.[12] In 1970 Congress continued the authority for these regulations under the William-Steiger Occupational Safety and Health Act.[13]

Late in 1970, Congress established the Office of Noise Abatement and Control within the EPA, giving it some authority over noise resulting from federal activities and requiring a comprehensive report on environmental noise.[14] In 1972 Congress responded to the report and enacted the Noise Control Act of 1972, giving EPA broad powers in source emission standards and reserving certain powers

to the states.[1] This act was amended by the Quiet Committees Act of 1978, which established a program for federal assistance to states and local communities, expanded noise research and ammended the Act to require aircraft noise abatement.[10,15] The NCA is currently being revised by the 97th Congress.

In 1979 the Congress passed an Aviation Safety and Noise Abatement Act, which directed the FAA to establish a single system for measuring airport noise, determining human exposure and identifying compatible land uses; and to provide for a system of airport noise compatibility planning, based on noise exposure maps.[16] Such maps are intended to provide public notice of noise exposure and limit airport liability for noise damages.

Examples of federal regulations and other information for noise control resulting from these legislative mandates are given in Table 2. The examples cover a variety of types of noise sources, and reflect environmental concerns in both home and workplace.

TABLE 3
RELATIONSHIP BETWEEN MAXIMUM A-WEIGHTED SOUND LEVELS IN dB WHICH ALLOW MARGINAL COMMUNICATION (95% SENTENCE INTELLIGIBILITY) OVER VARIOUS DISTANCES OUTDOORS*[26]

	COMMUNICATION DISTANCE (metres)				
VOICE LEVEL	0.5	1	2	3	5
Normal Voice	72	66	60	56	52
Raised Voice	78	72	66	62	58

*Subtract 20 dB to obtain levels for which no interference is expected

TABLE 4
COMMUNITY REACTION IN RESIDENTIAL AREAS AS A FUNCTION OF ESTIMATED RELATIVE OUTDOOR DAY-NIGHT AVERAGE SOUND LEVELS OF INTRUDING AND BACKGROUND NOISE WITHOUT THE PRESENCE OF INTRUDING NOISE[31]

		Example: For a Typical Urban Residential Background L_{dn} of 60 dB	
Community Average Reaction	Relative L_{dn} in dB (intruding minus background)	Intruding Noise L_{dn} in dB	Approx. Percent Highly Annoyed[32]
None	−5	55	3%
Sporadic Complaints	0	60	8%
Widespread Complaints	5	65	15%
Threats of Legal Action	14	74	34%
Vigorous Action (includes litigation and concerted efforts to obtain government regulation)	21	81	52%

These federal regulations are not developed through a consensus process. Rather, a proposed action is developed within the promulgating agency, often with assistance from competent individuals or groups outside the agency. The proposal is then published in the Federal Register, and a docket is opened to receive comments and other pertinent information from interested parties and the public. The response to these comments is usually contained in the preamble to the final regulation (and its background material). However, if there is considerable controversy, significant unresolved issues or the need to substantively revise the original proposal, a reproposal is normally published and the process is repeated. These procedures are set forth in complete detail in the Federal Government Administrative Procedures Act.[17]

The federal review process is designed to ensure that all interested parties in a regulatory matter have an opportunity to receive notification through the Federal Register and respond. In many cases, the important responses are directed primarily towards the economic or other implications of the proposal. The response time of typically 30 to 90 days is often too short for developing consensus on resolution of technical issues, unless voluntary standards already exist in the area. Consequently, the technical content in Federal Standards may vary depending on the agency, the subject, and the availability (or utilization) of existing voluntary standards.

Cooperation between the federal regulatory agencies and the voluntary standards development groups is increasing. The ANSI planning panel report and the report of the planning division of the recent workshop on environmental sound, are demonstrable examples of this cooperation.[5,9] The content of these reports should lead to the development of voluntary standards which will have high utility in technical portions of future federal regulatory standards.

Criteria for Noise Control

Criteria for noise control have evolved over several decades. The quantities used for their expression have become both specialized and numerous. There has been considerable pressure to reduce the number of acoustic descriptors in use, so that noises from various sources and different effects on people could be compared on a common basis. The result of this concern has been the adoption of the "A" frequency weighting for a wide number of purposes.

Although this broad use of A-weighting is most useful for communication, it should be remembered that its use is a compromise, and that the design of noise control elements often requires more detail in terms of the frequency spectrum. Further-

TABLE 5
AREAS WITH VARIOUS DAY-NIGHT NOISE LEVELS TOGETHER WITH CUSTOMARY QUALITATIVE DESCRIPTION OF THE AREA[3]

Qualitative Description*	Typical Range L_{dn} in dB	Average L_{dn} in dB	Average Census Tract Population Density, Number of People per Square Mile
Quiet Suburban Residential	48-52	50	630
Normal Suburban Residential	53-57	55	2,000
Urban Residential	58-62	60	6,300
Noisy Urban Residential	63-67	65	20,000
Very Noisy Urban Residential	68-72	70	63,000

*Rural and undeveloped areas typically have L_{dn} levels in the range of 33-47 dB

more, the information provided by more sophisticated descriptors, such as Effective Perceived Noise Level (aircraft noise certification), Octave Band Level (Spectrum), Speech Interference Level, etc., should be utilized wherever appropriate for design tradeoffs, *even if* the applicable regulation is stated in A-weighted sound level.

Speech Interference. Speech communication is the activity most frequently interfered with by noise. For decades it has been of concern in developing reliable telephone and radio communication systems, and in the design of work spaces, buildings, transportation vehicles and auditoria. Because of faulty understanding, reduction in speech intelligibility may result in accidents, improper learning in the school, or considerable inefficiency and frustration in attempting to communicate face-to-face or over the telephone.

Outdoors, or in any space which has considerable acoustical absorption, the level of speech sounds decrease at 6 dB per doubling of distance from the talker. Therefore, in the presence of noise, the talker and listener generally move closer together and adjust their voice levels to obtain improved intelligibility. Some of the relationships between distance, noise and voice level, are shown in Table 3 for the marginal value of 95% sentence intelligibility.[27] The condition for *no interference* (100% intelligibility) occurs at levels that are 20 dB lower.

In an enclosed space, such as a room in a home or office, the variation of speech level with distance only occurs very close to the talker and becomes zero in the reverberant field, which often begins at distances as small as one metre.

The level of 45 dB, shown in the EPA levels document for no speech interference in the home, was derived for a distance of 1.1 metre to the reverberant field, normal voice, and 100% speech intelligibility (20 dB below the values in Table 3).[3]

The standard for rating speech interference in noise, ANSI S3.14-1977, defines the speech interference level that is recommended for design use, and two reports contain new data relevant to the use of equivalent sound level (L_{eq}) for speech intelligibility in a variety of actual environments.[28,29]

Risk of Hearing Loss. Congress enacted the Occupational Safety and Health Act of 1970 to ". . . assure so far as possible, every working man and woman in the nation safe and healthful working conditions and to preserve our human resources." Excessively noisy workplaces do not provide "safe and healthful working conditions," and decreases in the hearing acuity of workers due to prolonged exposure to noise do not "preserve our human resources." The Department of Labor—the agency responsible for implementing the Act of 1970—has the task of establishing regulations that will reduce excessive noise in workplaces "so far as possible."

The current OSHA regulations contain an A-weighted noise limit of 90 dB for eight hours of continuous sound. Higher noise levels are allowable for shorter durations in accordance with a tradeoff rule of a 5 dB increase per halving of time, while not exceeding 115 dB. It is OSHA policy to require engineering controls when feasible when the noise exceeds these limits. Only when engineering controls are not feasible, does OSHA accept administrative controls, or the use of employee hearing protective devices. The definition of "feasible" has been most often made on economic grounds by the courts on the basis of cost per worker protected.

In 1972 the National Institute for Occupational Safety and Health recommended an occupational exposure level of 85 dB for an eight hour day to:

> "be applicable to all newly designed installations six months after the effective date of the standard. However, the level of 85 dB is not applicable to established installations until such time as determined by the Secretary of Labor in consultation with the Secretary of Health, Education and Welfare. Such a provision was necessary because of the lack of sufficient available evidence upon which to determine a reasonable time period for the development of technologically feasible methods to meet the 85 dB(A) level."[4]

The Environmental Protection Agency concluded in its Levels Document that the "yearly average equivalent sound level requisite to protect public health and welfare with an adequate margin of safety is 75 dB for an eight hour day, with a 3 dB increase per halving of time tradeoff rule."[3] This choice was made to protect the most sensitive part of the population against incurring more than a 5 dB noise-induced permanent threshold shift at 4000 Hz—the frequency at

which the ear is most easily damaged by noise.

The difference of 10 dB, between the NIOSH recommendation of 85 dB and the EPA goal of 75 dB, is a direct outcome of the difference in congressional mandates between OSHA 1970 and NCA 1972.[1,13] The latter requires protection of "public health and welfare with an adequate margin of safety, without consideration of either technology or cost." The former requires "assurance of safe and healthful working conditions so far as is possible."

OSHA has been in the process of proposing a revision to its regulations for the past several years. In August 1981, OSHA amended its regulations to define a hearing conservation program, and to request more information from the public and interested parties on other aspects of its proposed amendments. The hearing conservation program is required for employees whose time weighted sound level exceeds 85 dB, 5 dB below the limit at which engineering controls are mandated. Further, sound levels between 79 and 85 dB are counted in the weighting, whereas no sound level below 90 dB is counted in computing the time weighted average for engineering controls. OSHA has announced its intention to review all aspects of its noise regulations and their related outstanding issues. It is hoped that this process will result in final promulgation of a consistent, cost effective and protective set of regulations.

Although the final regulation cannot be foreseen at this time, it is fairly clear from the available evidence that an eight hour equivalent level ($L_{eq}(8)$) of 85 dB is a rational goal for the future protection of workers, when feasible. Therefore, noise control engineers should consider the practicality of specifying new machinery, processes and construction such that an 85 dB goal could be attained without excessive cost in the future.

TABLE 6
COMPARISON OF A-WEIGHTED SOUND LEVEL LIMITS WITHIN LISTED SPACES IN dB RECOMMENDED BY VARIOUS SOURCES, TOGETHER WITH CURRENT SUGGESTIONS BY AUTHOR[3]

Space	Range of Average Values of Sound Level Min.	Max.	Grand Average Value of Sound Level	Current Suggestion For Interior Equivalent or Day/Night Sound Level*
Bedroom	25	40	35	L_{dn} 35-40
Livingroom	25	40	37	L_{dn} 40-45
Hotel	35	45	39	L_{dn} 35-45
Restaurant	45	55	52	$L_{eq}(1)$ 50-55
Private Office	35	50	41	$L_{eq}(1)$ 40-45
General Office	38	60	50	$L_{eq}(1)$ 45-55
Light Industry	50	60	53	$L_{eq}(8)$ 50-75
Heavy Industry	70	85	71	$L_{eq}(8)$ 65-85
Classroom	35	40	37	$L_{eq}(1)$ 45-50

*$L_{eq}(x)$ is the equivalent sound level (L_{eq}) for any period of x hours

Community Reaction to Noise. Noise is a leading cause of annoyance due to neighborhood conditions. In a 1973 national survey of housing conditions, street noise was cited by 34% of the 60,000 respondents as a "condition existing in this neighborhood," 60% of those reporting the condition felt that street noise was "disturbing, harmful, or dangerous," and 18% of those reporting the condition felt that "it is so objectionable" that they would "like to move."[30] In addition, 20% of the respondents reported airplane noise as an existing condition in their neighborhood, 34% of that number were disturbed by it, and 6% wished to move because of it.

In addition to street noise, other conditions found disturbing in decreasing order of importance were heavy traffic, crime, street lighting and repair, trash/junk, odors, airplane noise, abandoned structures and rundown housing, and commercial activity.

Extrapolating these survey results to the entire nation suggests that over 41 million Americans may find street noise disturbing and over 12 million would like to move because of street noise. Furthermore, over 14 million Americans may find aircraft noise disturbing, and 2.6 million would like to move away from it.

The levels of environmental noise which are expected to interfere with human activity depend upon the activity and its contextual frame of reference. The cumulative effect of activity interference by noise is often measured in terms of annoyance. Although other factors, such as attitude towards the noise source, may influence an individual's reaction to activity interferences, the percentage of people annoyed, or highly annoyed, in a given environmental situation provides a useful index of the severity of the situation. Additionally, annoyance may be a useful indicator of potential noise induced stresses, which are thought by some to contribute to stress-related diseases—including heart disease and ulcers.

There have been two basic approaches to developing criteria, or regulatory limits, for environmental noise. One approach is to determine the maximum levels which are compatible with various human activities (such as speech communication in the home), or considered to be the maximum levels consistent with protection of the hearing mechanism. The second approach is to assess the relative intrusive quality of noise. This approach has been used in relating community reaction to an intruding noise to the relative levels of the intruding and background noise, accounting for attitudinal and other factors.

In its levels Document, EPA utilized the first approach.[3] To describe environmental noise, EPA defined the day-night average sound level (L_{dn}) which represents the average noise level in a 24-hour day, with a penalty of 10 dB for noise which occurs during the nighttime hours of 10 p.m. to 7 a.m. For residential areas it identified an L_{dn} of 55 dB as the *"level. . . requisite to protect the public health and welfare with adequate margin of safety,"* the words in quotations representing its congressional mandate.[1] This level was derived by selecting 45 dB within a home as compatible with 100% speech intelligibility, adding 15 dB to account for the average noise reduction of a home with partially open windows, and subtracting 5 dB as a margin of safety to account for other effects. It should be noted that this identified level of 55 dB is not a regulation.

EPA, in its strategy document, first recommended immediate efforts to reduce noise exposure to an L_{dn} value of no more than 75 dB.[23] This value is essentially consistent with the level previously identified as maximum with respect to protection of hearing. Second, EPA recommended reduction of environmental noise levels to L_{dn} 65 or lower through vigorous regulatory and planning actions. Third, EPA recommended adoption of L_{dn} 55 as a goal to be considered "to the extent possible" in the planning of future programs.

An L_{dn} of 65 dB is the maximum level acceptable to HUD for residential housing sites without special approvals (Sec. 24 CFR part 51). HUD also considers that noise levels above an L_{dn} of 75 dB are unacceptable for residential use. Similarly, the FAA (14 CFR part 150) considers L_{dn} values of less than 65 dB to be normally compatible with all land uses, and values of more than 75 dB to be normally incompatible with residential land use, even with increased noise reduction. More detailed sets of recommendations are contained in both of these regulations and in ANSI Standard S3.23-1980, "Compatible Land Use With Respect to Noise."

Analysis of the community reaction to a variety of types of intruding sounds demonstrates that the degree of reaction varying between "none" and "vigorous" is a function primarily of the relative level with and without the intruding noise. Corrections for other factors, such as prior experience, attitude, and the character of the noise, can improve the accuracy of this relationship. The principal corrections utilized in an analysis of 55 cases was to add +5 dB to the level of the intruding noise if there was no prior experience with the noise, if it was of impulsive character, or if it contained prominent pure tones.[31] A negative correction of 5 dB was applied to the level of the intruding noise if the community had considerable prior exposure and a good relationship with the noise maker (see Ref. 30 for additional detail).

The results of the analysis are summarized in Table 4 in terms of relative levels, together with an example of the levels of intruding noise for a background L_{dn} of 60 dB. This example was chosen because a background L_{dn} of 60 dB is the level typically associated with normal residential urban noise. It is also within one dB of the estimated median L_{dn} for the United States urban population of 150 million people.[3] The example also gives the approximate value of the percent of people highly annoyed, estimated from relating the data in the synthesis of major social surveys to the community reaction data, assuming that the average background L_{dn} for this annoyance data was 60 dB.[32]

These results indicate that for the *average urban residential neighborhood* with some prior exposure to an intruding noise of nonspecial character no reaction is expected when the L_{dn} of the intruding noise is 55 dB or less. This is consistent with the selection of 55 dB as a long term goal for the average urban environment. The identification of an L_{dn} of 65 dB with widespread complaints for a similar situation is consistent with its selection as an upper bound of acceptability for single family residences, or, as the lower bound of impact sufficient for study in an airport environmental impact statement. Thus, applying the community reaction approach to developing criteria for community noise in an *average urban residential area* yields results that are similar to those developed by EPA based primarily on consideration of speech communication in the home.

For new residential projects, criteria should be based on the values of relative L_{dn} in Table 4 to be added to the background L_{dn}, together with an upper limit L_{dn} of 75 dB. To design for "no reaction" in all but the noisiest urban residential areas, this recommendation implies that the maximum L_{dn} of the intruding noise should be 65 dB or less in all urban areas, and 50 dB or less in normal and quiet suburban areas. (See Table 5 for relationship between qualitative description of neighborhood and noise level.)

Criteria for Noise in Specific Spaces. In addition to the general criteria for community noise control, there have been many recommendations of criteria for specific types of spaces in buildings. Many of these individual recommendations were reproduced in the EPA Levels Document.[3] They were intended primarily for application to steady sounds. The range of the averages and the grand average of these values are summarized in Table 6 for a variety of spaces. Also given are current suggestions stated in equivalent levels, or day/night average levels, and intended for application to both steady and fluctuating sounds.

Summary

The information presented in this article is but a brief overview of standards and criteria for noise control. Additional information may be obtained from voluntary standards, federal regulations, documents highlighted under Federal Information, and cited references.

For the past decade the effort to develop standards and criteria has been at its highest level in our history. The results were expected to provide a

significant improvement in both the regulatory and engineering frameworks for noise control and ultimately in the noise environment. Unfortunately, the research efforts on the federal level are now being significantly curtailed, which presages a reduction in the flow of information on all aspects of noise control. Further, the efforts at the EPA are scheduled to be terminated in October 1982, thus eliminating any potential role it might have played in formulating national goals for environmental noise reduction. Thus, it may be anticipated that an increased share of the responsibilities for the planning and development of standards and criteria for noise control in the 1980's will rest on the professional societies in their voluntary standards development activities, and in their efforts to encourage the development and publication of new and useful information on noise and its control.

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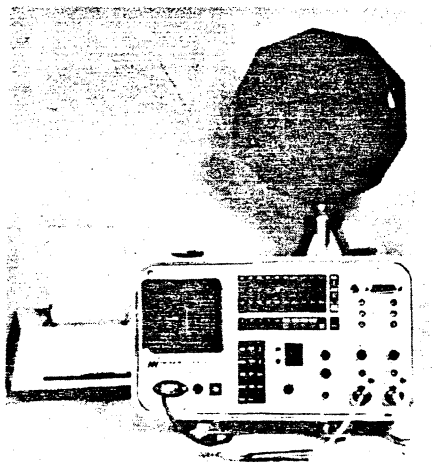

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About the Authors

Kenneth McK. Eldred worked at Bolt Beranek and Newman for eight years as Vice President and Director of the Architectural Technology and Noise Control Division before establishing his own consulting firm, Ken Eldred Engineering. His prior experience includes vibro-acoustic research and consulting for the space program at Wyle Laboratories; general consulting in architectural, environmental and aerospace acoustics at the Western Electro Acoustics Laboratory; research in airport, aircraft, and rocket noise and human response at the USAF Aeromedical Laboratory; and the diagnosis and solution of shipboard and submarine sound and vibration problems at the Boston Naval Shipyard. Mr. Eldred is a member of the National Academy of Engineering, serves on the American National Standards Institute Executive Standards Council and on many other standards committees. He is active in many professional societies including the Acoustical Society of America, Institute of Noise Control Engineering (Past President 1976), Institute of Environmental Science, Society of Automotive Engineers, the Society of Naval Architects and Marine Engineers, and the Operations Research Society of America. Mr. Eldred is a graduate of the Massachusetts Institute of Technology.

T.F.W. Embleton has worked at the National Research Council, Ottawa, Ontario, Canada since November of 1952. Currently Principal Research Officer in the Acoustics Section, Division of Physics, his fields of interest are: noise of machinery and methods of control, sound propagation outdoors, and acoustical standards. His many offices held and awards received include President of the Acoustical Society of America 1980-81; Vice President of ASA 1977-78; ASA Associate Editor for Noise 1970-74; Chairman ASA Technical Committee on Noise 1964-67; ASA Biennial Award 1964; Founding Secretary, Canadian Acoustical Association 1961-64; Founding Editor-in-Chief, Acoustics and Noise Control in Canada 1973-75; Society of Automotive Engineers, Arch T. Coldwell Award 1974; Rochester Institute of Technology, John Wiley Award 1976; fellow, Royal Society of Canada. Dr. Embleton's society memberships and degrees include DSc, University of London 1964; fellow ASA; member of the Canadian Association of Physicists; charter member, Canadian Acoustical Association; and, associate of INCE.

Adam Lipowczan was born in 1937, and is a postgraduate of the Technical University of Wroclaw, Poland, where he received the diploma of electronics in 1961. He obtained his PhD and Associate Professor degrees from the Technical University, Wroclaw and the Central Mining Institute, Katowice, in 1968 and 1979 respectively. Throughout 1962-1969 Dr. Lipowczan worked in the Physics Department, at the Institute of Occupational Medicine in Zabrze. Since 1969 he has been head of the Technical Acoustics Group in the Central Mining Institute in Katowice. Dr. Lipowczan's work has been concerned with the whole field of technical acoustics; the major portion of this activity has been focused on the design problems of audiometry and methods for the measurement of acoustical signals.