TRANSPORTATION NOISE BIBLIOGRAPHY

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16. Abstract

A basic bibliography on transportation noise that introduces the non-professional to the variety of information available in the field. The selections are intended to give the reader only an indication of the wide range of coverage of such topics as noise control and abatement; effects of noise on man; noise sources including aircraft, surface transportation and marine transportation; economic aspects of noise control; methods of implementing noise control; and noise control and land use.

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INTRODUCTION

This bibliography is intended for the use of the individual who is aware of the impact of transportation noise but has a minimum of technical knowledge of the subject. Items that have been included are those that disseminate basic information with a minimum amount of technical terminology. The formats of the selections range from short journal articles to longer research reports along with papers from conference proceedings. The main criteria for inclusion are topical interest to the non-specialist, intensive coverage of a subject, and readability. The field of transportation noise is widely researched and this bibliography attempts to give an overview of the scope of current activity. The individual abstracts have been derived from the original texts and are focused on the specific core of the author's work rather than giving a complete summary. In several instances, a short conference paper is selected because it gives a practical introduction to an author's research in a concentrated, non-technical format. These conference papers along with the journal articles and research reports usually include short bibliographies which will lead the reader to additional sources.

Chronologically, the bibliography gives preference to 1972-1974 literature. Earlier material is easily accessible through the excellent, though defunct Transportation Noise Bulletin, which provided an all-inclusive survey of the field. However, some selected older items are included because their contents have not been superseded by more recent research.

The items selected are those that might be obtained in technical libraries. These include the articles in the basic journals involved with noise studies and the well-known government reports. The technical reports for which a PB or an AD number is indicated, can be ordered from National Technical Information Service, Springfield, VA.

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AN OVERVIEW OF SOUND AND THE ELEMENTS OF NOISE CONTROL AND ABATEMENT 1020-1120

I An Overview of Sound and the Elements of Noise Control and Abatement 1020-1120

Part I includes general journal articles and books which give an overview of sound and noise. The problems of noise control and abatement are discussed from different perspectives, including that of the non-professional who sees noise as the most insidious and potentially damaging aspect of our current national pollution problem. Another point of view is given by the noise control specialist who attempts to introduce the non-specialist to the wide range of problems to be solved. Social implications of noise in our culture are discussed along with the aspects of modern technology which many believe to be the cause of the current noise situation. Current governmental involvement in transportation noise research is also represented by general articles.

1020 **IN QUEST OF QUIET.**
Still, Henry.
Stackpole Books, Harrisburg, PA. 1970 221p. refs.

An overview of the noise problem with "a call to citizen action." Technical and scientific data are reviewed in order to identify the main causes of the rising noise levels and to determine ways to alleviate the problem from the private citizen's point of view. Transportation noise is surveyed from the actual environmental and social cost of high speed travel. Continuing jet and airport noise is seen to be the result of ineffectuality on the part of government agencies. The jumbo jets are considered to be potentially helpful in reducing the number of individual aircraft that cause noise. The SST problem is also considered from the economic point of view and found to be not feasible when balanced against damage claims and those effects not easily calculated in dollars. Long term planning for urban noise includes depression of traffic underground as an ultimate solution to an inevitable problem. The nature of sound is examined, and the various ways of measurement ranging from the purely psychological to the purely physical are surveyed. Studies which deal with noise-induced physical harm are also extensively reviewed.

1030 **NOISE.**
Taylor, Rupert.
Penquin Books, Inc. Baltimore, MD. 1970 268p. refs.

An introduction to noise and noise control for the non-professional. An explanation is given of the contributions of acoustics, economics, law, mathematics, physics and physiology to the field of noise control. Among the topics covered are the psychological and physiological effects of noise and the processes of hearing and deafening. The philosophy expounded is that there are very few noise problems that are unsolvable if there is enough money to pay for the solution. The noise problem is seen to have grown to its present immense proportions in a very short time. Basic noise conditions are outlined, and economical and practical solutions are indicated. Good and bad examples of planning for noise are discussed, along with the basics of silencing and sound-proofing materials. Future improvements in technology should include a reversion to some 19th century ideas which would promise a substantial reduction in noise, as the steam engine and the Stirling engine.

1040 **NOISE – A SYNDROME OF MODERN SOCIETY.**
Bragdon, Clifford R.
Scientist and Citizen V.10 N.2 March, 1968 pp.29-37.

An analysis of the social implications of noise in our current culture. A basic overview of the effects on health is given, including speculation on the fact that defects in hearing may be the most common significant disability in the United States with noise the probable primary cause. A discussion of research which attempts to define hearing loss in old age suggests that it might be due in part to the cumulative effects of noise over a long period of time. The physiological effects of noise are discussed, including specifically its effects on sleep and interference with communications. Property damage and the economic implications of noise effects are considered. The current advanced position of technology is seen to require less keenness of ear in man. Previously, without artificial light, man necessarily depended more extensively on observation by ear. Today's emphasis on visual perception has tended to diminish awareness of the auditory character of the environment and the auditory sense has tended to atrophy.

1050 **NOISE AND MAN.**

Burns, William.

Lippincott, Philadelphia, PA. 1973 459p. refs.

An extensive physiological survey of the topic, dealing with the physical properties of sound and its measurement as well as the mechanisms of hearing. The problems of disturbance are discussed with the temporary and permanent effects of noise on hearing being emphasized. The particular types of aircraft noise are analyzed including impulse noise, intense noise, ultrasound, infrasound, sonic boom, and vibration. The present situation in industrial noise, local and general noise disturbance and new or changing patterns of noise is investigated. Rapidly expanding technologies create new noise sources such as hovercraft, air cushion vehicles, helicopters, STOL and VTOL aircraft, gas turbine road vehicles. Thus, noise is characterized as another by-product of technical advance which has not been adequately controlled, and efforts toward its restriction are suggested to be an intrinsic part of preventive and industrial medicine and environmental preservation.

1060 **NOISE AND SOCIETY.**

Richards, E.J.

Loughborough University of Technology, England. in *Purdue Noise Control Conference 1971, Proceedings* pp.1-18.

A discussion of the need for realistic control over the acoustical environment. It can be achieved by introducing over a period of time, a system of accountancy and control of noise in the area of occupational deafness, traffic location and airport design. Noise disbenefit-benefit studies at Heathrow Airport in Britain are considered. A philosophy is evolved that a right balance must be struck between the economic gain a nation derives from the existence of an airport, and the burden of amenity and property loss suffered by local people in the region of the airport. An index of disbenefit-benefit ratio is created, involving 1) the number of persons disturbed by noise in airport environs; 2) aircraft movements per year; and 3) average number of passengers. This allows an evaluation of the worth of an airport as it grows, and forms a basis for expansion planning. The impact of traffic noise on environmental planning is discussed. A loss of amenity is estimated according to a ratio based on the decrease in property values. Depreciation is calculated on the basis of the initial property value and relative proximity to intense traffic noise. Attempts to accurately estimate occupational deafness are surveyed. International legal control is seen to be the best hope for hearing conservation policies in all sections of industry.

1070 **NOISE CONTROL IN THE USA, THE PRESENT STATE OF AFFAIRS.**

Crocker, Malcolm J.

Purdue University, Ray W. Herrick Labs. in *Purdue Noise Control Conference 1971, Proceedings* pp.XV-XXV. 25 refs.

An overview covering the entire noise problem in perspective. The most important sources of noise include industrial noise, vehicle noise, aircraft noise, and noise in the home and during leisure time. The effects of noise on people are outlined, especially hearing loss. The whole theory of natural hearing loss due to age, presbycusis, has recently been questioned due to studies done in primitive societies. The ambient noise in some primitive societies is very low and practically no hearing loss due to age exists. In modern cultures men suffer more hearing loss than women, and since people living in rural areas suffer less than those in urban areas, it seems presbycusis may be partially caused by occupational noise. Studies have shown that there is an increase in the morbidity rate near airports and also an increase in miscarriages. Further studies have an increase in the incidence of heart attacks in intense noise environments. Recommended noise criteria are given for various noise situations, in view of the physiological effects on man. The current situation in legislation is surveyed, along with noise control approaches for the future. It is estimated that much noise control information currently exists, and needs only to be implemented by a more strongly motivated public concern. More acoustics personnel are being trained academically, but many more are needed in the noise control area.

1080 **FUNDAMENTALS OF NOISE: MEASUREMENT, RATING SCHEMES AND STANDARDS.**

National Bureau of Standards.

U.S. Environmental Protection Agency Dec. 1971. 161p. NTID300.15. PB206727.

An introduction to noise, including the interrelationship between physical measures and psychological responses. The basic principles of sound

generation and propagation are discussed as well as the measurements of both the physical attributes of noise and the effects of noise on people. The suitability and effectiveness of various noise exposure rating schemes, used to estimate or predict the effects of noise on man, are discussed and critiqued. Included are sample calculations of sound level, loudness level, and perceived noise level for five selected spectra. The need is stressed for inclusion of well defined procedures for those devices where the noise produced is dependent on the surrounding and the operation of the device. Also presented are a glossary of pertinent acoustic terminology and a compilation of existing standards related to noise, including a brief description of the intent and scope of each.

1090 **INTERNOISE 72 TUTORIAL PAPERS ON NOISE CONTROL.**

Crocker, Malcolm J. (ed.)

International Conference on Noise Control Engineering 1972, Washington 1972 134p.

A compendium of tutorial lectures presented at Internoise 72 intended for people just entering the noise control field. The basics of noise and vibration control engineering are covered. Topics include sound propagation, the effects of noise on man, and noise legislation. The basic techniques of noise reduction are enclosure, absorption and vibration isolation, all of which are discussed. Major noise sources are covered including industrial noise and noise in buildings, along with instrumentation and identification of noise. The appendices contain an overview of the physiology of the ear and noise impact and a selected bibliography on noise control. A list of useful standards connected with noise is also included.

1100 **LECTURES ON TRANSPORTATION NOISE.**

Lyon, Richard H.

Grozier Publishing Co. New York 1973 259p.

A textbook which comprehensively reviews the theory and practice in assessment of transportation noise problems. The sources, paths, and receivers of noise are discussed after consideration of basic acoustic theory, descriptions of sound fields, sound sources, sound propagation, and engineering formulas. The generation, propagation and effects of aircraft noise, automobile noise, motorcycle noise, truck noise and rail vehicle noise are examined. Also investigated are the noise sources of V-STOL aircraft, absorption, refraction and focusing of sound waves, annoyance, speech interference, psycho-acoustic criteria, noise impact, the propagation of automotive noise as affected by topography, and ground vibration. The format is designed to be a self-study introduction to the field, or a source book of data and engineering formulae for the practicing professional.

1110 **NOISE PROGRAMS OF PROFESSIONAL/ INDUSTRIAL ORGANIZATIONS, UNIVERSITIES, AND COLLEGES.**

Environmental Protection Agency, Office of Noise Abatement and Control. Dec. 1971 14p. NTID300.9. PB207125.

An overview of noise programs being sponsored or carried out, either directly or indirectly by professional, industrial and voluntary associations. Research by private industry is examined, along with educational programs including training and research in noise abatement. A bibliography of pertinent books and periodicals on noise and related problems is compiled, along with a list of current American National Standards Institute (ANSI) standards in acoustic vibration, mechanical shock and sound recording. Professional and industrial associations are seen to have contributed significantly to proposed testing procedures and the development of criteria and standards for noise control. Universities and colleges are increasing their training emphasis in noise-oriented programs and contribute significantly with basic and applied research programs in several areas of noise and acoustics.

1120 **SUMMARY, CONCLUSIONS AND RECOMMENDATIONS FROM REPORT TO THE PRESIDENT AND CONGRESS ON NOISE.**

U.S. Environmental Protection Agency Dec. 1971 13p. NRC.500.1

A condensation of the detailed material of the EPA Technical Information Documents and the transcripts of the Public Hearings held by the

Agency. The character of noise as an environmental problem is considered as well as the extent of the impact of noise in the U.S. Noise control technology and possible changes in the noise problem to the year 2000 are reviewed. Application of available technology is lagging because of inadequate social, economic, or governmental pressures for noise abatement. There is a need for balance between application of technology to noise sources and the other measures required in controlling the total noise environment, such as land use planning and regulation of source use. Projections of noise impact clearly indicate the need for aggressive efforts at all levels of government. Without such efforts, residual noise levels in typical urban communities can be expected to rise from the 1970 level of slightly over 46 dBA to just under 50 dBA by the year 2000 (the residual level is the lower noise level boundary that is exceeded approximately 90 percent of the time). Specifics of a program for the future include Federal leadership in noise abatement and control, new standards and regulation, new research and additional efforts toward education and public awareness of noise.

II The Effects of Noise on Man 2010-2130

Part II includes the psychological and physiological effects of noise on humans. Among the selections are reports of in-depth research by sleep psychologists on the effects of noise on human subjects, and the results of observations of wild and domesticated animals subjected to noise. Criteria documents from governmental agencies involved in noise are also included, along with public hearings containing the statements of citizens who are exposed to excessive noise. The cumulative effects of aircraft noise, especially sonic booms, are also discussed.

2010 **EFFECTS OF NOISE ON PEOPLE.**
Central Institute for the Deaf.
U.S. Environmental Protection Agency, Office of Noise Abatement and Control. Dec. 1971 153p. refs. NTID300.7 ,PB206723.

A review of well-documented effects of noise on health. Noise-induced hearing loss is examined in detail. Noise is seen to permanently damage the inner ear with resulting permanent hearing losses that can range from slight impairment to nearly total deafness. Temporary hearing loss or chronic hearing loss can result from repeated exposures to noise. Noise is seen to interfere with speech communication and the perception of other auditory signals. The disturbance of sleep, the annoyance factor, and the interference with the performance of complicated tasks are all important results of noise exposure. Noise and other acoustical considerations can reduce the opportunity for privacy, and adversely influence mood and disturb relaxation.

2020 **EFFECTS OF NOISE ON WILDLIFE AND OTHER ANIMALS.**
Memphis State University.
U.S. Environment Protection Agency, Office of Noise Abatement and Control. Dec. 1971 74p. 103 refs. NTID300.5 PB206720.

An overview of the possible effects of noise on wildlife undertaken to augment research on the potential non-auditory effects of noise on man. The suspected effects of noise on wildlife can be inferred from information dealing with 1) signal production and communication; 2) auditory ranges for different species; 3) direct effects of noise that have been demonstrated in laboratory or domestic animals; and 4) incidental observations of response to noise in wild animals. The suspected effects can be categorized as either interference with signals or direct effects on the animal. Noise can interfere with signals conveying distress, danger, warnings about territorial boundaries, recognition of young and presence of food. Acoustic jamming has been seen to be successful in controlling unwanted species such as blackbirds. The direct effects of noise on laboratory animals include specific physiological and behavioral changes that could occur in wildlife if its exposure is constant enough, which is unlikely. However, chronic exposure to moderate noise levels could produce some hearing loss or influence processes that are hormonally regulated due to noise-induced stress responses. Animals that rely on auditory signals to find mates, stake out territories, recognize young, locate prey and evade predators, could be critically affected even if the animals appear to be completely adapted to the noise. The non-auditory effects might include significant changes in reproductive organs and sexual function which affect reproductive capacity. Audiogenic seizures have been induced following noise exposure. Physiological changes have been recorded that effect animals' abilities to withstand additional stress, after noise exposure. Instances of panic or avoidance behavior could adversely effect an animal's survival. In general, none of the reported or suggested effects aid in an animal's survival, but do decrease his chances.

2030 **ENVIRONMENTAL NOISE, HEARING ACUITY AND ACCEPTANCE CRITERIA.**
Hermann, Edward R.
Archives of Environmental Health V.18 May 1969 pp.784-791.

Two grading techniques for the determination of hearing loss in the speech important frequencies are described. The Speech Average Loss (SAL) method uses puretone audiometric responses at 500, 1000, and 2000 hertz. The mean value of each ear is obtained, after which the hearing in both ears of an individual is compared with the limits set forth in a scale which is used to obtain a letter grade and an estimation of the individual's hearing ability. In addition to the use of SAL gradings, an Early Loss Index (ELI) may be employed which is

both diagnostic and prognostic for noise-induced hearing loss. The technique is based upon statistical analysis and quantification of hearing thresholds at 4000 hertz after correction for age and sex-specific presbycusis (hearing loss). The author applies SAL and ELI to an occupational group exposed to a noisy working environment and compares the prevalence and severity of hearing loss in the speech important frequencies with that of a control group composed of individuals engaged in quiet occupations. Indications of noise-induced hearing loss are apparent among those in the noisy occupations. As hearing loss progresses the rate of loss decreases in proportion to the amount of hearing acuity which remains.

2040 **HUMAN RESPONSE TO SONIC BOOM IN THE LABORATORY AND THE COMMUNITY.**

Von Gierke, H.E. and C.W. Nixon.

Journal of the Acoustical Society of America V.51 N.2 Pt.3, 1972 pp.766-782 30 refs.

Current estimate regarding the acceptability of sonic booms by man are derived from various observation, overflight programs and experimental field and laboratory studies. The loudness and annoyance of individual booms and their dependence on the boom overpressure and pressure time function as well as the complex reactions of individuals, groups, and communities exposed to sonic booms are discussed. A description is given of available experiments proving that even sonic booms of the maximum intensity presently feasible do not produce direct medical injury. Based on the integrated body of results of recent physiological, psychoacoustic, behavioral and sociological studies in various countries, estimates of the effects and acceptability of regular, supersonic commercial overland flights are discussed in terms of aircraft noise pollution in general. Potential certification of aircraft with respect to noise and sonic boom is also analyzed. Findings support the current policy that commercial supersonic transport aircraft will not be permitted in the U.S. until the noise factors are brought within acceptable limits.

2050 **NOISE DISTURBANCE AND SLEEP; THE RELATIONSHIP OF NOISE-DISTURBED SLEEP TO POST-SLEEP BEHAVIOR: AN EXPLORATORY STUDY.**

Kramer, M., T. Roth, J. Trinder, and A. Cohen.

U.S. Federal Aviation Administration Jan. 1971 157p. FAA NO. 70-16. AD729431.

A study of the effects of noise on sleep and post sleep behavior in a range of subjects. The tests were run for 15 consecutive nights. After each night's sleep, subjects completed a series of performance and psychological tests. Threshold sound levels for sleep were obtained for an impulse test and a continuous noise test and discussed in terms of type of sleep disturbance stage of sleep, time of night, adaptation, and age of subjects. The sleep profile results indicated that the pattern of noise-induced sleep disruption was related to age. The 25 year-olds showed an increase in the first stage of sleep and movement. The 70 year-olds showed an increase in the time awake and a decrease in time spent in the third and fourth stages of sleep (which are the deepest). The 50 year-old subjects were intermediate with respect to each measure. The daytime performance data revealed no effects of noise-induced sleep disruption in pursuit motor and reaction time tasks but some loss of efficiency were found in estimation, arithmetic and memory task measures. In addition, verbal sample scores demonstrated an increase in cognitive impairment and a decrease in human relations.

2060 **PSYCHO-ACOUSTIC RESULTS OF AN INTERDISCIPLINARY STUDY ON EFFECTS OF AIRCRAFT NOISE ON MAN.**

Martin, R., B. Rohrmann and H.O. Finke, Mannheim University.

in *International Conference on Noise Control Engineering, 1973, Inter-Con 73* pp.289-297.

A Western Germany interdisciplinary study referring to the acoustical and social-scientific aspects of the problem. The questions to be clarified are: which sociological, psychological and physiological effects of aircraft noise can be ascertained, how are reactions to aircraft noise co-determined by influences of the social environment or by psychic and somatic attributes of the individual; and to what extent do the acoustical characterizations of noise exposure vary with the ascertained noise effects on man. Basic conclusions reached from the study included: exposure to aircraft noise is a serious impairment to health, as defined by the World Health Organization 'as a state of an

optimal physical, psychological and social well-being'; and that reduction of aircraft noise is a problem for those producing the noise such as airlines and the aircraft industry and also for those distributing the noise such as city planners.

2070 **PSYCHOLOGICAL REACTIONS TO AIRCRAFT NOISE.**

Kryter, Karl D.

Stanford Research Institute

Science V.51 N.18 March, 1966 pp.1346-55.

A discussion of the attributes of sound, physiological and psychological reactions to noise, and community reaction to jet aircraft noise. It is noted that "noisiness" is more important than "loudness" in estimating reaction to sound. Loudness established by physical measurement does not usually correspond with loudness and noisiness as judged subjectively. The noisiness of sound increases when 1) the pitch is raised; 2) the complexity is increased; 3) the duration is increased beyond 200 milliseconds. People are distinctly annoyed by noise because of 1) concern about damage to their hearing; 2) masking of speech or other desired auditory signals; and 3) interference with sleep. Community reactions to aircraft noise are measured statistically. The most comprehensive such study was a 1961 survey of people living near London's Heathrow Airport, from which the British Noise and Number Index (NNI) was derived. Although the effects of aircraft noise on humans have been fairly well documented, it is more difficult to set criteria that specify what noise level should be considered unacceptable. An attempt to suggest criteria in different measures is made. It is noted that sonic booms from supersonic transport would expose millions of people to a noise as annoying as the sound of a jet 1½ miles from an airport after takeoff.

2075 **PUBLIC HEALTH AND WELFARE CRITERIA FOR NOISE, JULY 27, 1973.**

U.S. Environmental Protection Agency, Office of Noise Abatement and Control July, 1973

550/9-73-002

A criteria document prepared under the provisions of the Noise Control Act of 1972. It is a scientific overview of the cause and effect relationships associated with response to noise on the part of humans and animals. Possible hearing damage from environmental noise is discussed and it is noted that permanent hearing damage has been noted at noise levels as low as 75 dBA after 10 years (70 dB is accepted as the power level in normal voice conversation.) Noise can interfere with sleep but relating noise exposure to quality of sleep is difficult. The sound of rock and roll bands is exceeded in hearing hazard only by motorcycle and drag racing and intensive sport shooting with inadequate ear protection. Levels of annoyance caused by noise in a community are determined by factors which include 1) the fear associated with activities of noise sources such as fear of crashes in the case of aircraft noise; 2) socio-economic status and educational level; 3) the extent to which community residents believe they are being treated fairly and that the noise source could be controlled. The noise effects on animals seem to be mostly behavioral. Noise of high enough intensity can disturb or disrupt normal behavioral patterns, which can inhibit an animal's ability to survive. The physiological responses caused by noise are many, but no clear evidence exist to show that these responses lead to permanent health effects. Noise exposure can result in general stress but the relationship between level and duration of noise and stress is unclear.

2080 **PUBLIC HEARINGS ON NOISE ABATEMENT AND CONTROL, VOL. 7, PHYSIOLOGICAL AND PSYCHOLOGICAL EFFECTS.**

U.S. Environmental Protection Agency Oct. 1971

351p. EPI.2:N69/3/V.7

The text of the statements made in Boston EPA Hearings ranges from physiological experiments on laboratory animals to the political activities of Boston area citizen groups against noise. Among the testimonies are observations on the effects of noise including 1) ear damage and hearing loss; 2) annoyance; 3) disruption of work performance, rest and sleep; 4) possible effects on individuals with emotional distrubances and tension-caused conditions. Neurological effects of environmental noise upon the whole auditory system are considered. The problem of jet over-flights in Boston is seen to be the most serious. The activities of the Logan Airport Noise Abatement Committee are discussed in regard to alleviation of noise by monitoring efforts and a noise abatement program.

2090 **"SOCIOCUSIS" – HEARING LOSS FROM NON-OCCUPATIONAL NOISE EXPOSURE.**
Cohen, Alexander, Joseph Anticaglia, and Herbert H. Jones.
Sound and Vibration V.4 N.11 Nov. 1970 pp. 12-20 40 refs.

An analysis of "sociocusis," which is hearing loss from the everyday noises of modern living aside from loss due to occupation or the physiologic processes of aging. Exposures to noise conditions as encountered in recreation, in using home power equipment and from public services in urban and community areas are seen to be increasing in level and duration. An attempt is made to contrast the levels and durations of typical off-job noise exposures with those found in the work environment and believed hazardous to hearing. The potential for hearing changes caused by non-occupational noise sources is rated against noise limits designed to offer more complete ear protection than that provided by hearing conservation criteria used in industry. Data depicting both temporary and permanent hearing changes caused by off-job noise exposures are compared. It is concluded that there is some risk of hearing loss in those segment of the population receiving frequent and protracted exposures. While daily exposures to a single source of non-occupational noise may be no distinct hazard to hearing, the combined exposures from many different sources each day may have a cumulative effect. Hearing loss problems resulting from industrial noise may be aggravated by the inability of the worker to find an off-job environment quiet enough to allow his ears to recover from the occupational noise. Evidence for permanent losses are indicated to be at the higher frequencies and not in the range of speech frequencies.

2100 **SOME EFFECTS OF NOISE ON MAN.**
Nixon, Charles W.
Aerospace Medical Research Lab., Wright Patterson Air Force Base
in *Intersociety Energy Conversion Engineering Conference, 1971* pp.1024-1033 22refs.

An overview of the many types of acoustic exposure which affect the physiological and psychological functions of man. Specific responses to various types of noise exposure are described including auditory effects and non-auditory effects. In general, effects of noise exposure on the ear are predictable with very good accuracy within the variations of individual susceptibility. Extra-auditory effects, effects which effect systems other than the ear, are for the most part also mediated through the auditory system. General physiological effects include vestibular effects, sleep effects, startle effects, and performance effects. Specific exposures to infrasound and ultrasound are evaluated along with impulsive sounds and rock music. Changes in the auditory system, in voice communication and in interference with routine living have been measured and determined to be harmful under excessive exposure conditions. Some immediate effects on body functions include pupillary dilation, peripheral circulation and respiratory changes but the practical implications for the general health of the individual have not been determined. Long term exposure to noise has not been investigated thoroughly except in regard to actual hearing loss, but it is reasonable to assume that it is harmful to the general well-being of the individual.

2110 **A STUDY OF SENSITIVITY TO NOISE.**
Becker, R.W., F. Poza and Karl D. Kryter.
Stanford Research Center.
U.S. Federal Aviation Administration, Office of Environmental Quality

A study dealing with the exposure of 140 subjects to simulated sonic booms and recorded residential noises. The purpose of this research was to 1) determine whether there are different degrees of psychological and physiological sensitivity to noise in a large group of people; 2) to determine whether and how sensitivity varied in time, and 3) to relate such sensitivity to other psychological sensitivity to noise were found in the subject population. These differences remained stable and were also found to be related to the attitudinal and belief structures of the individuals. Average rating of a variety of noises provided a stable index of psychological sensitivity to noise. The subject population evolved into a most sensitive third, a middle group, and the least sensitive third. The noise-sensitive individual rated all kinds of noises as being more intrusive in their daily activities than the noise insensitive individuals. They were also more likely to perceive themselves as being more sensitive to noise than the average person, and

they were more likely to believe that noise was affecting their personal health. The noise sensitive individuals were also more negative in their ratings of non-noise factors in their environment and were more likely to have high anxiety scores than were the noise-insensitive individuals. Definite physiological responses to sonic booms were observed, however, the physiological indices used in this research did not show individual differences in physiological sensitivity to noise. These results do not preclude the possibility that more elaborate and extensive psycho-physiological measurement might demonstrate physiological sensitivity to noise.

2120 **URBAN STRESS: EXPERIMENTS ON NOISE AND SOCIAL STRESSORS.**

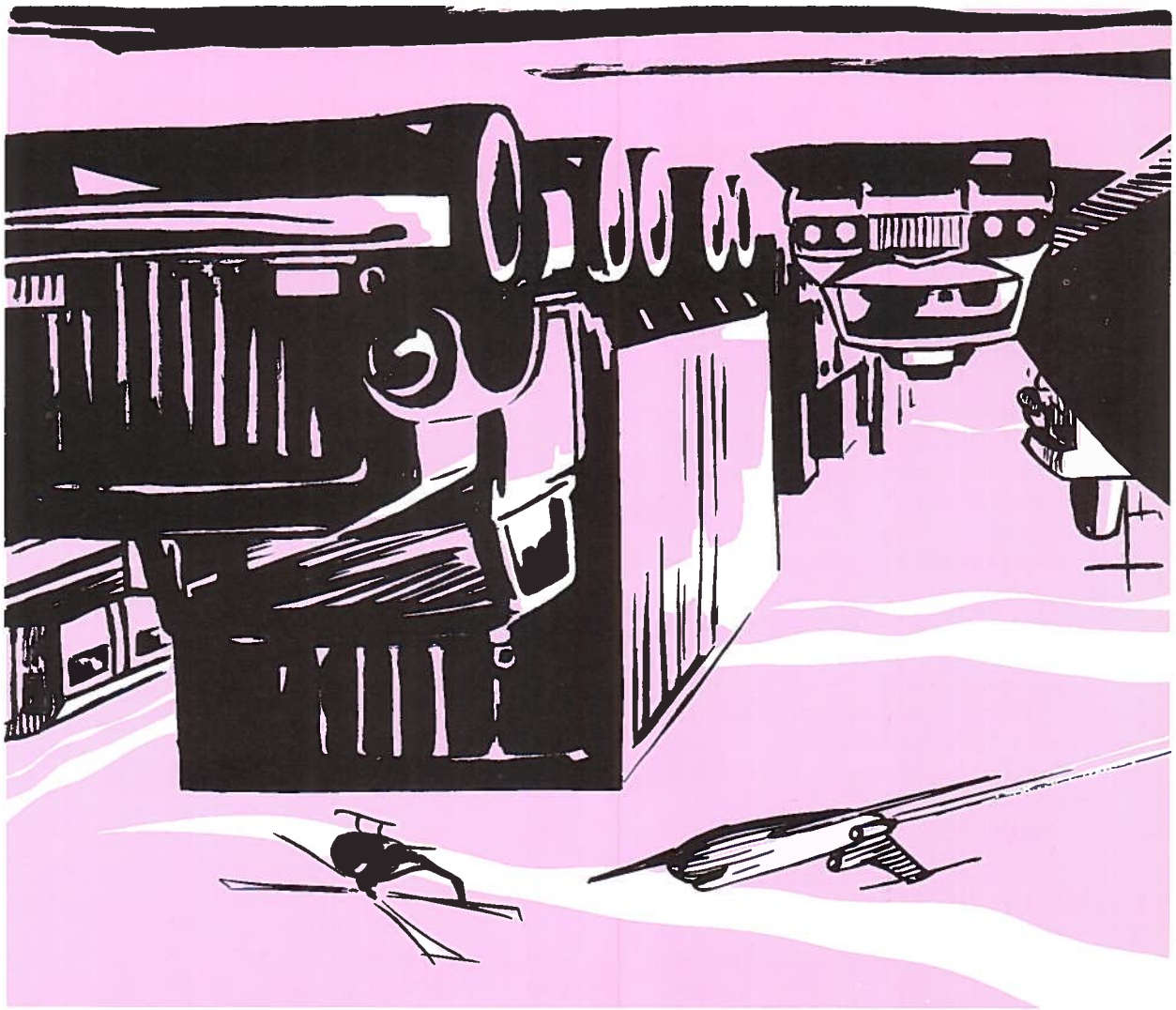
Glass, David C. and Jerome E. Singer.
Academic Press, New York. 1972 180p.

A discussion of several laboratory experiments on the psychological consequences of exposure to noise. Previous studies of noise as a stressor are reviewed, and it is concluded that noise *per se* does not impair task performance except when 1) long term vigilance is entailed; 2) the task is complex; 3) the noise is intermittant; or 4) the noise occurs in a context with unpleasant connotations for the individual. A series of experiments is described in which subjects were exposed to "Loud Unpredictable" (a 23 min. tape of 108 dBA noise occurring at random intervals), "Soft (56 dBA) Unpredictable", "Loud Predictable" (noise bursts occurring at fixed intermittant intervals) or "Soft Predictable" noise. None of the subjects had difficulty performing simple tasks during the experiments, but those exposed to unpredictable noise had difficulty performing complex tasks. Subjects were given additional tasks after the experiment. Those who had been exposed to loud or soft unpredictable noise showed substantial impairment in task performance and toleration of frustration. It was also found that problem solving ability declines when the subject feels helpless to control the noise, and when the subject feels "deprived" in relation to other subjects. However, expectation of intensity and feelings that the noise was necessary had no measureable effect on post-experimental performance. There is no experimental evidence that adaptation (decreased responsiveness to a stressful stimulus) is a cause of impaired task performance. It is hypothesized that this is due to "cognitive overload" – the subject must commit all his resources to coping with stress, and has none left for problem solving. This theory needs further testing. More research on the long term effects is also needed.

2130 **THE UNBEARABLE MENACE—AIRPORT NOISE.**

Journal of Environmental Health V.35 N.6 May-June 1973 pp.578-583 Reprinted from University of Washington *Environmental Health and Safety News.*

A discussion of the effects of aircraft noise on humans, with particular reference to sleep disturbance and interference with speech in schools. The most annoying characteristics of sound are defined as loudness, (high) frequency, intermittency and irregularity and (changing) localization. Aircraft noise possesses all of these characteristics. Studies indicate that noise interferes with sleep patterns by causing subjects to awaken or to shift from deeper to shallower stages of sleep or by interrupting dream sequences. Disturbance of sleep by noise leads to fatigue and a reduced sense of well-being; on a prolonged and regular basis it can cause more serious mental and physical disorders. Noise levels in schools near airports or freeways are high enough to cause psychological disorders, and to interfere with studying and speech communication. A survey of 12 schools near the Seattle-Tacoma airport revealed that all experienced unacceptable (above 60 dBA) noise levels. It is recommended that the noisiest schools, where the cost of sound attenuation is prohibitive, be relocated, and that all schools in noisy areas be air-conditioned so that it will not be necessary to open the windows.



III Transportation Noise Sources

This section considers air, surface, and marine transportation noise sources. Included are examples of the problems facing the manufacturers and designers of individual transportation modes, and of the projects undertaken by researchers with broader interests. The effects of noise on both passengers and operators of commercial and passenger vehicles are studied in depth. The effects of noise on the general public in the outside environment are also discussed. The noise levels of each transportation mode are compared with the current recommended criteria.

A. AIRCRAFT 3010-3040

3010 THE GENERATION AND SUPPRESSION OF AIRCRAFT NOISE.

McPike, A.L.

in *SAE-DOT Conference on Aircraft and the Environment, 1971* pp.5-10.

A review of the comparative noise levels of the turbojets, the low-bypass-ratio-turbofans and the newest high-bypass-ratio-turbofans. Flyover noise levels of the turbojets are seen to be dominated by the low-frequency roar of the jet-exhaust noise at both takeoff and approach power settings. On some turbojets, jet noise suppressors do reduce the noise levels under the takeoff flight pattern but do not reduce the noise levels under the approach flight path. Low-bypass-ratio turbofan engines produce less jet exhaust-noise than turbojet engines, but the discrete frequency components of the turbomachinery noise are more obvious; experimental use of acoustically absorptive duct linings can reduce the level of the turbomachinery noise at approach power settings, but they are less effective at the much higher takeoff power settings. The new high-bypass-ratio turbofan engines produce substantially less jet-exhaust noise than the predecessor engines, while turbo-machinery noise is reduced by careful selection of various engine parameters and by installation of acoustic treatment. Their increased use is seen to significantly reduce general airport noise levels. The potential for additional noise reduction by modified operating techniques in all aircraft still exists, to some degree.

3020 PERFORMANCE AND NOISE ASPECTS OF SUPERSONIC TRANSPORT.

Calmon, J. and R. Hoch.

S.N.E.C.M.A., France.

in *International Conference on Noise Control Engineering, 1973, Inter-Noise 73* pp.464-473 5 refs.

The discussion includes engine noise reduction problems of the supersonic transport and the connection of the problems with the fundamental performance aspects of these aircraft. Specific constraints due to aircraft aerodynamics, air intake and exhaust systems and gas generator efficiency, as well as constraints due to economics are discussed. SNECMA's work with the Concorde is specifically analyzed. Conclusions reached include the fact that the operating economics of a supersonic commercial aircraft are very sensitive to changes in the powerplant weight and propulsive efficiency, and despite improvements in noise control, the supersonic will be noisier than subsonic at the current level of technology. The second generation of supersonic aircraft, due to the current trend of aviation, will have to be substantially quieter, requiring varying aerodynamic and propulsive configurations between takeoff and cruise elements.

3030 PUBLIC HEARINGS ON NOISE ABATEMENT AND CONTROL, VOL. 2; MANUFACTURING AND TRANSPORTATION NOISE (HIGHWAY AND AIR).

Environmental Protection Agency, Office of Noise Abatement and Control 1971. EP1.2:N69/3/V.2

A text of the Chicago hearings, which were directed to the specific problems of transportation noise, and to potential solutions involving technology, regulation, and legislation. Discussion of highway traffic noise includes measurement, simulation, effects of landscaping and legal implication. The history of the aircraft noise problem is surveyed. Details are given of the intensification of the problem in 1968, due to the introduction of commercial jet aircraft and increased operations along with larger and noisier engines. The efforts of the O'Hare Noise Abatement Council in Chicago in regard to noise abatement programs at O'Hare Airport, are reviewed. Included are statements by

representatives of the aircraft industry, tire manufacturers, environmental lists, otologists, industrial unions, hearing societies, motor vehicle manufacturers and many others.

3040 **REVIEW OF CURRENT SONIC BOOM STUDIES.**

Kane, Edward J. Boeing Co.

Journal of Aircraft V.10 N.7 July 1973 pp. 395-399.

A review of several aspects of the sonic boom phenomena currently being researched at Boeing Co. Current activites include 1) a detailed study of data measured at the extremities of shock waves; 2) a summary and evaluation of the state of the art and sonic boom literature; 3) configuration studies devoted to establishing a lower bound sonic boom intensity for practical transport airplanes. The results of these studies are directed, toward 1) an improved understanding of the phenomena at caustics formed by atmospheric refraction and maneuvers; 2) a single reference volume designed for use by future researchers in determining the extent of past research and areas of useful future research; and 3) defining a sonic boom lower bound for viable transport type airplanes. It is determined that substantial improvements in current technology standards would be required to achieve lower sonic boom levels. For example, the US-SST would have to be 250,000 lbs. lighter and the Concorde about 150,000 lbs. lighter in order to reduce the cruise overpressure which reflects the sonic boom signature.

B. SURFACE TRANSPORTATION 3405-3510

3405 **AN ANALYSIS OF RECREATIONAL SNOWMOBILE NOISE.**

Curtis, Jack and Richard C. Sauer.

Sound and Vibration V.7 N.5 pp.49-50 May 1973 3 refs.

A survey of the noise levels of 10 current models of snowmobiles, measured under controlled conditions. The mean sound levels are 96 dBA for eight snowmobiles at idle and 113 dBA for full throttle for six vehicles. A comparison of the total data with current damage risk criteria indicates that an operator should not be exposed to the noise of the "average" snowmobile for more than one hour in any 24 hour period. Further research needs to be done on quieting snowmobiles below 90 dBA. Until this is implemented, either restricted exposure or ear protectors are necessary. A chart format shows current state sound level requirements passed by 17 states.

3410 **AUTOMOBILE TIRE NOISE: A REVIEW OF THE OPEN LITERATURE.**

Leasure, William A., Jr.

National Bureau of Standards

in *National Conference on Noise Control Engineering,1973, Noise-Con 73* pp.187-195 11 refs.

An overview of the results of current research on the origins of vehicle tire noise. Aspects of tire design are detailed. Levels of interior passenger car noise are examined in regard to tire origin. Analysis of exterior noise levels include consideration of the effects of speed, tread design and road surface characteristics. Individual analysis is made of load effects, tire inflation pressure effects, and tread wear effects. Miscellaneous effects include number of plies, tire reinforcing fabric, tire dimensions, and wet road surface. The three generic tire noise mechanisms are basically aerodynamic, air pumping and vibration, and more work is needed in the evaluation of these mechanisms. General conclusions from available data indicate that vehicle speed, road surface characteristics and the tread design (with attendant wear condition) are the major factors affecting tire noise, although much research is needed in lesser known areas as tire carcass construction which could prove to be important.

3415 **A BASIC STUDY OF AUTOMOBILE TIRE NOISE.**

Hilquist, Ralph K. and Philip C. Carpenter.

Sound and Vibration V.8 N.2 Feb. 1974 pp. 26-28

A survey of the results of a 1971 GM parametric study of automobile tire noise. Vehicle speed is found to be the most important factor affecting tire noise: sound levels increase 8 - 10 dB with an increase of 40 to 70 m.p.h. Wear to 50 percent of tread depth resulted in a 2 dB increase in sound level; wear to 75 percent of tread depth brings no

further increase in sound level; wear to 100 percent of tread depth brings a slight (0.5 dB) decrease in sound level. Variations in road surface results in a 5-7 dB range in sound levels. Vehicle load, tire inflation pressure, tire carcass construction, and tire size do not appear to have a significant effect on tire noise.

3420 CHARACTERISTICS AND CONTROL OF CAR, TRUCK AND BUS NOISE.

Groening, James A.
General Motors, Proving Ground, Noise and Vibration Laboratory.
in *Purdue Noise Control Conference, 1971, Proceedings* pp.28-31

A general analysis of cars, trucks and buses as noise sources. Exhaust noise is the main source of noise in cars, which is accentuated by wide-open-throttle driving at high engine speeds. At normal driving speed, tire noise is an equal contributor. Fan noise is third in importance, but will be more prominent as technology reduces exhaust noise. Truck noise is predominently exhaust-originated, and the 1971 estimate was that half of the operating trucks had either inadequate exhaust mufflers or no mufflers at all. If a truck is adequately muffled, tire noise is usually the predominant source on high speeds. Radiated engine noise, as well as transmission gear noise, accessory noises, hydraulic pump system noise will become more noticeable when exhaust and tire noise are alleviated. Rattles and loose loads are an ever present factor. Bus noise is predominently caused by wide-open-throttle acceleration after bus stops. This places the highest noise level closest to people and other vehicles. Exhaust noise from buses should not be a major problem, because structural space is available and has been used to provide large enough mufflers. Cooling fan and engine noise cause the major noise, both inside and outside coaches. After performance factors are considered, actual significant noise reduction in vehicles is seen to be a potential expense to the consumer. Compromises with performance factors are thought to be inevitable. For example, cargo limitations will be imposed in order to quiet trucks, and there would have to be a reduction of space in automobile interiors to implement quiet design factors.

3430 COMMUNITY NOISE – SURFACE TRANSPORTATION.

Thiessen, G.J. and N. Olson.
Sound and Vibration V.2 N.5 April, 1968 pp. 10-16.

A survey of community noise sources including automobiles, trucks, buses, motorcycles, trains and power-driven equipment. Analysis of noise sources shows that current noise levels are largely unnecessary in view of the present state of relevant technology. Passenger cars are seen to be relatively quiet, but their noise does present a problem because of their large numbers. For other seriously bothersome noise sources, technology is quite capable of dealing with the problem at a moderate cost. However, the resultant increase in the price of the vehicle will discourage a manufacturer from taking such measures unless he can be assured that his competition will do likewise. Legal control seems to be the only way to assure this, unless quiet performance is desired by the user himself.

3440 INTERIOR AUTOMOBILE NOISE MEASUREMENTS UNDER VARIOUS OPERATING CONDITIONS.

Nichols, R.H., Jr.
Bell Telephone Labs.
Journal of the Acoustical Society of America V.44 N.2 Pt. 1 pp. 407-410 2 refs.

A study to evaluate the interior noise of various automobiles. The automobile manufacturers' general claims of "quietness" are investigated in cars of different design and year, selected at random. The tests consist of 4 operations: 1) idling the automobile in an open space, 2) driving the automobile at a constant speed of 15 mph over a gravel road; 3) 35 mph at a constant speed over a smooth asphalt road with curves, and 4) a constant speed of 70 on a smooth concrete expressway. Results indicate that noise measured within the automobiles during the course of the tests followed the same general trend independent of the automobile make. Average noise levels are 1) idling, 59 dBA; 2) gravel road at 15 mph, 66 dBA; 3) asphalt at 35 mph, 70 dBA; 4) expressway at 70 mph, 78 dBA.

3450 **THE MANY-WHEELED NOISE MONSTERS MUST BE TAMED!**

Berland, Theodore

Citizens Against Noise, Chicago.

in *SAE-DOT International Conference on Transportation and the Environment, 1972, Proceedings* pp.148-153 15 refs.

A review of the extent and the effects of truck noise on the environment. The effect of noise on the human body is discussed in regard to current research, particularly sleep disturbance. The responsibility for truck noise control is seen to be partially that of the operators, as well as the manufacturer. Tire design and roadway surface materials are seen as important factors that can be improved. However, the difficult task of redesign of truck engines for significant noise reduction must be immediately implemented by the manufacturers, because of the time gap between research and implementation in the truck industry; trucks currently operating are basically the same design as that of the 1940's. Noise abatement ordinances dealing with trucks on the local level are seen to be ineffectually vague in comparison with the comparable laws of France, West Germany and Great Britain. As a result, the Federal government is seen as the only effective regulator against truck noise because of its scope.

3460 **NBS MEASURES NOISE IN TRUCK CABS.**

National Bureau of Standards Technical News Bulletin V.57 N.2 Feb. 1973 pp.32-33 2 refs.

A survey made by the National Bureau of Standards of truck noise levels within truck cabs. The continual noise has the capacity to impede safe driving and if it is loud enough, can lead to a partial loss of the driver's hearing. A series of measurements is made on 15 typical trucks, 13 with diesel engines and two with gasoline. Interior measurements are taken with a microphone located 6 inches from each ear of the driver. The engine is idled and accelerated at wide open throttle to governed rpm, as well as subjected to moving tests. The data shows that in many cases the noise level in the cab exceeded 90 dBA which is the limit set under the authority of the Occupational Safety and Health Act for noise exposure during an 8 hour work day. The Department of Transportation is developing a single stationary measurement that will correlate well with over-the-road measurements, in order that criteria be adequately applied for the protection of drivers.

3470 **NOISE EXPOSURE STUDY OF THE MASSACHUSETTS BAY TRANSPORTATION AUTHORITY RAPID TRANSIT SYSTEM.**

Apgar, Edward and Thomas Trella

U.S. Dept. of Transportation

in *National Conference on Noise Control Engineering, 1973, Noise Con 73* pp.164-170 3 refs.

A simple model of noise exposure is presented for the noise characterization of urban rapid transit systems. A physical description and operational data are included, as well as noise measurements within cars, on station platforms, and in the wayside community. Sources of noise include 1) wheel squeal due to rail connections, rail roughness and wheel roughness; 2) power collectors; 3) propulsion equipment; 4) auxiliary equipment; 5) door operation; and 6) brake system. The noise paths include 1) airborne paths which are direct, reflected and reverberated, and 2) structure-borne paths from the vehicle and guideway, along with secondary radiators. The following noise levels were measured: In car: 70-95 dBA; in station: 80-95 dBA; wayside at 50 ft.: 80-95 dBA. These are typical for U.S. rapid transit systems, and singularities such as intermittent wheel squeal exceed this. The dominant range of noise for all receivers is between 80 and 90 dBA which need abatement efforts, according to current guidelines.

3480 **NOISE ENVIRONMENTS IN PUBLIC TRANSPORTATION.**

Bray, Donald E.

Applied Acoustics Corp., Houston.

Sound and Vibration V.8 N.4 April, 1974 pp. 16-20 19 refs.

A survey of noise levels obtained at passenger seat locations on aircraft, buses and railcars while they are operating in regular commercial service. Noise levels on these vehicles have been measured before, but the results have been presented in either a broad spectrum of environments or in a particular aircraft, highway or rail situation, and lacking real passengers. The specific area of interest within the vehicle is one seat-width which extends from the head position to the back of the seat ahead. Sound levels are measured at slow response on the A and

C scales of a sound sensitivity of the human ear. C scale measurements are equally sensitive through a wide range of frequencies. The data is graphically illustrated by modal groups with cruise noise levels shown in dBA. The aircraft are seen to be generally noisier than the other modes, however some of the aircraft data are at the same level as most intercity and city buses. The noisiest rail commuter car is seen to be comparable to the median levels of aircraft noise and the long distance rail coaches are seen to be quieter than any other mode. The range is 73 dBA for a Boeing 707 to a railroad sleeping car at 57 dBA.

3490 **OPERATOR'S AT-EAR NOISE EXPOSURE FOR OFF-ROAD RECREATIONAL VEHICLES.**
Harrison, Robin I.
in *National Convention on Noise Control Engineering, 1973, Noise Con, 73* pp. 224-229.

A study to determine the noise exposure levels to which users of snowmobiles, off-road motorcycles and all-terrain vehicles (ATV) are exposed. Helmet-mounted microphones and magnetic tape recorders are utilized to determine the intensity of noise at ear level. The mean and standard deviation of the level of noise is determined to obtain a relative measure of the potential damage to the vehicle operator's hearing. The spectrum of noise reaching an off-road vehicle operator's ear is seen to be markedly different from the noise spectrum of the same vehicle at 50 feet, which is the usual measurement of noise level associated with the vehicle. Type and location of operation, experience of operator, and differences in outwardly identical machines do not markedly change the noise dose an operator receives in a given period of operation. In normal recreational use of all the snowmobiles tested, all but one of the motorcycles and all but one of the ATVs tested could damage the operator's hearing.

3500 **ORIGINS OF AUTOMOTIVE VEHICLE NOISE.**
Priede, T.
Journal of Sound and Vibration V.15 N.1 1971 pp.61-73.

A review of the characteristics of the noise produced by the various major elements of a vehicle. Any of these are capable of being predominant sources of noise within a particular operating range of the vehicle. It is shown that the noise emitted by the vehicle elements is determined primarily by the operational speed. The engine, transmission system and accessories are contrasted with the factors of road excitation and air buffeting. A quieter vehicle can only be produced by close cooperation between vehicle and engine designer. The following are essential: 1) Design of a vehicle giving adequate attenuation of the engine noise; 2) Appropriate choice of engine design parameters including limitation of the maximum engine rated speed and limitation of energy capacity; 3) Design of a quieter engine structure. It is believed that if research is directed on these proposed lines then it should be possible to produce a vehicle which is quieter by 10-15 dBA, without conflicting with economic considerations of design and operation.

3510 **SURVEY OF MOTOR VEHICLE NOISE.**
Olson, N.
Canada, National Research Council.
Journal of the Acoustical Society of America V.52 N.5 Pt.1 Nov. 1972 pp.1291-1306.

The study, based on measurements of noise, shows that the statistical properties of any given category of motor vehicle, accelerating from a stop or cruising at speeds within a given range, are predictable. Speed and vehicle weight are important parameters. The rate of increase with speed is such that in going from 30-39 mph to 60-69 mph, the sound level increases 8.5 dBA for passenger cars, 9 dBA for trucks and buses, 7 dBA for tractor trailers, and 12 dBA for motorcycles. For an estimated doubling of weight (motorcycles not included) sound levels increase 3.5 dBA. For motorcycles, maximum noise occurs for full throttle setting, independent of road speed, gear or engine loading. The octave-band spectrum of the average vehicle has a shape which is characteristic of each category and shows progressive change in level and shape with increasing speed.

C. MARINE TRANSPORTATION 3810-3820

3810 A SURVEY OF NOISE LEVELS ON-BOARD PLEASURE BOATS.

Campbell, Richard A.
U.S. Veterans Hospital, Miami.

Sound and Vibration V.6 N.2 Feb. 1972 pp. 28-29 5 refs.

A survey to determine the noise levels encountered at various locations at different operating speeds in representative pleasure boats and the problems caused by the noise. Although the small boat is not a major source of community noise, the operators and passengers may be exposed to noise levels that exceed damage risk criteria for hearing loss. Under normal operating conditions, the noise levels in the majority of power boats at the above cruising speeds are comparable to those measured in jet airliner cockpits and are sufficient to render speech communication and radio monitoring virtually impossible and also to produce danger of hearing loss with prolonged daily exposure. The risk of hearing loss is secondary, however, to the risk of a total boat disaster because of the inability to hear a command or a warning due to a high noise level.

3820 NOISE CONTROL ON DIESEL TUGS.

Dyer, Thomas R. and Bertel Lungard.

Marine Technology Oct. 1973 pp.321-333 11 refs.

A review of a silencing program on two diesel-powered tugboats. Basic acoustic definitions are given along with an explanation of concepts used in noise control. The mechanics of noise generation and the various methods used in noise suppression are explained. The particular problem of noisy diesel engines in a relatively small hull is explained along with the accelerating trend toward power and higher speed which means even noisier engines. Among the acoustical treatments employed are 1) separation of machinery spaces from the accommodation spaces as far as possible; 2) use of bulkheads to separate noisy and quiet spaces; 3) use of stiffeners on noise-isolating bulkheads on the noisy side so that acoustic treatment can be more easily applied to the quiet side; 4) use of heavy and simple propulsion machinery foundations; 5) design of the shafting to allow for maximum motion of the gear flange. Different combinations of these treatments are applied to two tugs and the highest sound level is reduced from 86 dBA to 79 dBA. The overall sound energy level in the accommodation (working) spaces is reduced by 87 percent in the tug with the greater amount of acoustical treatment. The apparent noise level heard by the human ear has been reduced about 45 percent. The average noise difference between the two tugs is calculated by individual acoustic improvements and it is seen that very significant noise reduction may be achieved as the combined product of several small improvements.

IV

IV Community Reaction to Transportation Noise

Part IV deals with social and political studies of communities exposed to high levels of transportation noise. Instances of successful community opposition to aircraft and airport noise are detailed. The methodology of noise monitoring used in conjunction with sociological surveys is explained. The elements of predictive noise models are discussed in order to give the non-specialist an understanding of these important forecasters. Successful participation in local and governmental noise programs is outlined.

A. COMMUNITY STUDIES 4000-4090

4000 APPRAISAL OF COMMUNITY RESPONSE TO AIRCRAFT NOISE AT THE GRASS ROOTS LEVEL.

Gach, Martin
U.S. Federal Aviation Administration.
Society of Automotive Engineers, SAE Reprint 710317, 1971.

A study which appraises the problems of aircraft overflight and the effect on neighboring communities. Specific emphasis is placed on the short-term problem and the reaction of the community to the noise experience of daily aircraft operations. Hours of duration of noise and the occurrence during the times of day are also analyzed. Airport officials are seen to be involved with the problem of community reaction for some time to come, until technology reduces the problem. Interim alleviation of the problem is discussed with respect to reduced long time runway usage. By careful analysis, a partial solution is reached at JFK International Airport without high cost. Noise complaints can be significantly reduced if runway usage is limited to controlled periods of time so that no one community is the receiver of inordinate and lengthy exposures. In addition, if the same community is not exposed during the same periods on successive days, a further reduction in noise complaints can be achieved.

4010 COMMUNITY OPPOSITION TO AIRPORT DEVELOPMENT.

Lantner, Gary H.
M.I.T. Dept. of Civil Engineering.
V.7 of Massachusetts Institute of Technology Airport Location and Planning Series Jan. 1972 232p. 15 refs.

A survey which investigates the experiences of 10 American airports relative to community opposition to their respective expansion programs. The case studies demonstrate airport opposition and a similarity in strategies utilized by the opponents in order to combat airport growth. The categories of community opposition are seen as local, regional, and national. Local opponents to airport expansion programs are those persons that will either find themselves physically displaced by the land acquisition program or subjected to increased aircraft noise. On the regional level are groups that want airport planning to be done in conjunction with the planning of other transportation systems in order to restrict traffic congestion or decrease regional impact. National opposition groups are usually conservation organizations that want to reserve large areas of unspoiled land. The tendency has been for airport opposition to evolve from a community level, to an extended and perhaps national level. Since the introduction of jets in 1958, the problem of noise has broadened the scope of opposition. The alternatives to community opposition are seen to involve either future aircraft/engine technologies or airport land-use planning methods that are not applicable to high density residential areas. Current noise regulation laws are the most effective means by which court litigation has been encouraged and successfully used to stop airport expansion. The most promising avenue of recourse appears to be the seeking of injunctions on the national level against the disbursement of Federal assistance funds to aid airport growth.

4020 A COMMUNITY NOISE PROBLEM/RESOLUTION.

Hart, F.D., W.F. Reiter and L.H. Royster.
North Carolina State University.
in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp. 44-48.

A history of a noise problem in a small community in North Carolina. An initial noise survey was made to determine the ambient noise levels. By several techniques for predicting community

response to noise, it was calculated that the measured noise environment would normally cause a community to initiate legal action. This report led to a court order for a detailed noise study of the indicated offending manufacturing facility. A series of measurements was coupled with a community noise and attitude survey. The noise control analysis recommended determining an acceptable noise level. This was based on 1) the attitude survey; 2) presence of noise continuously during the working day; 3) community composition near the industry; 4) presence of noise only during working hours; and 5) prior community exposure to noise. Based on the detailed study and analysis, the court ordered for the plaintiffs and the company was ordered to restrict noise or to move. The court further ordered damages to be paid to the plaintiffs. This settlement was a first in North Carolina in regard to a suit involving an alleged practice of environmental noise pollution on the part of a company.

4030 **NOISE AS PERCEIVED BY THE COMMUNITY.**
Borsky, Paul N.
in *SAE-DOT Conference on Aircraft and the Environment, 1971.* pp.11-20.

Different composite noise indexes are compared and CNR or NEF is believed best suited for judging community annoyance and physiological effects. Noise levels in areas close to airports are very high and in some communities may constitute a hazard for hearing loss. Other physiological reactions are less well known and need study. The most serious effect of aircraft noise exposure is seen to be interference with communications and sleep, with sleep interruption rated more annoying. Increasing noise accounts for about 25 percent of the total variance in human annoyance, while attitudes, experiences and other human factors are even more important. High annoyance levels for one-third of a community are NEF 20-25 and almost half are affected at NEF 30+. Measures for noise abatement include: 1) a time schedule for reducing maximum noise levels; 2) modifying existing engines; 3) introducing new "quiet" engines producing less noise than existing FAA regulations permit; 4) reducing the number of flights by rationalizing duplicate flight and optimizing the capacity of airplanes; and 5) development and enforcement of compatible land use zoning regulations.

4040 **NOISE COMPLAINTS AND COMMUNITY ACTION.**
McKennell, Aubrey C.
in *Evaluating the Noises of Transportation* pp.263-281 8 refs.
DOT-OST-ONA-70-2 PB191117.

An attempt to establish a model for predicting and understanding community complaints about noise. The report is based on a survey of people living near Heathrow Airport, London. Not everyone exposed to the same noise source is annoyed to the same degree. This is because of differences in attitudes toward noise. Few of those annoyed ever complain, i.e., take formal public action against the noise source. The number of complaints depends more on social factors than on actual noise levels. Complainants are usually middle class, politically active, and sensitive to noise. They are convinced that noise is preventable and dangerous to health. More data is needed on the differences between complainants and non-complainants. More research is also needed on the composition of noise protest groups.

4050 **NOISE MONITORING AND A SOCIOLOGICAL SURVEY IN THE CITY OF TORONTO.**
Koczkur, Eugene et al.
Journal of the Air Pollution Control Association V.23 N.2 Feb. 1973 pp.105-109 3 refs.

A study of the ambient sound levels throughout the City of Toronto and the opinion of citizens regarding them. To establish the ambient sound levels, a comprehensive system for measuring sound has been established for points on a predetermined orthogonal grid superimposed on a topographical plan of the city. Measurements are made so as to provide a statistical sample of the sound level at each of these points over a period of 24 hours. These data are used to produce graphs and charts showing 1) the range of noise levels during each sampling period; 2) the proportion of time during which any chosen level is exceeded; 3) daytime levels; 4) nighttime levels; and 5) the maximum level reached. To establish the reaction of the population to the various

sounds measured, a sociological study based on personal interviews at the place of residence and of work of citizens is being continued. The results from the noise monitoring and sociological survey completed to date indicate that noise is most bothersome at home, becoming more annoying as the day progresses. Traffic and construction are identified as the main sources. 65 percent of the residents are disturbed by noise levels exceeding 65 dBA and feel that noise is a problem that should be controlled by legislation.

4060 **PREDICTING COMMUNITY RESPONSE TO NOISE FROM LABORATORY DATA.**

Galloway, William J.

Bolt Beranek and Newman, Inc.

In Evaluating the Noises of Transportation pp.305-331 18 refs.

DOT-OST-ONA-70-2 PB191117.

The paper attempts to relate lab experiments in human judgment of noise to engineering problems associated with the selection of criteria for noisy community environments. Laboratory experiments are traditionally used for measuring the frequency and amplitude of noise. In limited field experiments, subjects are exposed to "real" noises and asked to rate them on an adjective scale. Responses tend to be subjective, since people apply the same adjectives to widely different noises. Artificial noises are usually rated more unacceptable than "real" noises. Laboratory experiments are useful in identifying the attributes of noise entering a community environment, but they cannot be used as a sole criterion for predicting community response to the noise.

4070 **PREDICTIONS OF NOISE DISTURBANCE NEAR LARGE AIRPORTS.**

Hazard, W.R.

Journal of Sound and Vibration V.15 N.4 1971 pp.425-445.

An analysis of the relationship between public annoyance with aircraft noise, objective measures of the noise itself, and mediating social or psychological conditions which affect the noise-annoyance relationship. Noise readings and interviews were gathered in the vicinity of four major airports. Noise measurements of different types including the CNR (composite noise rating) and NNI (modified noise and number index) and others are evaluated. Seven major social-psychological predictors of annoyance are identified. In order of importance (determined by their ability, in combination with the noise measures, to predict annoyance) the measures are: 1) fear of aircraft crashing in the neighborhood; 2) distance from the airport; 3) susceptibility to noise; 4) noise adaptability; 5) city of residence; 6) belief in misfeasance in the aircraft or airport industries; and 5) the extent to which the airport is seen as important to the local economy. These variables are found to be consistently the most powerful predictors of annoyance measure when used in conjunction with a noise predictor. Of the noise predictors studied, CNR proves to be the most stable in conjunction with the social predictors. An equation is developed to reduce 63 percent of the variance between predicted and observed mean values of the annoyance measure.

4080 **REACTIONS OF PEOPLE TO AIRCRAFT AND OTHER ENVIRONMENTAL NOISE.**

Borsky, Paul N.

in *Interagency Symposium on University Research in Transportation Noise, 1973* V.2 pp.705-726.

A description of research which involves a new methodology for assessing human responses to aircraft noise pollution. Noise abatement efforts are being somewhat impeded by disagreements as to the extent of community annoyance at different levels of noise exposure. Purely acoustical research does not take into account prior attitudes of subjects with prior experience with the actual noise source being tested. A specific acoustic environment is created and the subjects emanate from airport impact areas. Units of "environmental annoyance" are determined for simulated flyovers with different levels of noise and different engine treatments. Judgments of annoyance for different levels of noise are seen to be related to a subject's prior complaints and noise exposure. This study of real people in environmental stress can result in a significantly revised estimate of liveable aircraft noise levels.

4090 **THE SOCIAL IMPACT OF NOISE.**
National Bureau of Standards.
U.S. Environmental Protection Agency Office of Noise Abatement and Control Dec. 1971 25p. 29 refs. NTID300.11 PB206724.

A survey of the medical, psychological and social consequences of noise. Noise is seen to be a result of civilization and has much in common with other pollutants because it is usually difficult to establish a simple causal relationship between the pollutant and its consequences. There is general agreement, however, in several aspects. Specific medical effects are seen in hearing damage, along with the strong hypothesis that there might be cardiac, vascular and neural effects as well. Psychological effects include interference with sleep, relaxation and recreation, which are all necessary for the individual to recover from daily noise. Social effects include the recent phenomenon of concerned organizations which have resulted in the defeat of the SST and in altering highway and airport designs due to noise considerations. However, individuals often find themselves in conflict as noise producers and noise receivers. Disadvantaged people might be extremely affected by noise in their particular environment, but complain less because of the lack of past successful protest. Noise is seen to affect suburban living, because use of the outdoors is made uncongenial. Public institutions such as churches, libraries and hospitals have their essential functions disturbed because of noise. The scope of the adverse effects is seen to be ever-growing, but there are great possibilities in the growing social awareness of noise and the potential impact of organized citizen protest against it.

B. PUBLIC PARTICIPATION IN TRANSPORTATION NOISE CONTROL AND ABATEMENT PROGRAMS 4600-4630

4600 **THE AVIATION NOISE PROBLEM.**
Pattarini, C.B.
Journal of Sound and Vibration V.5 N.2 1967 pp.370-376.

A history of aviation noise abatement at JFK International Airport and the resulting problems of airport management. Attempts to control noise have evolved since 1958 when the concept of "perceived noise decibels" as a measure of annoyance was introduced. An overview of the legal actions taken by the public against the airport due to noise is discussed. Dating back to 1952, an early attempt at local regulation of aircraft noise was made by the village of Cedarhurst, located 2 miles east of a very active runway. Since then, there have been many legal actions with the advent of the jet age. The airport is seen to have responded to some degree due to these actions, which have been varied and of differing effectiveness.

4610 **DEVELOPMENT OF AN ENFORCEABLE NOISE ORDINANCE.**
Jhaveri, A.G.
in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.39-41 7 refs.

A consideration of the mechanism followed and the type of problems encountered by non-governmental groups (such as the Citizens Task Force appointed by the Mayor of a city) during the complex process of noise ordinance development, with regard to Seattle. The problems encountered included 1) the non-uniform nature of many proposed and/or existing urban noise legislations; 2) hesitancy on the part of state and federal agencies to provide information on noise and its control within the city; 3) lack of data on citizen complaints; 4) unresolved problems due to varying interpretation of existing nuisance laws in the city's codes; 5) lack of interest of various city departments to prepare themselves for enforcing the proposed noise ordinance; 6) opposition of some city officials against even considering adoption of a minimum amount of noise control legislation. Recommendations for those involved in developing an enforceable city noise ordinance, in view of these problems, are: 1) Review of all existing codes and regulations that affect noise is most important; 2) Compilation of citizen complaints is essential; 3) Acoustic and noise control specialists with a local orientation are valuable; 4) Obtain citizen participation to ascertain priorities, including use of questionnaires; 5) Consult state and federal agencies through elected officials for prompt and effective actions, consistent with the provisions of the proposed city noise ordinance; 6) Avoid qualitative noise control requirements, in favor of specific realistic quantitative performance noise standards that can be enforced.

4612 **THE FIGHT FOR QUIET.**
Berland, Theodore.
Prentice Hall Inc. Englewood Cliffs, N.J. 350p. Refs.

A general overview of the noise problem and the individual's potential involvement in aiding noise abatement. Among the topics covered are hearing and deafness, the annoyance factor of noise, and the general physiological and psychological impacts. An analysis of the most important sources of noise pollution is made which includes environmental, industrial and transportation sources. The methods for noise abatement are discussed including building and acoustical design, municipal noise abatement programs. The citizen's role in influencing noise abatement legislation is explored and the importance of the individual's involvement is stressed. A list of anti-noise agencies in the U.S. is included, along with an extensive list of sources on specific topics mentioned in the text.

4618 **NOW HEAR THIS.**
U.S. Environmental Protection Agency
U.S. Government Printing Office No. 5500-0072
13p.

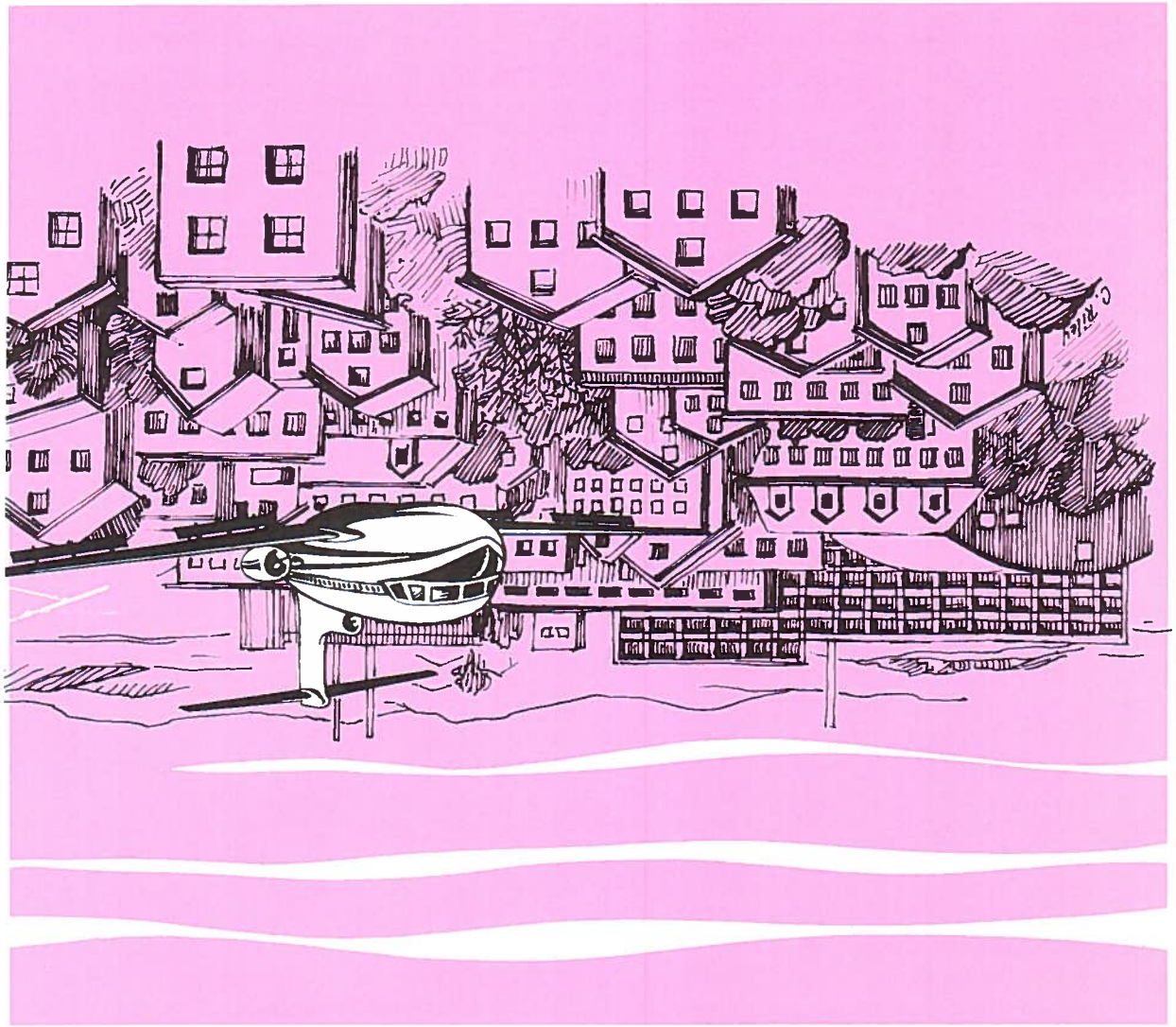
A general discussion of sound and noise, and the effects on health. Sound levels in relation to human response are examined in detail, and the insidious impact of noise in daily life is stressed. Suggestions for public involvement in noise abatement are made. The importance of support for noise abatement legislation is apparent, along with the need for the formation of effective citizen's groups against noise. Involvement with the news media is seen to be important. A review of each individual's role as a noise contributor is seen to be essential for a true understanding of the problem and some of its solutions.

4620 **TOWARD A QUIETER CITY: REPORT OF THE MAYOR'S TASK FORCE ON NOISE CONTROL.**
New York City Mayor's Task Force on Noise Control, New York 1970 55p.

A review of the work of the New York Mayor's Task Force on Noise Control. The anti-noise efforts of other groups are discussed, including the Upper Sixth Avenue Noise Abatement Association, the Emergency Committee Opposing the Pan Am Heliport, the Queensborough President's Committee on Aviation Problems, the Thruway Noise Abatement Committee of Westchester, and many civic associations, particularly those in neighborhoods under airport approach and take-off paths. The Citizens for the Quieter City, Inc. is anticipated to be an important force to serve the New York Community by volunteer efforts in support of present and coming municipal action on noise abatement. It is seen to have already influenced the implementation of machinery noise standards and supported legislators towards the goal of a quieter New York.

4630 **REQUIREMENTS FOR COMMUNITY NOISE CONTROL PROGRAMS.**
Poertner, Herbert G.
in *Purdue Noise Control Conference, 1971 Proceedings* pp.257-262 2 refs.

A discussion of the ways in which community noise efforts can be developed into effective area wide noise control programs. The need for identifying and establishing "incentives to quiet" is analyzed and the feasibility for various groups of individuals and organizations to unite and motivate others is explored. An overview is given of attitudes, problems and difficulties in developing coordinated action programs. Positive incentives for quiet need to be identified, without relying entirely on the deterrent value of legal penalties. Economically, a noise producer has no potential advantages in noise reduction unless the recipient is part of the same economic unit and willing to absorb part of the cost. Social awareness of the effects of noise needs to be developed. Some general estimates of the dimensions of community noise problems and the costs of remedies are explored. An overview is given of successful citizen action and support groups such as N.Y.C. Citizens for a Quieter City and Chicago's Citizens Against Noise. The need to develop technical guidance programs and to attract public attention and support is emphasized. An outline is given of the general questions to be contemplated by municipal governments before starting a noise control program. Some low cost methods of immediate noise control are indicated such as 1) traffic controls strictly enforced on urban streets including the lowering of vehicle speeds, and 2) eliminating some turns, stop signs, and electric signals. This would reduce the generation of noise from engine accelerations and decelerations, braking and tire friction. Ordinances to prevent prolonged idling of vehicles in public streets would cost very little. Financing could be done by collection of fines from violators.



V. Economic Aspects of Noise Control and Abatement 5000-5120

Included in this section are cost-benefit analyses of noise control measures applied to various noise sources. An overview is given of the damage functions of noise in general, along with actual noise control and abatement costs. Specific noise situations discussed include a school environment where noise disruption is a problem, as well as the multiple problems faced by various airports. The development of mathematical models for the prediction of noise reduction costs is also covered. Property values as affected by transportation noise are analysed and several techniques for calculating financial depreciation are developed.

5000 **AIRCRAFT NOISE DISRUPTION IN PUBLIC SCHOOLS: A DEFINITION OF AN IMPASSE.**
Kravontka, Stanley.
New York City Board of Education.
in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.362-365 9 refs.

A discussion of a particular noise problem involving a Queens, New York City School at the end of a JFK runway. The Port of New York Authority, the FAA, and the Board of Education agree on the noise level as being unacceptable at 80 to 100 dBA. The basic remedies at the school and on the runway would cost $800,000. The responsibility for the cost is unclear. The general implications for the nationwide problem involving all schools and aircraft noise is considered. The cost factor of noise abatement in schools is seen to be enormous, although the need is great. Current noise control technology is not focused enough on actually implementing practical and economically feasible approaches to compliance with current laws. The effectiveness of the FAA in implementing aircraft noise control is questioned, and the Environmental Protection Agency is seen as a more suitable arbiter of noise abatement functions.

5010 **AIRCRAFT NOISE REDUCTION-ALTERNATIVES VERSUS COSTS.**
Safeer, Harvey B.
U.S. Dept. of Transportation.
Sound and Vibration V.7 N.16 Oct. 1973 pp. 22-27.

The consequences of implementing alternative engineering and operational strategies for reducing noise around airports are being analyzed for 23 U.S. airports, to determine the increased costs involved and the reductions in noise-impacted areas and numbers of people exposed to noise. The elements discussed include 1) retrofit effectiveness, 2) combined effects of retrofit and operational procedures, 3) cost analysis, and 4) effectiveness versus cost. A methodology is evolved to compare the relative cost-effectiveness of alternative approaches to the reduction of airport noise, based on an analysis of data from 6 airports. These results are tentative but illustrate the methodology to be employed in the complete study.

5020 **COMPARISON OF MEASURED JET NOISE LEVELS TO GOVERNMENT STANDARDS, LEGAL LIMITS, AND HEALTH CRITERIA.**
Lane, S.R.
University of California, Los Angeles.
in *Interagency Symposium on University Research in Transportation Noise, 1972* V.2 pp.754-769 14 refs.

A survey of the research conducted at L.A. International Airport which was conducted to determine the social and economic cost of jet aircraft noise. The results and implications are applicable to comparable conditions at most jetports in the U.S. Specific problems, which are studied and have been reflected in previous studies, concern the intrusion of jet noise into urban areas beneath air traffic corridors far from airport areas. The specific noise impact on schools beneath landing and takeoff paths is also considered. The meaning and accuracy of noise exposure rating methods and their validity in urban planning decision models is also explored. Results include the fact that considerable noise impact exists in air corridor areas, and on nearby schools, there is enough intermittent high level noise to seriously impede instruction and to potentially cause hearing damage. FAA levels and California airport noise limits are being exceeded continuously in varying degrees. The city of Inglewood estimates that property values have been reduced by 50 percent in large areas beneath approach paths, and estimates 21 million to be the cost of airport improvement for significant alleviation of noise impact.

5030 **ECONOMIC ANALYSIS AND NOISE POLLUTION: A SURVEY OF THE STATE OF THE ART.**

Bennett, James T. and Mary A. Holman.

Akron Business and Economic Review Winter, 1972 pp.22-30.

A discussion of various aspects of noise pollution and their economic implications. It is suggested that because of the nature of noise – it is non-persistent and reactions to it are subjective – economic quantitative analysis is difficult. Public and private expenditures for noise research and abatement are reviewed. The cost of transportation noise including noise abatement easements, litigation, changes in property values, loss of education, and the social and economic benefits of transportation noise abatement are assessed. Very little data are available on the cost of noise pollution in the residential or working environment. Trends in the growth of noise as a pollutant are considered. It is concluded that the cost of any major attack on noise pollution would be astronomical in comparison with the measurable benefits. However, nuisance and annoyance are psychological states which to date have defied quantification or measurement, and it may never be possible to obtain valid estimates of either the cost of noise or the benefits to be derived from noise abatement. The tolerance to noise varies and thus, the most promising areas of research probably involve the actual effects of noise on hearing, where the consequences of exposure are more quantifiable than the psychological effects.

5040 **THE ECONOMIC COSTS OF AIRPORT NOISE: THEORY AND MEASUREMENT.**

Feller, Irwin, and Jon P. Nelson.

Pennsylvania State University.

in *Interagency Symposium on University Research in Transportation Noise, V.2, 1973* pp.727-743 19 refs.

A summary version of *Economic Aspects of Noise Pollution* (DOT-OS-20196). The report attempts 1) to assess recent developments in contemporary economic analysis, particularly as they relate to the formation of public policy concerning aircraft noise; 2) to evaluate existing empirical studies on the costs of aircraft noise; and 3) to evaluate the applicability of the theoretical and empirical literature to emerging public policy on aircraft noise. One conclusion that is reached shows the need for the continued use of benefit cost analysis in property values to aid in implementing noise abatement programs, despite the inconsistencies. However, a distinction must be made between existing property values which may already reflect equilibrium values and those properties whose values might be reduced in the future by exposure to new or heightened sources of noise. Allowance must be made, as well, for the increase in property values for uses which are complementary with aircraft activity.

5050 **ECONOMIC IMPACT OF NOISE.**

National Bureau of Standards.

U.S. Environmental Protection Agency, Office of Noise Abatement and Control Dec. 1971 101p. refs. NTID300.14 PB206726.

A survey of the economic impact of noise. Current data on noise and its abatement is too rudimentary for intensive economic analysis. It is demonstrated that the number of sources of noise is growing at a dramatic rate. These noise sources are heterogeneous and transient, and, therefore, a universal solution for abatement of noise at the source is not available. From the economic viewpoint, it has been demonstrated that substantial costs are associated with equipment redesign, right-of-way, and receiver insulation are discussed in detail. More research is seen to be needed on the relationship between noise, its abatement and its impact on wages, prices, productivity, production costs, employment, balance of payments, real property values, and health. Research using the principles of economics should identify and analyze the most cost-effective alternative solutions to noise. A discussion of allocations for noise research is included.

5055 **THE EFFECT OF NOISE CONTROL LEGISLATION ON THE OPERATION, MAINTENANCE AND EXPANSION OF THE NEW YORK CITY TRANSIT SYSTEM.**

O'Neill, John T.

New York Transit Authority.

in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.158-163.

A discussion of the effects of the 1972 New York City Noise Control Code on subway construction, equipment purchase, the operation of the existing subway, and the design of new subways. Proposed new noise legislation is also discussed in terms of its impact on the system. The conclusions indicate that costs can rise significantly. One example is a 40 percent increase in cost for a tunnel project, due to 1) legislation restricting the noise levels of construction equipment; 2) ordinances limiting the hours of work involving noise; and 3) limits on noise in transportation equipment. A need is seen for a prior investigation of the economic effects of such regulations, as well as a need for broad-based research to aid technologically and economically in the goals of these regulations.

5060 **HUMAN RESPONSE TO TRANSPORTATION NOISE AND VIBRATION.**

Zepler, E.E. et al.

University of Southampton, England.

Journal of Sound and Vibration V.28 N.3 1973 pp.375-401 52 refs.

A review of research during the past decade at the Institute of Sound and Vibration Research, University of Southampton. A number of aspects of human response to transportation noise are covered. Included are studies on: sonic boom, subjective acoustics test procedures, human response to vibration, the effects of noise on performance and comfort, and effects on communities of aircraft noise and construction site noise. A major study concerns the development of a mathematical model to determine the economic impact of achieving reduced community noise levels from aircraft. The model considers the noise characteristics of all the different airplane types, including future advance technology engined aircraft, as well as using all the major British airports. The factor of the cost of retrofitting noise-suppression devices to existing types of airplanes, along with the possibility of introducing new aircraft types, is balanced against the alleviation of noise disbenefit resulting by so doing, at some predetermined future date. Incorporated into the model is the function of correlating land usage in five categories, along with population density counts and thus predicting noise exposure bands. This enables the effect of land use strategies to be considered in conjunction with aircraft routing and various take-off and approach noise abatement procedures. The model is also required to be based on some standard method of costing.

5070 **IMPACT OF TRANSPORTATION NOISE ON URBAN RESIDENTIAL PROPERTY VALUES WITH SPECIAL REFERENCE TO AIRCRAFT NOISE.**

Paik, Inja Kim.

Consortium of Universities, Urban Transportation Center, Washington 1970 19p. 6 refs. PB194 101.

An attempt to establish some statistical evidence bearing on the hypothesis that, in general, transportation noise affects residential property values adversely and, especially, the values of residential properties in the strictly residential area in comparison to those in the more commercial area. The study is made up of two parts. The first is an attempt to measure the impact of variations in the level of aircraft noise on residential property values in the vicinity of John F. Kennedy Airport. The second consists of a comparative evaluation of the noise effects between the relatively commercialized neighborhood and the strictly residential neighborhood in the same vicinity. Although the analysis is limited to aircraft noise and its effects on an area immediately adjacent to a major airport, an analytical model relevant to other forms of transportation is proposed. The model employs several independent variables which influence property values, such as area population, number of residential properties, number of single-family dwelling, median number of rooms per unit, nonwhite population, persons per room and median

income. The results tend to support the two initial hypotheses, demonstrating that noise does exert a negative influence on property values and that these effects were more pronounced in residential areas.

5080 **INDICATORS OF THE EFFECT OF JET NOISE ON THE VALUE OF REAL ESTATE.**
McClure, Paul T.
Rand Corp. July 1969 37p. refs. AD690827.

A survey report dealing with the effect of jet noise on the value of real estate. The effects are usually manifested either by a change in the price (market value) of property or by the cost of countermeasures needed to obviate or compensate for the effect of jet noise. The indications studied are 1) market value change; 2) insulation costs; 3) easement costs; and 4) litigation. All of which show evidence that jet noise has a negative effect on the value of residential property. The most credible of these indicators is the cost of an easement, which is theoretically the estimated market value of the property right transferred by the easement. Legislation in most states sets the price at fair market value of the property right. The purchase of an easement is a financial assuagement but does nothing to reduce jet noise, so that insulation costs should also be included as a factor. Insulation costs are more useful to airport managements, who are inclined toward direct remedial action than toward awaiting litigation. The market survey technique is seen to be the most valuable source of information, while the least reliable information comes from financial claims in cases of litigation. In conclusion, a case can be made that on the basis of insulation and easement costs, property exposed to jet noise is worth 10 to 20 percent less than it would be if not exposed to jet noise.

5090 **JET AIRCRAFT NOISE IN METROPOLITAN LOS ANGELES UNDER AIR ROUTE CORRIDORS.**
Hurdle, P., S.R. Lane and W.C. Meecham.
University of California, Los Angeles.
Journal of the Acoustical Society of America V.50 N.1 1971 pp.32-39 7 refs.

A review of the noise intrusion problems due to overflights of jet aircraft in the approach and departure air routes over the communities of the Los Angeles metropolitan area which previously had been largely ignored. Previous research had been centered on airport community noise exposure to jet aircraft takeoff and landing activity in communities adjacent to the airport. Preliminary measurements indicate that in at least 10 peripheral residential communities at distances up to 15 miles from the L.A. airport, the noise levels caused by jet aircraft overflight exceed 20 dBA above the average ambient noise levels. In 1970, there were four major approach and departure corridors with a total number of 500 commercial jet overflights every day. This resulted in 100 overflights during peak traffic periods of about 3 hour duration, during which hundreds of thousands are subjected to a significant annoyance every 2 minutes for sustained periods. In most instances, the noise levels exceed the municipal codes on noise but were not enforced. It is estimated that if the aircraft operators were fined accordingly, the total would be a billion dollars per year.

5100 **NOISE: ECONOMIC ASPECTS OF CHOICE.**
Foster, C.D. and P.J. Mackie.
Urban Studies V.7 N.2 June 1970 pp.123-135.

A discussion of the cost associated with different methods of reducing noise levels and the corresponding amount of reduction of noise achieved. It is proposed that if even the cheapest method of reducing noise costs more than the amount at which the people affected value the noise reduction, it is not worth taking that step to reduce noise. Finding a reliable method of valuing people's dissatisfaction is a key problem. The noise situation in a residential situation is considered, and the various cost reduction factors are reviewed. The costs considered are those of 1) reducing noise-creation by vehicle; 2) eliminating traffic noise from noise sensitive areas; 3) motorway and road design in order to improve smoothness of traffic, or to create buffer zones or barriers; 4) sound-proofing and other structural measures; 5) long-range town planning. It is concluded that it is possible to estimate noise reduction costs, but it is a problem to input a value to the reduction in noise. A physical measure of noise which correlates reliably with the dissatisfaction caused must be derived, and it is vital to ascertain the worth which is placed on a

reduction in the noise level, in order to know on what scale to take action. This can be achieved currently through special attitude surveys, that have careful wording and presentation of questions. An alternate theory of utilizing house prices is discounted because of complication non-related to noise factors.

5110 **NOISE BURDEN FACTOR – A NEW WAY OF RATING AIRPORT NOISE.**
Richards, E.J. and J.B. Ollerhead.
Loughborough University of Technology, England.
Sound and Vibration V.7 N.12 Dec. 1973 pp. 31-33.

A review of current methods of measuring airport noise nuisance. A need is seen to relate the amenity value of an airport to the noise annoyance factor. The proposed community "noise burden factor" measures the relation between the person days of serious noise nuisance to one housedweller for each passenger arriving or leaving the airport. The amenity factor of an airport is related to the saving of passengers' time, the freight carried, the size of the airport and its staff along with the number of movements of aircraft connected with number of passenger movements per year. The disamenity value of an airport is related to the number of persons living on the ground who are seriously annoyed by noise of such aircraft, the housing value losses, the cost of moving and any community loss of "well-being." The ratio of these factors is a measure of the relative nuisance of the airport in providing its services to the flying public. If the ratio is seen to be increasing it means that homes are being built in unsuitable places or that flight paths have been badly chosen. If the ratio has gone down, quieter aircraft have been utilized or more passengers have been flown with less annoyance. This provides a convenient means for comparing noise problems at different airports and for monitoring the effectiveness of noise control measures over a period of time.

5120 **NOISE IN AN AIRPORT COMMUNITY.**
Hurlburt, Randall L.
City of Inglewood Dept. of Environmental Standards.
in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.366-371.

An overview of the City of Inglewood, California noise abatement program. The city lies directly under the approach path to the four runways at Los Angeles International Airport (LAX) and the noise from landing aircraft has affected the city to the degree that Inglewood has instituted a full-time noise abatement program including technical staff and monitoring equipment. Among the projects involving a mobile monitoring unit was the measurement of approach angles of aircraft landing at San Diego International Airport. San Diego was chosen because of high terrain which causes aircraft to fly steeper than normal approaches. The average approach height at San Diego is 1370 ft., while at L.A. it is 864 ft. If the same procedures were used at L.A., it is estimated that aircraft noise would be reduced approximately 12 EPNdB or 56 percent. In addition to its mobile lab, Inglewood has a network of fixed monitoring stations which keep a constant check on noise levels. The city has also conducted a study to see if there was any correlation between aircraft noise levels and residential land values and dwelling vacancy rates in Inglewood. The results were compiled by a linear regression analysis based on census data and assessor's data. The results showed that high noise levels were correlated with low land values and with high vacancy rates. On the average, residential land values were approximately 50 percent higher in areas where aircraft noise is less than 80 PNdB compared to areas where aircraft noise exceeds 110 PNdB. A soundproofing ordinance has been considered by the City, and a feasibility study has shown that construction costs would be increased by 3-10 percent with the addition of the necessary additional materials.

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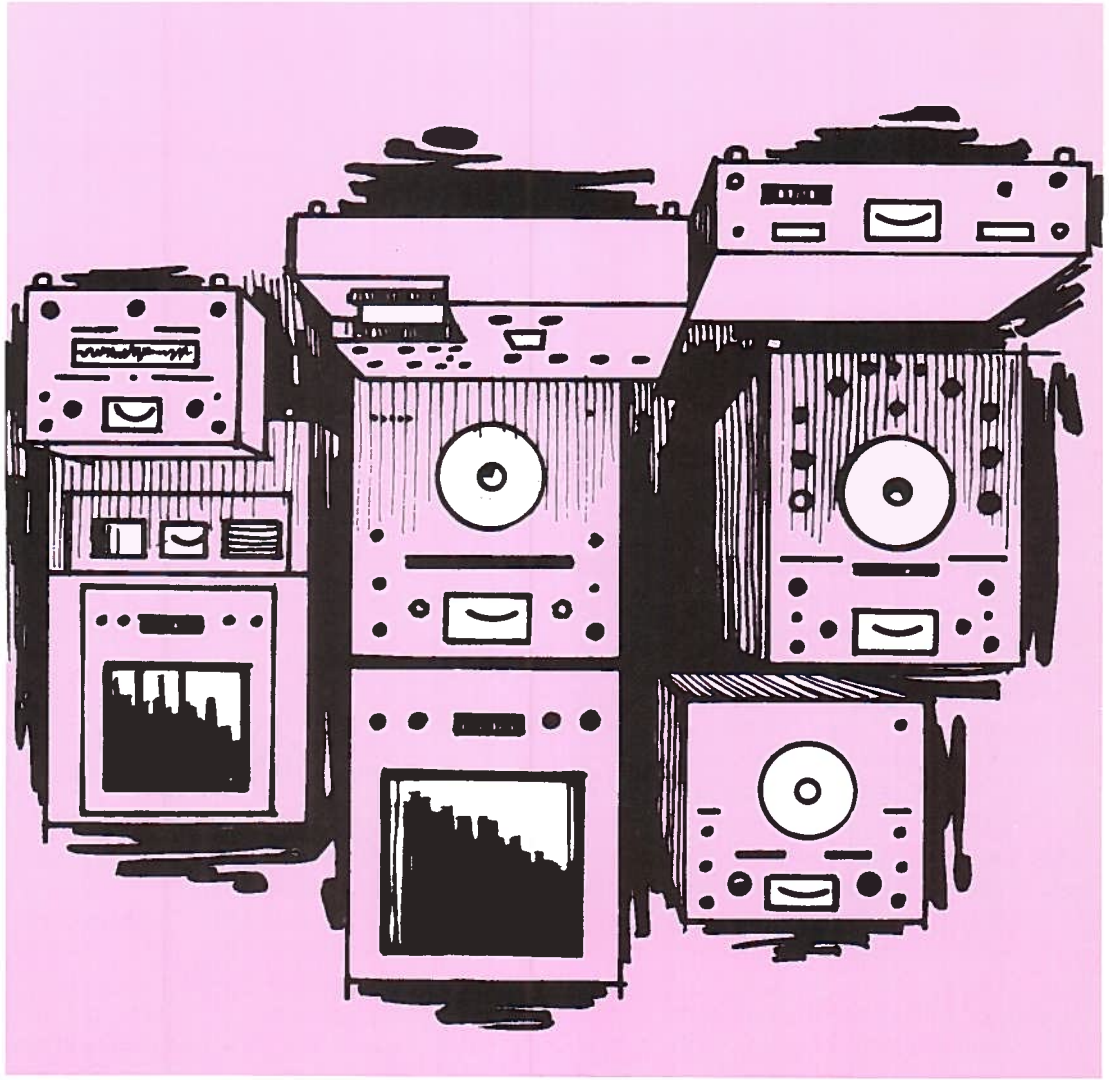

METHODS OF MEASURING, SURVEYING AND EVALUATING ENVIRONMENTAL TRANSPORTATION NOISE

VI Methods of Measuring, Surveying and Evaluating Environmental Transportation Noise 6000-6240

Units of measurement used for transportation noise are explained as well as methods of conducting noise surveys. The emphasis is on methods that can be understood by the non-specialist in noise control and on those measurements which utilize simple techniques and equipment. The functions of various noise control devices are explained as well as the use of mobile acoustical laboratories. The methods of evaluating noise exposure data are also detailed.

6000 **ANNOYANCE: PERCEIVED NOISINESS.**
Kryter, K.S.
Stanford Research Center.
in *Evaluating the Noises of Transportation* pp.87-104 27 refs. DOT-OST-ONA-70-2 PB191117.

Noise control problems occur when the average person perceives a sound as annoying, due to masking, loudness, startle, distractive or fatigue effects. A system is needed for calculating the perceived noise level (PNL) of sounds. Five aspects of sound appear to be determinants of PNL: 1) spectrum content or level; 2) spectrum complexity; 3) duration of total sound; 4) duration of increase in level prior to the peak level of non-impulsive sounds; 5) maximum level reached by impulsive sounds. Previous efforts to measure these aspects are reviewed. Better understanding is needed of what to measure and how best to measure it.

6010 **BACKGROUND-NOISE LEVELS IN SUBURBAN COMMUNITIES.**
Ostergaard, Paul B. and Ray Donley.
Goodfriend and Assoc.
Journal of the Acoustical Society of America V.4 1964 pp.409-413 refs.

An analysis of special noise surveys made in recently developed suburban communities, as well as established communities, all of which are not penetrated by major expressways or railroads. Actual background noise levels are determined for the purpose of formulating zoning codes for noise and for prediction purposes in noise control. Old codes are seen to need reexamination based on noise survey information, in regard to maximum permissible noise levels, due to unforeseen aircraft noise intrusion. Techniques and procedures for implementing the survey are discussed, along with the other published surveys of background noise that invite comparison.

6020 **COMMUNITY NOISE LEVELS – A STATISTICAL PHENOMENON.**
Safeer, Harvey B.
U.S. Dept. of Transportation.
Journal of Sound and Vibration V.26 N.4 1973 pp.489-502 8 refs.

A review of the problems associated with obtaining statistically reliable and representative community noise level data and suggestions as to the solution of some of these problems. Increasing need has generated numerous community noise measurement programs, and there is much occasion for statistical variability and potential error associated with the data collection and analysis procedures. The need for proper study design is emphasized and order of magnitude estimates of the degree of error which can be introduced by improper design are developed. Community noise levels should be treated as a statistical phenomenon varying as a function of a large number of variables. In order to obtain a noise level number (or set of numbers) which is a statistically reliable descriptor of the noise environment one must consider: 1) number of measurement sites in an area; 2) location of the measurement sites; 3) frequency of measurement at each site; and 4) method of measurement. The combined effects of all the potential sources of statistical error can generate statistics which differ by as much as 10 dB, whereas the true noise levels may be equal. The more probable statistical error range is of the order of 3-5 dB, which, in many cases, exceeds the observed difference between 2 places or 2 different time periods which are being compared. The level of adequacy of measurement program design must be brought up to the level of precision that now exists in the measurement and analysis equipment in order to obtain meaningful community noise levels.

6030 **CRITERIA FOR DESIGN.**

Little, John W.

Boeing Co.

in *Evaluating the Noises of Transportation* pp.332-347 6 refs. DOT-OST-ONA-70-2 PB191117.

Two criteria can be applied to transportation noise: 1) the difference between the noise in question and prevailing ambient (background) noise, and 2) absolute limits. Ideally, the first criterion should be used to establish zones of different ambient noise levels. Absolute limits, determined in the laboratory, are used to set standards for protecting hearing. It is believed that it will be difficult to make any real progress in controlling transportation noise until workable criteria for evaluating all components of the system are established. Recommendations include: 1) setting noise limits for all components of the transportation system; 2) establishing a long-range noise reduction program; 3) establishing criteria for an "integrated rating" to measure the noise exposure of a community from all transportation sources; 4) measuring the existing system against the ideal; 5) devising a standard method for measuring subjective reactions to noise.

6040 **ERRORS DUE TO SAMPLING IN COMMUNITY NOISE LEVEL DISTRIBUTIONS.**

Safeer, H.B., J.E. Wesler and E.J. Rickley.

U.S. Dept. of Transportation.

Journal of Sound and Vibration V.24 N.3 1972 pp.365-375 2 refs.

An analysis of a commonly used scheme for sampling community noise levels, which involves collection of one "x-minute" sample, one each hour over a 24 hour period, where "x-minute" is less than 60 minutes. The assumption is that an "x-minute" sample is representative of the statistical distribution of the sound levels in the community which would be obtained from a full 60 minute analysis. Analysis of the *Medford Noise Survey* (an extensive community noise survey) is made along with a description of techniques involved. Data is used to determine that only under a very limited set of conditions can such an assumption of representativeness be made unless errors greater than ±2 dB are acceptable. An alternative time compression sampling scheme is discussed, which reduces the probability that significant differences between the sample estimates and the true (60 minutes) values will result. It will give a more accurate picture of noise levels if the noise history is not highly variable. It is most important that a researcher should have some prior knowledge of the time-dependent history in an area before designing a measurement program. At locations where the noise sources are fairly homogeneous and static, a small number of short continuous samples may be adequate to determine the shape of the noise climate distribution. Where the sound levels are from a variety of different sources which randomly appear, then either more extensive sampling or some form of time-compressed sampling may be necessary.

6050 **EQUIPMENT AND TECHNIQUES FOR NOISE MEASUREMENT.**

Donley, Ray.

Goodfriend Assoc.

Sound and Vibration V.1 N.1 Jan. 1967 pp.12-19.

An overview of the various goals of noise measurement with the analysis of the types of instruments available to implement these goals. The considerations include: 1) the type of noise involved; 2) the purposes for obtaining the data; 3) the ultimate use of the data; and 4) the amount of time available for measurement of the noise. An explanation of the basic equipment covers: 1) sound-level meters; 2) transducers including microphones; 3) frequency analyzers; and 4) indicating meters, including graphic level recorders, cathode ray oscilloscopes, and impact noise analyzers; 5) data storage devices; and 6) miscellaneous equipment including field calibrators and headphones. Procedures for acoustical measurements are described with an emphasis on accuracy and checking the validity of the data. Basic examples of record-keeping are outlined.

6060 **FREEWAY AND HIGHWAY TRAFFIC NOISE: AN INFORMATION BASE FOR URBAN DEVELOPMENT DECISIONS.**

Lane, Samuel R.

U.C.L.A. School of Architecture and Urban Planning.

U.S. Urban Mass Transportation Administration DOT-UMTA-URT-4(70)-71-2 August, 1971 90p. PB204434.

A survey which analyzes the noise levels adjacent to the freeways in the Los Angeles core area and the effects of this noise on human activity. In the 30 by 50 mile core area of Los Angeles, there are 350 miles of freeway which carry a million commuters daily and a high level of truck traffic. In general, freeway traffic is seen to cause almost continuous noise levels of 90 to 70 dBA in the five block wide strips on either side of the freeways. The estimate of population in this area is about one million people. In addition the noise levels at four or more blocks from the freeway sometimes are 60 dBA or more, which constitutes an intrusion of at least 10 dB above the average urban residential area background noise. Further detailed study is needed to determine actual traffic noise zones in the area, because of the complex sound propagation patterns caused by shielding and reflection variations at different locations and heights above the ground. Accurate assessment of traffic noise conditions and impact in specific Los Angeles residential areas requires special noise measurement programs and surveys to establish residential building characteristics, activity patterns (time and space), demographic factors, and exterior and interior noise levels. This is required to provide baseline information for: 1) comparison and evaluation of changes in the existing central area; 2) in decisions regarding property use planning which affect the property rights of individuals; and 3) to aid in the determination of criteria for further community noise regulation.

6070 **INSTRUMENTATION FOR COMMUNITY NOISE SURVEYS.**

Schultz, Theodore J.

Bolt Beranek and Newman, Inc.

in ***International Conference on Noise Control Engineering, 1973, Inter-Noise 73*** pp.559-568 8 refs.

Past surveys of community noise, coupled with questionnaires to determine the corresponding annoyance, have consistently shown poor correlation between any measure of the noise and the annoyance of individuals. This disappointing result has usually been attributed to non-acoustic personal biases of the individuals, leading to an erratic response to the noise environment. This paper considers whether or not some of the scatter may be accounted for by bias in the noise measurements. The results of community noise surveys are scrutinized as to dynamic range, dynamic characteristics, sampling the noise exposure (temporal), microsampling, sampling the noise exposure (spatial). The conclusions reached show doubt about the relevance of the background outdoor noise as affecting the response of people indoors. The peak outdoor noise levels are to be emphasized despite the difficulty of measuring them accurately. A rethinking of the models of noise annoyance is suggested. By identifying only the prominent peak levels, the study could maximize the noise events that contribute to a feeling of annoyance. This presupposes a conclusion that people's internal selective mechanism, that sorts out the noises that annoy them, depends simply on the relative statistics of indoor/outdoor noise levels that determine which outdoor noises we actually hear. There will be still some way to draw a stimulus response curve relating annoyance to some measure of the intruding outdoor noise, based on the proposed "peak" statistics. A procedure is also described for reducing error resulting from the use of simpler cheaper equipment. Essentially, the procedure involves making repeated readings of a sound level meter and averaging the result. This method was developed for use in industrial noise environments and is most useful in determining at the distribution of *steady state* noise in an area within a community.

6080 **LOW COST APPROACH TO AREA-WIDE NOISE MONITORING.**

Siddon, T.E. and K.D. Harford

Acro Acoustic Systems, Ltd., Canada.

Journal of the Acoustical Society of America V.54 N.3 Sept. 1973 pp.646-649 refs.

The current approach to noise survey work emphasizes the importance of spatial and temporal noise-level variations, with less stress on frequency content. It is shown that a simple clock-switched

sound monitoring package, A-weighted at the input stage, and with dynamic range of 45 dB, yields adequate information on which to base a concise, statistical model of the acoustic landscape. Because of the low-cost nature of individual terminal units, a large number of units may be operated simultaneously over an extended area. This insures that important spatial information is not lost. Such a detailed picture is not possible with the more conventional sequential (point to point) techniques which are normally employed.

6090 **MANUAL TRAFFIC NOISE SAMPLING—CAN IT BE DONE ACCURATELY?**

Yerges, James F. and John Ballinger.
University of Wisconsin.
Sound and Vibration V.7 N.12 Dec. 1973 pp. 23-30 7 refs.

A discussion of a method of manual periodic sampling of traffic noise which uses simple low-cost equipment and which is an alternative to continuous recording with elaborate instrumentation for routine highway planning. This is seen to be necessary to aid non-specialized personnel to implement F.H.A. PPM 90-2 which requires environmental impact statements. The measurement must include L_{50} (the sound pressure level exceeded 50 percent of the time) and L_{10} (exceeded 10 percent of the time) with satisfactory accuracy. Conventional methods for field measurements and data analysis are described, and a statistical model is evolved which predicts the desired accuracy results for the new method. A hand-held sound level meter, a wrist watch and a data sheet are then utilized to gain readings of adequate accuracy following the recommended practices. A method is constructed to avoid erroneous conclusions about the statistical distribution of noise levels, and L_{10} and L_{50} noise levels and other slowly varying sources are thus successfully measured.

6100 **MEASURING NOISE POLLUTION.**

Starr, Edward A.
Bolt Beranek and Newman, Inc.
IEEE Spectrum June, 1972 pp.18-25 34 refs.

An overview of the methods and problems of measurement of noise pollution. Measured sound pressure levels are only part of the actual effect of noise. A main problem is that the quantities to be measured must include man's reaction to sound — a reaction that may be determined by such varied factors as the time of day, his physical comfort or discomfort, characteristics of the sound and attitude toward the person or device generating the sound. Varied psychoacoustic experiments have been made to attempt to define these relationships of relative loudness and/or noisiness or annoyance. The various current noise measures are surveyed including loudness level, C-scale measure, A-scale measure and the Perceived Noise Level (PNL). Commonly used ratings which average noise effects over a longer period are explained including: 1) Noise criteria (NC) curves; 2) Composite noise rating (CNR); 3) Noise and Number Index (NNI); 4) Effective perceived noise level (EPNL); 5) Noise exposure forecast (NEF); 6) Traffic noise index (TNI); 7) Noise pollution level (NPL); 8) Single-event noise exposure level (SENEL); 9) Community noise exposure level (CNEL). The elements of a generalized noise measurement instrument are detailed along with the techniques of on-the-site measurement. Airport monitoring systems are analyzed as an example of on-the-site techniques.

6110 **METEOROLOGICAL EFFECTS ON NOISE LEVEL CONTOURS NEAR HIGHWAYS.**

Oliver, C.C., R.A. Brown and G.A. Wilson.
University of Florida.
in *National Conference on Noise Control Engineering 1973, Noise-Con 73* pp.121-126 3 refs.

A description of a tentative model to be employed to determine the effects of wind and temperature on highway noise levels. Results obtained in the experimental research indicate specifically that 1) Noise levels predicted with no consideration of wind and temperature gradients may be up to 6 dBA too high, upwind of a highway and 3 dBA too high downwind during daytime; 2) Without wind, excess attenuation of up to 10 dBA may occur within a few hundred feet of a highway due to negative temperature gradients; 3) Reduction of noise levels with distance from a highway is diminished at night, especially with no wind. During the daytime surface temperatures are greater than air tempera-

tures. Under these conditions sound paths from a highway are diverted upward from adjacent land areas by rising warm air with a consequent attenuation of sound levels over and above that due to distance. At night temperature gradients are reversed and attenuation of highway noise may be significantly reduced. Under certain conditions relative noise amplification may occur at night.

6120 **NATIONAL BUREAU OF STANDARDS MOBILE ACOUSTICAL LABORATORY.**

Winzer, George E.

National Bureau of Standards.

Sound and Vibration V.4 N.5 May, 1970 pp.12-15.

A description of a mobile laboratory that has been designed for research and measurement of the acoustical performance of buildings and for the study of environmental noise. The measurement capabilities are of a quality usually associated with fixed acoustical laboratories. The objective is to provide field measurement capabilities applicable to research in building acoustics and noise control so that existing methods of measurement can be improved and new methods developed in various noise situations. Along with application to structural noise and vibration, the equipment can be applied to exterior noise as community noise, traffic, industrial and aircraft noise. The laboratory is built into a conventional van truck with good maneuverability and with an interior design that allows equipment to be removed and used in fixed locations. The operation can be conducted by two personnel.

6130 **THE NEED FOR FREQUENCY ANALYSIS IN THE IDENTIFICATION AND SOLUTION OF NOISE PROBLEMS.**

Phelps, A.H.

Proctor and Gamble Co.

Journal of the Air Pollution Control Association V.23 N.1 Jan. 1973 pp.17-22 2 refs.

An analysis of an aspect of noise identification and measurement. The inefficient practices of attempting to characterize a noise problem by a single decibel level reading or by an A-scale decibel level reading is examined. Both simplified approaches are seen to be subject to error in overlooking the major importance of decibel levels in each frequency band, particularly when there are pure tone components present. Annoyance is very strongly dependent on the energy level in each frequency band. Identification of pure tone components, when present, is an extremely useful diagnostic tool for finding and quieting the source. Proposed noise criteria for neighborhoods which reflect the effect of frequency are discussed along with the types of noise regulations that avoid the problem of a single decibel level specification.

6140 **OBJECTIVE AND SUBJECTIVE MEASUREMENT OF TRUCK NOISE.**

Hillquist, Ralph K.

Sound and Vibration V.1 N.4 April, 1967 pp. 8-13.

A new method is used to determine the relation of various objective measures of truck passby noise to subjective appraisal of this noise. The experiment involves: 1) acquisition from the participants of some evaluation that is representative of their subjective response to the stimulus; 2) the determination of the objective measures of this noise; 3) a correlation of these with the subjective data. Truck passby noise is seen then to be best evaluated by techniques involving band analysis measures and subsequent conversion to empirical loudness or annoyance measures; however, more cumbersome they may be. As a monitoring or enforcement tool, A-weighted sound level is shown to be a satisfactory direct measure. It represents the optimum of existing weighted sound levels and provides quite adequate approximation to the subjective appraisal of truck passby noise.

6150 **ON THE QUANTITATIVE EVALUATION OF NOISE.**

Stevens, S.S.

Harvard University, Laboratory of Psychophysics.

in *Evaluating the Noises of Transportation* pp.136-150 18 refs. DOT-OST-ONA-70-2 PB191117.

A survey of the current methods used to calculate the loudness of noise. The author believes that the many terms and units of measurement

applied to noise are confusing to the public. Experiments have failed to show any measurable difference between a loudness level and a "noisiness" level or annoyance level. Acceptability of noise depends on context, and is impossible to measure. There is still no universally accepted scale for measuring perceived noise level. The use of the two current measures, Mark VI and PNdB is discussed and their relative efficiency and precision in evaluating broadband noise is compared. In measuring sonic booms, MARK VI is seen to have the greater precision in loudness level while the Perceived Noise Level in PNdB is seen to have more variation. An ideal combination would be to combine the best aspects of the two procedures into one, as they really differ in the form and spacing of the frequency-weighting contours.

6160 **PLOT YOUR OWN NOISE CONTOURS.**
Bricken, Gordon L.
Olson Labs. Inc.
Airport World Aug. 1973 pp.45-47.

A do-it-yourself guide to airport noise measurement and analysis. This is intended particularly for airport managers who need noise measurements which they can implement themselves with basic training. The types of sound level meters that are available are explained. The procedures for making measurements are outlined, along with the development of a noise exposure index. The proposed simplified system will give an exposure value within ±5 dB of the true value, providing the dBA is within ±dB of the true average. Sources of additional materials on sound measurements are mentioned for more self-help information.

6170 **PREDICTING THE REDUCTION IN NOISE EXPOSURE AROUND AIRPORTS.**
Galloway, William J.
Bolt Beranek and Newman, Inc.
in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.356-361

An analysis of the use of airport noise models to identify areas of noise exposure around airports. A model usually considers the noise characteristics of the various types of aircraft operating at the airport, individual runway and flight path utilizations, day/night operations and the total number of each aircraft type operating in some time period, usually a 24-hour day. The effect of altered flight procedures, changes in aircraft mix, or the impact of a new runway can be evaluated for planning purposes. Currently there are many proposals for changes in air carrier fleet composition as well as for uniform adoption of noise abatement flight procedures. These proposals need assessment of their relative impact at more than 500 airports and a model is proposed that would avoid the need for detailed knowledge of operations at each airport. The simplified model analyzes the NEF contours for nine representative airports and derives a representative NEF analysis with a standard deviation. A basic mechanism for evaluating procedural changes is created by defining a series of "base case" conditions which are made up of various mixes of current aircraft found at typical airports. The relative effect of new procedures or equipment or any other set of conditions, can be calculated by determining the ratios of specific NEF areas for the base cases. The model thus can assess policy implications, and with individual detailed data can be used for individual airport planning.

6180 **A PROTOTYPE INDEX FOR ENVIRONMENTAL NOISE QUALITY.**
Goldstein, Steven N.
Mitre Corp.
Sound and Vibration V.6 N.2 Feb. 1972 pp.30-33 2 refs.

A prototype technical standard for environmental noise is proposed in terms enabling an index of noise quality to be defined and calculated. The standard takes into account the damaging aspects of chronic exposure to loud noise as well as psychologically disturbing aspects of typical community noises which are not loud enough to be physically dangerous. The method is operationally feasible. It is based on cumulative normal distributions of sound intensities expressed in dBA. The reference levels are based on average noise levels of environmental settings as reported in the literature and "reasonable" times of exposure to each. This new approach is compared to the other methods of measuring overall environment

noise: the Composite Noise Rating (CNR), Noise Exposure Forecast (NEF), Noise and Number Index (NNI), and the Noise Pollution Level (NPL). It is not intended for use in the legal regulatory sense of required level of performance and differs mainly in that it relates average life styles to representative noise levels as reported in the literature.

6190 **SCALES FOR EXPRESSING NOISE LEVELS.**

Young, Robert W.

Naval Undersea Research and Development Center.

in *Evaluating the Noises of Transportation* pp.151-176 12 refs. DOT-OST-ONA-70-2 PB191117.

A description of nine different scales for expressing noise levels, each measured on a decibel scale. All the levels are used as predictors of some human response to noise. Speech interference level and the articulation index are applied mostly to sources that would interfere with understanding speech. Loudness levels calculated by the Stevens and Zwicker methods are physical measures expected to correlate with the sensation of loudness. Perceived noise level is usually calculated from measured noise spectra as a predictor of the noisiness or annoyance of aircraft sounds. Sound level A is also useful for predicting speech interference, loudness and annoyance. All the several physical measures can be integrated with respect to time to arrive at predictors of human reactions that depend both on magnitude and duration. Examples are A-weighted sound exposure level and integrated perceived noise level. Just how people respond to the temporal character of sounds is a subject of further investigation.

6200 **STATISTICAL SAMPLING IN COMMUNITY NOISE MEASUREMENTS.**

Fisk, D.J.

Great Britain, Building Research Station.

Journal of Sound and Vibration V.30 N.2 1973 pp.221-236 19 refs.

An analysis of the statistical theory of community noise sampling for purposes of deriving the optimum sampling procedures. A review of possible other sources of error is made in order to put sampling strategy into some perspective. Several techniques are dealt with including: 1) the use of a sound level meter in which the instantaneous level is recorded at constant well spaced intervals (spot sampling); 2) the idealized case of continuous sampling in which the level recorder trace itself is used; 3) the statistical analyzer technique in which the instantaneous level is recorded at constant, closely spaced intervals. Three variables are seen to affect the sampling theory: the number of samples, the interval between samples, and the total sampling period. For spot sampling, the optimum strategy is to space the samples far apart in time so that they are effectively independent at least 5 seconds apart. Under these conditions, expressions for the sampling errors in needed percentiles are easy to derive and hold for any noise source. A model is derived to show that the most effective approximation for continuous sampling is a sampling rate of 2 per second. The use of microsampling is shown to improve sampling accuracy, if care is taken with the right choice of equipment for the particular situation to be measured.

6210 **STANDARDS ON NOISE MEASUREMENTS, RATING SCHEMES, AND DEFINITIONS: A COMPILATION.**

Fath, Jack M.

National Bureau of Standards.

N B S Special Publication 386 1973 91p. refs.

A compilation of material assembled from various standards, industrial and trade organizations and technical and scientific societies concerned with acoustics. The topics covered include measurement techniques, rating schemes, definitions, equipment and product specifications, subjective measurements and response to noise, and calibration methods. A brief summary of the intent and scope of each standard is given, in some cases the official description. Organizations and societies and their acoustical standards committee are listed.

6220 **TRANSPORTATION NOISE: IMPACTS AND ANALYSIS TECHNIQUES.**
Nelson, K.E. and T.D. Wolsko
Argonne National Laboratory.
Illinois Institute for Environmental Quality IIEQ 73-16 Oct. 1973 PB226806.

A review of background information and a description of computerized models that can be used by transportation engineers, planners, and environmentalists to assess the impacts of transportation noise problems generated by highways and airport facilities. The characteristics of transportation noise are discussed in terms of generation, effects and impacts, measurement, and control. The economic, physiological, psychological, and societal effects of urban noise are described in detail. A computerized highway noise model for the prediction of noise levels generated by proposed highways, is described and is accompanied by a user's manual and a discussion of its application to transportation planning. Also described is a computerized noise model for the prediction of noise impacts of airports.

6230 **THE USE OF HOME OR ENTERTAINMENT-TYPE MAGNETIC TAPE MACHINES FOR NOISE RECORDING.**
Sprinkle, Melvin C.
in *National Conference on Noise Control Engineering, 1973, Noise Con 73* pp.284-290.

An analysis of the use of magnetic tape recorders for instrumentation purposes. The basic use of an instrumentation recorder is seen to be the recording of the phenomena which may later be used for quantitative analysis. The limitations of magnetic tape machines are examined in this context, and suggestions are made as to the particular pitfalls which cause inaccuracy when attempting to record noise levels. Problems include high frequency limitations, wide ranges of recording levels, distortion, lack of precise tape speed, lack of precision in recording and playback level adjustments. Despite these and additional considerations, recommendations for adjustments to these drawbacks are optimistically made in detail.

6240 **WAYS TO WEIGH NOISE OUTDOORS.**
Kamperman, George W.
Noise Control Engineering V.1 N.1 Summer 1973 pp.40-45 11 refs.

An analysis of the methodology for measuring outdoor environmental noise. Fluctuations of outdoor environmental noise level always upset statistical analyses unless long samples are analyzed. Microsampling is described as a technique more likely to assure correctness, even of short samples. The usage of an inexpensive reliable field data recorder is described along with the development of a data analysis system to make the microsampling technique effective. Equipment includes a Sony TC-40 tape recorder with a few modifications and additions, along with a digital clock to control the recorder drive motor. The total recording system is very compact and weighs only 2 pounds. In operation, the microsample duration time can be varied, and the recorder can be left unattended for 24 hours. The tape recordings are then used for analysis in the specially-designed data system, which then can give the cumulative distribution of the input noise level plotted in dBA versus percent of time the noise level was exceeded.

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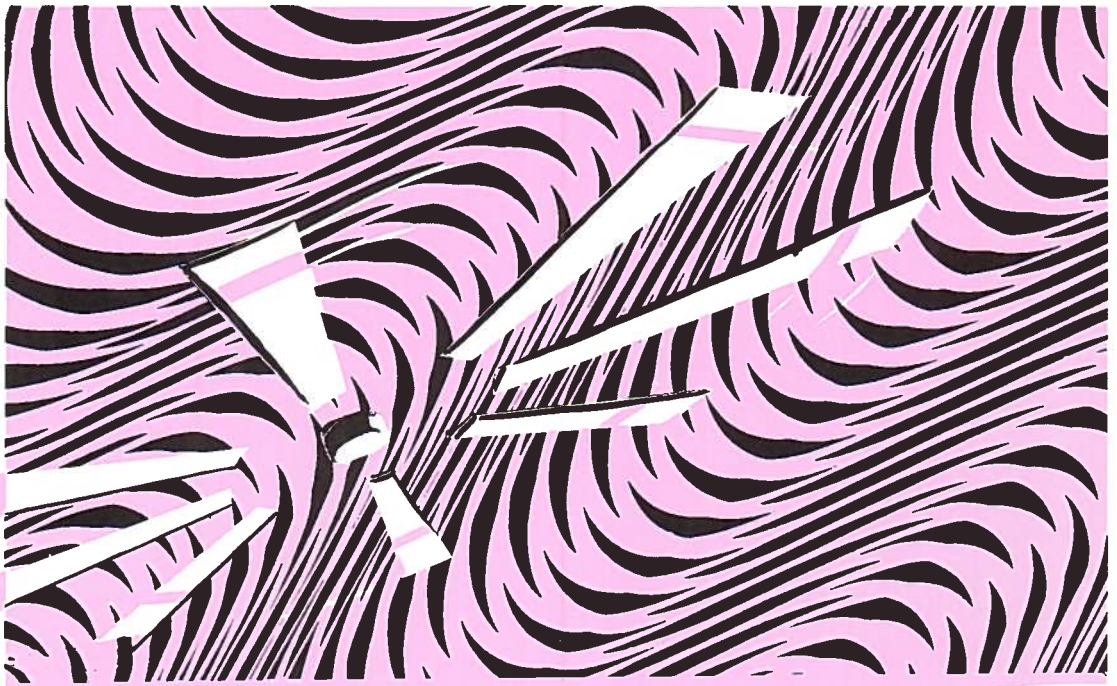


LEGAL, ADMINISTRATIVE AND OPERATIONAL ASPECTS OF IMPLEMENTING NOISE CONTROL AND ABATEMENT PROGRAMS

VII Legal Administrative and Operational Aspects of Implementing Noise Control and Abatement Programs 7010-7060

A representative survey is given of federal, state and local statutes which are effective examples of noise control measures. The governmental framework and the operational aspects of implementing noise control are explained. Specific standards and criteria are analyzed and successful implementations of noise programs are explored. Environmental impact statements are reviewed, particularly their role in implementing noise control at the planning stage.

A. FEDERAL, STATE AND LOCAL LEGISLATION 7010-7060

7010 CITY NOISE ORDINANCES – A STATUS REPORT.

Bragdon, Clifford R.

Sound and Vibration V.7 N.12 Dec. 1973 pp. 34-35.

A chart compilation of current municipal ordinances, reflecting major legislative updates. 288 municipalities have enacted noise regulations, representing a combined population of over 52 million people, along with 113 additional cities listed. The ordinances are organized by category, including: Nuisance, Zoning, Vehicle, Aircraft and Building. Ordinances containing acoustical criteria, referred to as quantitative or performance type regulations, are identified. Ordinances without acoustical criteria, referred to as non-quantitative, or nuisance type regulations are also indicated.

7020 LAWS AND REGULATORY SCHEMES FOR NOISE ABATEMENT.

George Washington University.

U.S. Environmental Protection Agency Dec. 1971 592p. refs. NTID 300.4

A survey of the existing Federal, state and local laws, ordinances and regulations governing the abatement and control of environmental noise. Abatement functions are distributed among the various levels but are largely uncoordinated. The environmental noise problem context is composed of a wide variety of discrete noise sources and noise environments. Numerous partial attempts have been made to regulate "excessive" or "unnecessary" noise through regulatory schemes directed to abatement at the source, reduction of the effects of noise and to remedies to abate the source or to reduce the effects. Regulation by the Federal government has been slight. In regard to aircraft noise, the pace of abatement at the source has been gradual with no short term prospects for substantial relief. Regulation by the states has mostly been limited to selected noise sources, although some states are now in the process of enacting comprehensive noise abatement statutes. Most noise abatement regulation has taken place at the local level by means of general noise ordinances or ordinances directed to specific noise sources or by noise zoning. Enforcement has been generally weak and in the hands of under-trained personnel. However, quality of noise abatement and control techniques has been slowly improving.

7030 MUNICIPAL NOISE ORDINANCES.

Bragdon, Clifford R.

Sound and Vibration V.7 N.12 Dec. 1973 pp. 16-22.

A review of current municipal noise ordinances. A history is given of the regulatory control of noise dating from the 1850's in the U.S. The first modern noise provision dealt with muffler requirements for motor vehicles and restrictions on construction noise. Stationary and mobile noise sources were regulated, but industrial activities were the prime regulated source. Currently, more comprehensive ordinances having acoustical provisions are evolving, and these regulations are often the basis for instituting complete noise control programs. Their scope includes zoning and land use, surface and air transportation, construction and building codes. They can be classified as either nuisance or performance type regulations. The impact of the intended program is seen to be varied due to individual levels of quality, control and administration. If a program lacks the budget to adequately support the necessary personnel and equipment, it is most likely ineffectual. If these factors are not adequate, then the regulations are unenforceable. New York, Chicago and Inglewood have 77 percent of the total budget for current municipal noise control expenditures.

7040 **NOISE CONTROL THROUGH LEGISLATION.**

Karplus, Henry B.

Illinois Institute of Technology.

in *Purdue Noise Control Conference, 1971, Proceedings* pp.242-245.

An analysis of successful noise legislation in cities that have had an early history of noise concern. The different approaches of Memphis, Chicago and other cities are discussed. In Memphis, the basic type of nuisance law has proved to be a successful noise control ordinance due to the support of the citizens, whereas elsewhere the same type is mainly ineffective because of the difficulty of enforcement. Chicago has used an objective noise ordinance that limits industrial noise. This type of legislation is more easily enforced because it deals with a stationary source that can be more readily measured and analyzed. The widespread use of the A-weighted sound pressure level as a standard in legislation is evaluated and found to be effective. Chicago's current attempt to approach a desirable state over a period of time involves a comprehensive program covering a variety of noise sources. Building codes are also seen as an effective means of implementing noise control.

7050 **NOISE REGULATION IN BRITAIN.**

Taylor, Rupert.

in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.28-30.

A survey of the current basic types of laws relating to noise abatement. The Noise Abatement Act is general, while statutory regulations deal with vehicle noise emissions. There is a substantial body of case history and precedent concerning noise as a form of common law nuisance. The pertinent laws, however, are universally regarded to be unacceptably weak. The Noise Abatement Act lacks provisions for its enforcement other than making noise a statutory nuisance so it can be dealt with in the same way as other nuisances. The penalty fines, however, are too low to discourage repeat violations. New proposed measures include the design of Noise Abatement Zones which are intended to halt the rise in noise levels and to gradually decrease them by setting target levels. Traffic noise is to be attacked on a planning level rather than a legislative one. Currently only new vehicles are subject to control and in addition, regulations are too complex to be adequately enforced. A cheap noise measuring device is needed to aid in implementing spot checks. A status noise test is also needed for diesel powered vehicles as a standard part of an annual roadworthiness check or in spot checks. The statutory legislation needs to be strengthened as well, because there is a lack of laws concerning hearing damage. However, despite this, noise control is now being achieved to a considerable degree, because 90 percent of nuisance cases are dealt with by local authorities on some form of informal basis and with relative effectiveness.

7060 **TRAFFIC NOISE LEGISLATION IN EUROPE.**

Alexandre, Ariel.

Organization for Economic Cooperation and Development.

in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.23-27.

A survey of the international regulations adopted in parts of Europe for motor vehicle noise. In 1972, the Common Market countries put into effect standards derived from International Standards Organization Recommendation No. 362. The permissible levels are equivalent to U.S. levels of 78 dBA at 50 ft. for private cars, 85 dBA for trucks and buses of less than 200 DIN HP, and 87 dBA for trucks and buses with more powerful engines. The United Kingdom has announced 1975-76 goals of U.S. equivalents of 75 dBA for cars, 81 dBA for commercial vehicles of less than 200 HP and 84 dBA for more powerful commercial vehicles. These standards are lower than the Common Market's and a difficulty might arise when the U.K. joins the Common Market and is obliged to allow import of vehicles that reach only the lower standards. The U.K. is also financing a "Quiet Truck" research project with the goal of 75 dBA (American level) which would make trucks quieter than the ISO quiet cars. The ideal objectives of noise measurement procedure, in general,

are examined are found to be: 1) to measure maximum noise, irrespective of circumstances, 2) to measure noise in a vehicle in normal city traffic conditions (which does not pinpoint nuisance causes such as sports cars, motorcycles and general aggressive driving techniques), and 3) to provide a simple and rapid method of checking noise levels either on the road or during periodical inspections. The ISO procedure only achieves the second objective, and European objectives are to work out improvements. One alternative is a noise emission cycle rating based on the actual nuisance ratio to the public. The general question of extending governmental concern beyond maximum standards is examined. The regulatory approach is seen to perpetuate the status quo, and an incentive approach is suggested to augment this regulatory approach. An economic incentive, taxation, such as a tax based on the level of noise produced by a new vehicle, could be levied at the time of sale, and thus this economic incentive could encourage manufacturers to apply noise abatement technology.

B. ORGANIZATIONAL FRAMEWORK AND OPERATIONAL ASPECTS OF IMPLEMENTING NOISE CONTROL AND ABATEMENT PROGRAMS 7210-7320

7210 **AIRCRAFT NOISE AS A CONTINUING NATIONAL PROBLEM.**
Hinton, Lloyd.
Minneapolis-St. Paul Metropolitan Aircraft Sound Abatement Council.
in *International Conference on Transportation and the Environment, 1972, Proceedings* pp.134-145 23 refs.

A survey of the aircraft noise problem using many references to particularly important studies. Emphasis is placed upon the similarity of the solutions found during 20 years of research on the problem. The concern of noise-impacted airport community residents is seen in view of the lack of progress in aircraft noise abatement. This lack of progress has persisted in spite of general agreement on measures needed, and is the basis of a demand for the reallocation of authority among federal agencies having responsibility both for the regulation of aviation and for the planning and development of urban areas. The recommendations include an amplified role for the FAA in a short term alleviation of the problem; while a long term solution of the overall problem would have the EPA authorized to develop and coordinate the implementation of national "guidelines" for maximum aircraft noise exposure impact in all airport communities within the U.S., based upon current and predicted operations. These guidelines would be established by the EPA after consultation with FAA, NASA, HUD, HEW, Dept. of the Interior, etc. for a range of compatible land use programs. It is suggested that only by substituting a generalist planning/environmental agency (EPA) for the single-purpose functional district (FAA/DOT) agency, can current and future problems constraining the growth of aviation be overcome.

7220 **A BALANCED APPROACH – A LAWYER'S VIEWPOINT.**
Howe, Jonathan T.
in *International Conference on Transportation and the Environment 1972, Proceedings* pp.246-255 refs.

A discussion of laws controlling noise and the need for the role of various local, state and federal agencies to be balanced against their respective interests, the limitations of technology and environmental goals. A review of the historical attempts to control noise is made, and the current legal situation is detailed. The past uses of common law involving nuisance, inverse condemnation and physical damage and trespass are seen not to be a remedy because each case requires separate judicial action. The statutory or regulatory approach through federal and state means, must focus on a uniform balanced standard based on technological and economic feasibility if it is to succeed.

7230 **CONSIDERATION OF ENVIRONMENTAL NOISE EFFECTS IN TRANSPORTATION PLANNING BY GOVERNMENTAL ENTITIES.**
Mayo, Louis H.
George Washington University.
in *International Conference on Transportation and the Environment, 1972, Proceedings* pp.183-197 56 refs.

A study of various technology-based regulatory agencies and statutory measures to control technological applications. Early noise controls are seen to have been reactive measures rather than

positive efforts to assure development of a new technology in the public interest. Currently the situation is evolving as new environmental codes are being implemented. A review is made of current attitudes involving advancing technology and social values. The constitutional framework for the allocation of governmental power with respect to transportation systems planning is studied along with the extent to which the noise factor is considered in the assessment of highway projects and vehicular operations. The history of the Federal governmental assessment of the aircraft noise problem is reviewed, along with an explanation of how current regulations evolved. A discussion is given of the critical assessment factor in planning which focuses on the social benefits of noise abatement.

7240 **CONTROL OF NOISE THROUGH LAWS AND REGULATION.**

Kaufman, James T.

in *Noise as a Public Health Hazard*

American Speech and Hearing Assoc. 1969 pp.327-341 36 refs.

A discussion of noise control through Federal, state and local legislation and case law. Noise control, in this context, can be considered in three parts: 1) the rights of a complainant against the noisemaker; 2) the duty of a noisemaker to a complainant; and 3) the relationship of Federal, state, and local legislation and case law to achievement of a proper balance between the first and second considerations. Special emphasis is placed upon legislative approaches to the control and abatement of aircraft, highway and general community noise. Conclusions reached include: 1) Each noise regulation, whether local, state or Federal should be interpreted with regard to other existing noise regulation, and not in a vacuum; 2) If aircraft noise abatement is to be successful, ultimate Federal responsibility is necessary; 3) When considering noise pollution, regulation is really secondary to the basic need for noise reduction and control at the source, which should be a cooperative effort of government and industry; 4) Any regulation controlling noise should include quantitative measures or standards based on scientific experts; 5) In balancing the rights of an individual disturbed by a particular noise against a government authorized activity causing noise nuisance and deemed essential and free from negligent operation, the government activity will prevail. Recoveries against the government for nuisance will be broader under states with constitutions containing language for compensation for damage.

7250 **GUIDELINES FOR THE PREPARATION OF A MODEL NOISE ORDINANCE.**

Bragdon, Clifford R.

Georgia Institute of Technology.

in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.41-43 2 refs.

A survey of the work of the Working Group on Measurement and Evaluation of Community Noise of the American National Standards Institute. The basic project is the drafting of guidelines for the preparation of a model noise ordinance whose provisions are to protect inhabitants from any noise interfering with human activity. A need is seen for guidance in this area because only 40 million people are covered by a proportionally few ordinances. The utility of these ordinances is questionable since they tend to lack acoustical criteria or standards, or are practically unenforceable. In addition, the provisions of many noise ordinances often are not current, or they contain requirements that are preempted by state or federal jurisdictions. The document in preparation seeks to cover these needs. Among the general provisions is enough information to enable a governing body to understand the extent of the general community noise problem, acoustical instrumentation, acoustical measurement and criteria, administration requirements, enforcement and implementation. Specific provisions deal with 1) Noise impact, hazardous and nuisance effects; 2) Acoustical instrumentation, sampling methods and maintenance; 3) Acoustical measurement and procedures for mobile and stationary sources; 4) Acoustical criteria, including Federal and state standard preemption and zoning ordinances; 5) Enforcement and administrative procedures; and 6) Variances and permit procedures.

7260 **LEGAL ASPECTS OF AIRCRAFT NOISE AND SONIC BOOM IN THE UNITED STATES.**
Christopher, Warren.
in *SAE-DOT Conference on Aircraft and the Environment, 1971, Proceedings* pp.47-53.

The major legal aspects of aircraft noise are reviewed. Federal legislation and regulations involved in abatement are discussed with an overview of the comprehensive federal scheme. State and local agencies which deal with aircraft annoyance through altitude, noise level and curfew ordinances, are also discussed in terms of particular legal cases. Legal actions by these bodies are seen to have been ineffectual as far as establishing their authority to make regulations attempting to control aircraft noise. The effectiveness of the airport proprietor with respect to enforcing aircraft noise measures is also examined, and is seen to be limited under existing laws. Court cases in which either injunctions or damages are sought have been brought as class actions, or by municipalities or by state Attorney Generals. A review of the cases indicates that airport operations at public airports have rarely been restricted by court action. Damages recovered in suits on public airports are also relatively small. Sonic boom problems are discussed with the emphasis on the difficulty of proving specific damage claims.

7270 **LEGAL AND INSTITUTIONAL ANALYSIS OF AIRCRAFT AND AIRPORT NOISE AND APPORTIONMENT OF AUTHORITY BETWEEN FEDERAL, STATE AND LOCAL GOVERNMENT.**
U.S. Environmental Protection Agency
Aircraft/Airport Noise Study Report July 1973 210 refs. NTID73.2.

A section of the aircraft/airport noise study which deals with 1) the existing legal/institutional structure; 2) the criteria for analyzing legal and institutional arrangements to control and abate aircraft/airport noise; 3) the problems in the present legal/institutional scheme for aircraft/airport noise regulation; and 4) the potential options for modifying the existing legal/institutional systems and alternatives. The recommendations include 1) the Federal government should promulgate, administer and enforce an airport noise regulation, designed to limit the cumulative noise exposure received in residential communities; 2) until a nationwide Federal airport noise regulation goes into effect, the California airport noise regulation is suggested for adoption as a Federal (FAA) regulation, only applicable in California for testing purposes; 3) the FAA should, with EPA participation, establish a national resource to provide assistance to airport proprietors and state and local agencies in developing skills necessary to implement the Federal noise regulation. An adequate time for FAA to promulgate the needed regulation after its proposal by the EPA is no later than one year. As a part of States' participation, state airport land use commissions or alternative mechanisms should be formed to incorporate the interests of both local governments and airport proprietors into effective land use controls around airports. Congress can encourage the States to establish adequate mechanisms for positive land use control within airport impact zones, by appropriate noise regulation and certification standards, and regulations aimed at producing consistently quieter generations of aircraft. All U.S. regulations regarding aircraft noise should be equally applied to all aircraft operating into U.S. airports unless the aircraft conform to a comparable international standard. An ultimate national plan to reduce noise should also include a continuing, cooperative interagency group to assist FAA in implementation of the proposed airport noise regulations.

7280 **THE MAKING OF A NOISE CONTROL REGULATION.**
Rupert, Harter M. and John E. Wesler.
Sound and Vibration V.7 N.10 Oct. 1973 pp. 34-35.

The background leading to the publication of the Federal Highway Administration's promulgated PPM-90-2 "Highway Design Noise Level Standards" is discussed. It is shown that the development and promulgation of a Federal policy is not a quick process, particularly when environmental issues are at stake. The involvement of a Federal program with a $4 billion annual expenditure, necessitates deliberate caution to assure that

proper balance is achieved between environmental protection and the need to provide safe and efficient transportation. The procedure of preparing the standards with repeated review by affected groups is discussed. The fundamental goals of PPM-90-2 are to require: 1) a thorough analysis and assessment of noise effects on Federal highway projects; 2) incorporation of noise abatement measures into those highway projects where they will be effective; and 3) creation of local awareness that future development of currently undeveloped land should be compatible with noise considerations.

7290 **NOISE CONTROL ON THE LOCAL LEVEL.**

Fredrikson, Harold M.

Archives on Environmental Health V.20 N.5 May 1970 pp.651-654 10 refs.

A review of the types of legislation, past, present and future, which are available for noise abatement. In the past, noise abatement has been attempted via 1) the public nuisance statute or ordinance; 2) the private action to restrain or seek damages from the offending source; and 3) indirectly, the use-by-category type of zoning ordinance restricting land use by area, to some form of residential, commercial, or industrial use. It is apparent that neither enforcement of the public nuisance ordinance nor private access to courts will have much effect in halting the growing increase of urban noise. The current approach is specific legislation indicating allowable noise levels in decibels for different noise sources. The decibel measurement, although it measures the intensity or pressure of sound, does not take into account frequency of pitch, which is an important annoyance factor. If the decibel limit approach to transportation noise is used, there will have to be a trade-off of the extent to which equipment can be quieted with the allowable level beyond which noise becomes intolerable. Local units of government are seen to have inadequate resources to legislate against all aspects of the noise problem, which necessitates cooperation of local, state and Federal governments.

7300 **THE OBSERVABLE EFFECTS OF STATE MOTOR VEHICLE NOISE LIMITS.**

Dietrich, Charles W. and Warren M. Heath.

Bolt Beranek and Newman, Inc.

in *National Conference of Noise Control Engineering, 1973, Noise-Con 73* pp.9-13 8 refs.

The description of a methodology that attempts to quantify the noise limit benefits which result from enforcement of vehicle noise regulation. The results of several surveys conducted by California and Washington enforcement agencies are compared to include the benefits of noise limits which are most readily seen for trucks, the most common loud highway noise sources. Enforcement of operational noise limits in California has significantly reduced the number of loud (93-100 BA) "heavy duty" trucks. Operational noise levels of "all trucks" not just "heavy duty" tend to be the same in states with and without noise limits.

7310 **REGULATORY APPROACHES TO CONTROLLING RAIL RAPID TRANSIT NOISE.**

Knight, Kenneth.

De Leuw, Cather and Co.

in *International Conference on Transportation and the Environment, 1972, Proceedings.* pp.370-380 5 refs.

A survey of the feasibility and the need for regulatory approaches to controlling rail rapid transit noise and available alternatives. Many technological advances are seen to have been made in the field of rapid transit design, construction and maintenance. These are generally incorporated into second generation systems thus counteracting the trend toward noisier systems caused by increases in speed and size of transit vehicles. Surveys indicate that noise is the most uniformly important problem of existing systems, and is the most frequently community complaint against first generation systems. To rectify the noise and vibration problem of the first generation systems, further research and financing by the Federal government is seen to be necessary. Voluntary standardizations of noise control specifications such as the design guidelines being worked on by the Institute for Rapid Transit, are seen to be preferable to the possibility of Federal standards. Mandatory controls on the manufacture of new equipment could be introduced as well. Joint efforts of industry and government should be made

to develop realistic acoustical guidelines for both new and existing transit systems. A cooperative effort at both the national and local level is seen as superior to legislation establishing mandatory controls which would unnecessarily consider all systems alike, although they have varied problems.

7320 **VEHICLE NOISE STUDY, FINAL REPORT.**
Foss, Rene N.
University of Washington, Applied Physics Laboratory.
Washington State Highway Commission, Dept. of Highways 1972 73p. refs. PB222193.

The purpose of the study is to obtain factual data on noise levels being emitted by vehicles currently using the highways in the state of Washington. The study was requested by the Washington State Highway Commission to help it make rational and meaningful recommendations to the Legislature for enactment of vehicle noise control legislation. The aim is to set noise limits as low as possible without placing an unreasonable or technically impossible standard on vehicles in the state. An overview of legislation in other states is considered, especially the state of California. The main focus of the study is the controls for trucks operating on freeways and other roadways with posted speeds above 35 mph.

C. STANDARDS AND REGULATIONS 7410-7450

7410 **HOW NOISE AFFECTS PEOPLE.**
Jacobson, Richard A.
Machine Design Oct. 18, 1973 pp.133-136.

An overview of the effects of the Noise Control Act and the resulting role of the Environmental Protection Agency. An overview is given of the three basic reports emanating from the Agency as a basis for the preparation of Federal regulations on noise. The first is a criteria report, *Public Health and Welfare Criteria for Noise*, discussing the effects of noise on people. The report substantiates that exposures to high levels of noise are potentially detrimental not only to human health, but also to work performance and efficiency. All aspects of the cause and effect relationships associated with response to noise on the part of humans and animals are explored. The second EPA report is intended to deal with the recommended levels of environmental noise (in defined areas under various conditions) which must be adhered to for the protection of the public. The third document will deal with products and/or vehicles which are major sources of noise and give information on techniques for the control of noise. Using the information developed in the three reports, the EPA will then set emission standards for products which have been identified as major sources of noise and for which standards are deemed feasible. The products covered will be construction equipment, transportation vehicles, all motors and engines, and all electrical and electronic equipment. Manufacturers will be required to label products to designate compliance with available standards, and the specific noise level if the product emits noise capable of adversely affecting the public health or welfare. This labeling is designed to allow the consumer an informed choice as to the product's noise generating characteristics.

7420 **NOISE SOURCE REGULATIONS IN STATE AND LOCAL NOISE ORDINANCES.**
U.S. Environmental Protection Agency, Office of Noise Abatement and Control.
March 1973 15p. NTID 73.1.

A summary in chart format of noise source regulations encompassed in current state laws and local ordinances. Data is included only from laws and ordinances stipulating specific decibel levels. The state ordinances summarized deal with several different aspects of the noise problem, such as restricting noise from transportation systems and from construction equipment and limiting the noise transmitted across property lines. Because of the many variations among local regulations, the specific noise level requirements contained in local zoning laws and building codes are not listed. The summary is intended to be periodically updated to given an accurate overview of current regulations.

7430 **NOISE STANDARDS AND PROCEDURES.**
U.S. Federal Highway Administration.
FHWA-EIS-72-02F Nov. 1972 202p. refs.

A survey of the impact of implementing highway noise standards. The effects of Federal Highway Administration's (FHWA) PPM-90-2 and accompanying Noise Standards are specifically reviewed and commented upon by a variety of Federal, state and local agencies. The standards provide for a weighing of the costs of noise abatement measures on a case by case basis. A specific factor to be considered is the need for additional land to serve as buffer strips and the cost benefit aspect of this is a major consideration. This will insure a weighing of the use of resources against the benefits achieved. It is possible that the standards may lead to more land being required for future highways. The major part of the report consists of responses and constructive criticisms. Some of these point out that the acceptable noise levels of the standards are, in some cases, higher than those provided by H.U.D. or E.P.A.

7440 **STATE STANDARDS, REGULATIONS, AND RESPONSIBILITIES IN NOISE POLLUTION CONTROL.**
Tyler, John M., Lloyd V. Hinton and John G. Olin.
Journal of Air Pollution Control Association V.24 N.2 Feb. 1974 pp.130-135 refs.

A research study which developed the basis for the State of Minnesota pollution standards and regulations. Comprehensive noise standards are developed for all sources of noise, including airports, highways and industrial sources. Two of the three dimensions of noise, intensity and frequency, are measured by the use of the unit dBA, whereas the third dimension, duration, is measured by use of the temporal distribution, expressed as Lx, where x is the sound pressure level in dBA exceeded x percent of the time. Standards are established for 5 zones: 1) residential-single family; 2) residential-apartment, public buildings; 3) commercial; 4) manufacturing; and 5) industrial. The Lx standards apply to most noises including industrial and highway noises. Aircraft noise and impulse noise standards are also discussed. The instrumentation plan is scheduled in 6 phases: 1) Map drawing of existing zoning, existing land use and proposed future land use; 2) Incompatibility analysis, to determine areas of concern; 3) Short-term noise limits and zoning plan; 4) Long-term noise limits and zoning plan; 5) Measurements and instrumentation; 6) Implementation of long-term noise reduction.

7450 **THE USES AND ABUSES OF CODES AND STANDARDS.**
Yerges, Lyle F.
Sound and Vibration V.8 N.4 April 1974 pp. 12-15 4 refs.

The purpose, production and essential elements of good codes and standards concerning noise are reviewed. Any standard difficult to understand, expensive to enforce and not truly expressing the consensus of those affected is seen to be worse than useless because it might make inaccessible the common law remedies otherwise available for the abatement of nuisances. Essentials of good codes and standards are 1) Do they fill a real, important, immediate need? 2) Will the code or standard promote the health and welfare of society? 3) Can the purposes of the code or standard be clearly and realistically defined? 4) Are the codes readily enforceable? 5) Are the effects of the codes and standards worth the cost and effort involved in writing, promulgating and enforcing them? Examples are given from state and federal regulations to illustrate workable and unworkable standards. When simple effective standard procedures involving ordinary competent technicians are seen to be not adequate to assess a noise situation, it is doubtful whether any code or performance standard can cover the situation.

D. IMPLEMENTATION OF NOISE CONTROL AND ABATEMENT PROGRAMS 7610-7690

7610 **DEVELOPING A STATE-WIDE NOISE CONTROL PROGRAM, THE ILLINOIS EXPERIENCE.**
Moore, John S.
in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.19-22.

A description of the functions of the Illinois Pollution Control Board, the Illinois Environmental Protection Agency and the Illinois Institute for Environmental Quality. The Control Board is

a quasi-judicial body whose purpose is to consider enforcement cases as well as variance petitions and permit appeals. It issues orders and sets penalties through open public hearings as well as adopting environmental quality standards and regulations as a result of these hearings. The Institute for Environmental Quality develops interdisciplinary approaches to environmental problems as well as selecting environmental projects for study. Long-range goals are recommended for technical, administrative and legislative changes in the development and proposal of standards and regulations governing environmental problems. The Illinois Environmental Protection Agency proposes, advises on and responds to formal inquiries for standards controlling environmental pollutants. It conducts surveillance activities to detect violations of the law, standards or regulations and provides evidence adequate for successful prosecution of violations. The interaction of these three state agencies is intended to eventually evolve into a comprehensive program dealing with all types of noise.

7620 **EPA ANALYSIS OF NOISE PROBLEMS POINTS WAY TO FUTURE LEGISLATION.**

Automotive Engineering V.30 N.4 April 1972 pp.28-35.

A summary of the 1972 EPA Report to the President and Congress on Noise, which was published prior to passage of the Federal Noise Control Act of 1972. The history of Federal regulation of aircraft and highway noise is traced. State and local noise control efforts are briefly surveyed. Problems and progress in controlling noise from aircraft, highway vehicles, trucks and buses, recreational vehicles, construction equipment, and other sources are examined, and indications for future legislation and noise control at the source are made. A need for continuation and expansion of Federal research and on the physiological and psychological effects of noise is recommended, along with federal support for the improvements in the measurement and evaluation of noise. The projected reduced noise levels calculated on the capabilities of ongoing technology are seen to be easily attainable with only the economic considerations of higher costs impeding faster improvements. Uniformity of noise code regulations and standards on a Federal level will be helpful.

7630 **EPA IMPLEMENTATION PLANS FOR THE NOISE CONTROL ACT OF 1972 (PL 92-574).**

Sound and Vibration V.7 N.5 May 1973 pp.4-12.

A summary of a detailed work plan developed by the Environmental Protection Agency to implement the Noise Control Act of 1972. The development of noise standards entails the combination of criteria documents, environmental noise reports, control technology and cost documentation. The actual development and promulgation of the standards follows after the preliminary preparations. The standards will cover interstate rail carriers and motor carriers, along with regulations limiting noise emission of major product sources as well as labeling regulations. The monitoring and surveillance activities which are needed are detailed. Provisions for assistance to state and local governments are included. These aids cover the development of model state legislation for noise control and guidelines for city ordinances, the development of training techniques for noise control technicians, and the development of simpler and more inexpensive equipment than is presently commercially available. In addition noise workshops will be held to help orient state and local officials of noise control programs. Public information materials and documents will be developed for use in informing the public about the effects of noise and method for its measurement and control. Plans are outlined for EPA coordination of all noise related activities by Federal agencies towards the eventual goal of actualizing an effective, cooperative nationwide noise control program.

7640 **ENFORCEMENT OF FEDERAL MOTOR CARRIER NOISE REGULATIONS.**

Seiff, H.E.

U.S. Federal Highway Administration, Bureau of Motor Carrier Safety.

in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.42-47 6 refs.

A description of the development of federal motor carrier regulations and the resultant need for effective inspection procedures on the part of the Bureau of Motor Carrier Safety. Procedures

for a stationary cab noise inspection are detailed. Inspection enforcement procedures for exterior noise levels are described, including the use of general purpose sound meters. Data collected by the Bureau is used to insure that Federal standards are not proving unreasonably restrictive to interstate commerce. At the same time this data will contribute to the creation and enforcement of more improved noise emission standards.

7650 **EXPERIENCE OF LOCAL AND STATE GOVERNMENTS IN CONTROL OF ENVIRONMENTAL NOISE.**
Coates, Vary T.
George Washington University.
in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.13-17.

An outline of the regulatory structure for noise control at state and local levels, with emphasis on the general effectiveness of noise control legislation. States are seen to be using increased technical proficiency in evolving noise control programs, but lack effectiveness in controlling vehicle noise because of technical, legal and financial constraints, and are generally preempted from dealing effectively with aircraft noise. City ordinances in general, are still technically deficient in controlling noise from all sources. Difficulties lie in formulating feasible criteria, in budgetary constraints, in technical difficulties in monitoring, and in adminstrative and personnel weaknesses in enforcement. Courts are seen to become increasingly involved in the controversies over noise, but in general, private suits for money damages have not accomplished a great deal of noise suppression. If this situation changes, local governments themselves suffer serious financial losses. The most promising outlook is for control at the source, as the federal government sets standards for a wide range of noise-producing equipment; and for more rational and effective control at the operating level by local governments.

7660 **RESULTS OF A SURVEY OF MUNICIPAL NOISE ORDINANCES IN NORTH CAROLINA.**
Royster, L.H. and C.E. Scott.
North Carolina State University.
in *National Conference on Noise Control, 1973, Noise-Con 73* pp.33-35.

This North Carolina survey was intended to aid in the development of objective noise criteria for residential, industrial, and residential-industrial boundaries. 500 local governing bodies commented on existing local noise problems. With the General Nuisance Ordinance as a standard, an analysis of different local ordinances, which attempted to define objective criteria, revealed a definite lack of knowledge in the acoustics area. There seems to be a lack of seriousness in enforcing some existing regulations and it is obvious that the state government is going to assume the major responsibility for developing realistic and effective criteria and assisting in the training of local personnel in the procedures of developing effective and enforceable noise ordinances.

7670 **STATE AND MUNICIPAL NON-OCCUPATIONAL NOISE ABATEMENT PROGRAMS.**
U.S. Environmental Protection Agency, Office of Noise Abatement and Control. Dec. 1971 14p. NTID300.8.

A report on state and municipal government non-occupational noise abatement and control programs prepared from information obtained in response to a questionnaire disseminated by the Environmental Protection Agency (EPA). Each state and 153 cities having populations in 1970, of 100,000 or more, were included. Information was requested concerning the level and scope of existing and planned noise abatement and control programs. A description of each responding governmental agency's programs is included, along with individual opinions on what additional support programs could be developed by the Federal government.

7680 **STATE AGENCY/LEGISLATIVE NOISE CONTROL INTERACTIONS IN FLORIDA.**
Winn, Stanley.
Florida Dept. of Pollution Control.
in *National Conference on Noise Control, 1973, Noise-Con 73* pp.14-19.

A discussion of Florida's recent public and legislative interest in noise control, and its evolution from motor vehicle noise legislation to current comprehensive noise abatement laws. The interactions of several state agencies are discussed in regard to their various noise control responsibilities.

The role of the 1400 Official Inspection Stations over the state is examined, and the retraining of personnel and the modification of equipment is needed. The FDPC is attempting to establish a program that is the best available "trade-off" between noise reduction potential, cost-effectiveness, training and administrative requirements and other socioeconomic considerations. Overall state plans for noise abatement involve immediate local action to precede large-scale, state-enforced noise limits which are going to take longer to legalize. This involves the attempt to implement the maximum degree of community noise reduction and control at minimum cost, by utilizing the resources of the local state colleges. The cooperation of academic qualified experts is utilized in consultation, sound measurements and data to local authorities for the eventual development of quantitative noise ordinances. Training programs and regional conferences are also to be used to aid local noise enforcement officials, with the goal of eventual statewide concurrent enforcement and legal mechanisms.

7690 **S/V STATUS REPORT, 3 COMMUNITY NOISE PROGRAMS.**

Caccavari, Cosimo et al.

Chicago Dept. of Environmental Control.

Sound and Vibration V.7 N.5 May 1973 pp. 42-48.

A series of 14 questions is presented to the administrators of noise programs in three cities: Boulder, Col., Chicago, Ill., and Inglewood, Cal. All three cities have substantial noise control programs, which are described through the answers. The aspects covered include 1) operating costs; 2) organizational and administrative functions; 3) methods of acoustical instrumentation; 4) ways of cooperation with other public agencies; and 5) the extent of public and private awareness in each city. Boulder's specific problems include a need for noise ordinance revision to incorporate maximum allowable noise levels for the different zoning districts. Chicago is seen to need a construction site noise regulation and a building code regulating interior noise. Inglewood's major concern is aircraft noise, and improvement is needed in handling noise complaints and follow-up action on local noise problems.

E. ENVIRONMENTAL IMPACT STATEMENTS 7810-7840

7810 **MANUAL FOR CONDUCTING ENVIRONMENTAL IMPACT STUDIES.**

Walton, L. Ellis, Jr. and James E. Lewis.

Virginia Highway Research Council.

Federal Highway Administration June 1971 39p. PB210222.

A review of methodologies for measuring the anticipated environmental impact of proposed highways at the conceptual location and design planning stages. An interdisciplinary team approach is recommended. The research emphasizes the systematic collection and evaluation of data on various types of impact, including those related to community facilities, relocation of people and businesses, employment, noise, air pollution, and historic sites. Worksheets, utilizing monetary values and other suggested factors, are proposed for evaluating the anticipated impact. The results of the weighting scheme are summarized for each type of impact in an environmental ratio worksheet. The suggested weighting scheme tends to penalize proposed routes which display certain characteristics such as division of a neighborhood, demolition of hospital or historic sites and potential employment losses to the community. Types of individuals and agencies which should be interviewed for opinions on possible impact are indicated.

7820 **NOISE CONTROL FOR INTERSTATE 205 IN PORTLAND, OREGON.**

Simpson, Miles. A.

in *International Conference on Noise Control Engineering 1972, Inter-Noise 72* pp.214-219 2 refs.

An analysis of the techniques developed for defining noise impact areas and the considerations involved in determining effective noise control measures while an environmental impact statement is being prepared. The study is specifically designed to pinpoint areas of impact along the proposed highway route and to recommend specific countermeasures. A computer program based on National Cooperative Highway Research Program 117, *Highway Noise Design Guide*, is used to help predict noise levels from the future highway traffic. The program takes a section of highway and

divides it into point sources, with a power level defined in each source for car and truck noise. The noise level heard at a location near the highway is determined by adding the contributions from all the point sources. From results presented in a graphic format, it is easy to recognize areas along the freeway route which will be exposed to high levels of noise. Areas are categorized into 1) no impact, 2) minor impact, and 3) significant impact areas. A variety of measures is then considered including depression or elevation of the highway, relocation of a ramp, uses of braided ramps, or even realignment of main lanes of the highway. Many times it is economically feasible to use noise barriers along a section. In some situations, the cost of noise control is totally out of proportion to its benefits, and visual impact caused by barriers would cause more objection than the noise level. It is then not always feasible to decrease traffic noise to levels which would be satisfactory to all residents and compatible with all land use. Successful planning of a highway section adjacent to a school is seen in the use of a barrier that could be used for school sport activities. It is possible that motor vehicle noise will be lowered at the source by regulations and highway noise will be lower than that predicted on 1972 vehicle noise characteristics. Therefore current highway planning might result in even lower noise levels than expected.

7830 **A REVIEW OF THE BACKGROUND, PREPARATION AND USE OF ENVIRONMENTAL IMPACT STATEMENT.**

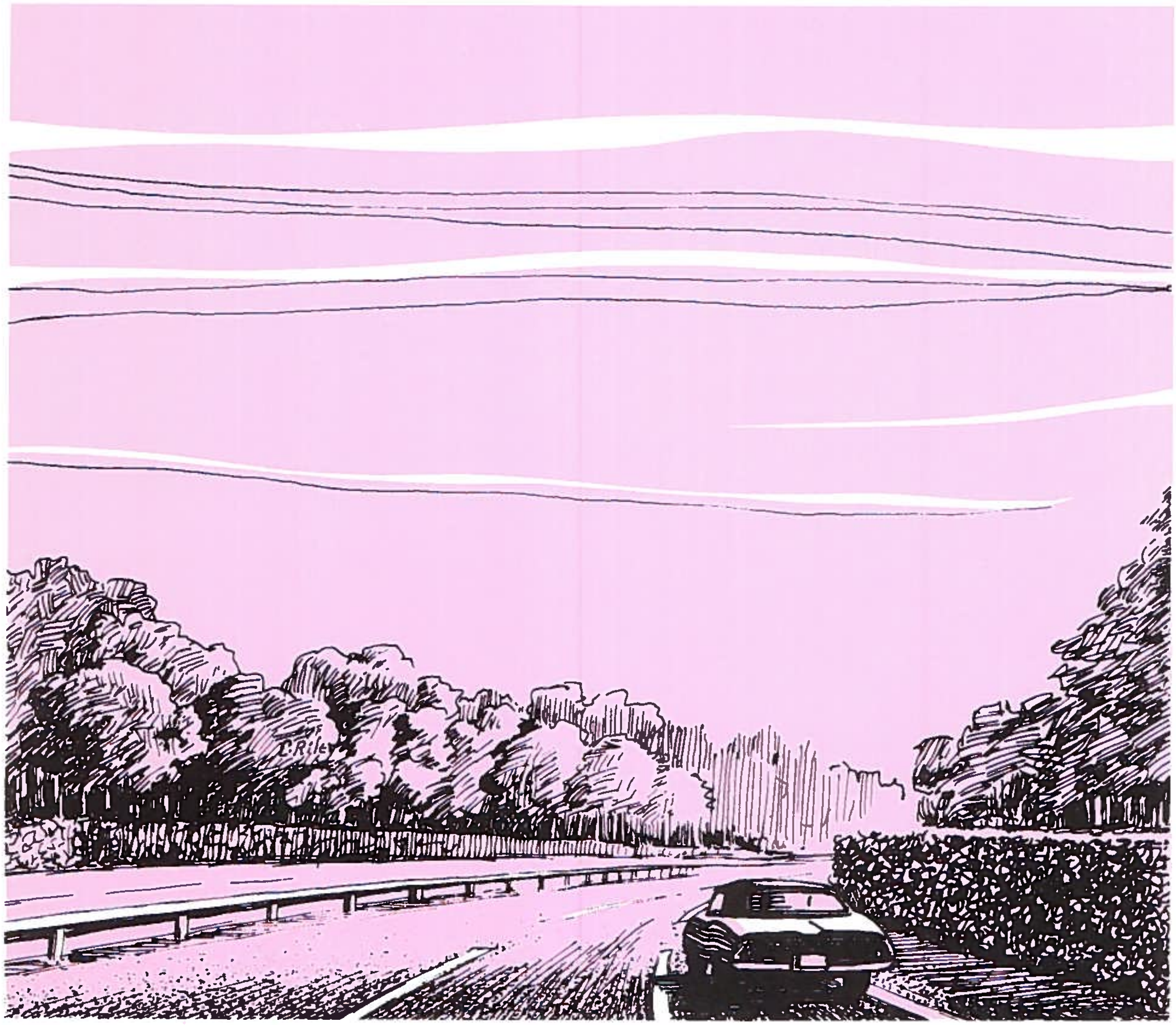
High, Dean M.
Engineering-Science Inc.
Journal of the Air Pollution Control Association V.24 N.2 Feb. 1974 pp.111-114 6 refs.

A review of the general problems associated with environmental impact statements from the viewpoint of one who prepares them. Particular reference is made to court cases involving the National Environmental Policy Act (NEPA) and to the August 1973 guidelines issued by the Council on Environmental Quality (CEQ). Questions explored include: 1) Which federal actions require an EIS? 2) On what substantive and procedural grounds can an EIS be challenged in court? 3) Which social and economic factors not directly related to the physical environment should be included in the EIS? 4) How far must agencies go in investigating alternatives to a proposed action? 5) How far should one go in balancing costs and benefits to the environment? and 6) How can public participation be maximized?

7840 **TRAFFIC NOISE ABATEMENT RESPONSIBILITIES OF STATE HIGHWAY DEPARTMENTS.**

Cohn, Louis F.
Kentucky Dept. of Highways.
in *International Conference on Noise Control Engineering, 1972, Inter-Noise 72* pp.210-213 refs.

A discussion of the short and long range results of Federal Highway Administration's PPM-90-2, by which a state is eligible for Federal aid, only if it has a functioning and effective state noise abatement engineer. Guidelines are provided for environmental impact studies for Federal projects, and specifically, noise impacts must be included. An interdisciplinary state team is required with at least one noise abatement engineer. Difficulties have arisen because of the scarcity of graduates in environmental noise control, so most state highway departments have resorted to the retraining of civil highway engineers on their staffs. Minimum equipment required is a sound level meter and a calibrator, and the state of Kentucky estimates that enough equipment to monitor all relevant projects in the states will cost less than $10,000. A state is also required to make predictions on future traffic levels that will exist in the design year of a project. The National Cooperative Highway Research Program Report 117 "Highway Noise-A Design Guide for Highway Engineers" is recommended as a design guide that can be used to predict noise level contours. The suggested numerical limits given by FHA are seen to be workable after adjustment was made to 70 dBA for noise impact on residences and noise-sensitive areas.



VIII

INTERRELATIONSHIPS OF NOISE CONTROL, TRANSPORTATION AND LAND USE 8010-8190

VIII Interrelationships Between Noise Control and Transportation and Land Use 8010-8190

The roles of highway design, traffic management, and general land use planning are discussed in relation to the noise levels of different transportation modes. The problems of airport planning in conjunction with land use techniques are covered, including zoning and land banking. Aspects of highway design for noise abatement are detailed, including the use of models for highway noise prediction. The specific engineering features discussed for noise abatement include barriers, cuts and buffer zones.

8010 **ASPECTS OF HIGHWAY DESIGN AND TRAFFIC MANAGEMENT.**

Burt, M.E.

Great Britain Road Research Lab.

Journal of Sound and Vibration V.15 N.1 1971 pp.23-24.

An analysis of the influence that the design of the highway and the management of the traffic on it can have on noise problems. An overview is given of the noise characteristics of individual vehicles and of traffic. Alternative methods of reducing traffic noise are compared and their effects on other aspects of the highway and the traffic are considered. Some conclusions reached include the fact that control of traffic flow may not be feasible on motorways and other major through roads and that the generated noise should be treated by barriers and environmental design. On urban main roads carrying mixed traffic where there is a conflict between transport and environmental considerations, some reduction in flow should be sought, and traffic management techniques used to encourage modest but steady traffic speeds. In residential areas where quiet is a consideration, it may be necessary to discourage through traffic and take measures against individual noisy vehicles. The use of noise barriers on the highway does not present engineering problems, except for the additional drifting of snow due to the barrier. More research is seen to be needed in improving road surfaces for purposes of reducing noise.

8020 **AUTOMOTIVE NOISE, ENVIRONMENTAL IMPACT AND CONTROL.**

Kugler, B.A. and Grant S. Anderson.

National Highway Research Board, Washington, 1973.

in *Highway Research Record No. 390* pp.45-55 refs.

A discussion of the effects of automotive noise on people and a method available to highway designers and engineers by which the environmental impact of the proposed highway on the surrounding community can be predicted. If a new highway route is undecided, accurate methods can predict the noise levels of the alternate routes. Community response can be predicted in such a way as to create noise trade-off studies, which can be readily included in the route selection and adjacent land planning process. In the case of new highways, which must pass through already densely populated areas, noise control can be achieved by detailed design of roadway configurations and alignments in order to minimize noise impact on adjacent land and structures. By manipulating exact highway designs in local areas, the designer can vary the subjective loudness of future traffic noises by as much as a factor of 2 to 4. Distance is a means of control, as well as depressing or elevating the highway from its original ongrade configuration. Other approaches involve using earth berms or walls, partial shielding provided by other structures, or vegetation. The choice of the most effective method of noise control for a particular situation depends on an evaluation of many environmental and social factors needed for successful planning.

8030 **COMPATIBLE LAND USE PLANNING ON AND AROUND AIRPORTS.**

Transportation Consultants Inc.

U.S. Federal Aviation Administration June 1966 AD650267.

A guide for the use of airport planners and executives to aid in complying with Federal regulations to insure compatible uses of land in the vicinity of airports. It is intended primarily to provide them with an overall evaluation of land uses on and around airports in relation to noise and hazards in the operation of aircraft, based on surveys of actual experience. Secondly, it can

assist city, regional and state planners in locating acceptable facilities, industries, and activities in airport vicinities. The priorities of the FAA are safety first and noise second in the handling of aircraft traffic. Other publications such as FAR Part 47 "Objects Affecting Navigable Airspace," establish standards and procedures for the identification of obstructions in the navigable airspace. Although noise is the primary consideration in this report, land uses that adversely affect flight operations are pointed out. Data were obtained from operations at 120 airports in the U.S. and Canada. Actual experience with noise and hazards obtained from investigating a large cross section of airports, aircraft traffic, operating conditions and geographic surroundings is detailed. In-depth treatment is given of the noise problem, individual land use, and zoning practices.

8040 **CONTROL OF HIGHWAY NOISE.**
Goodfriend, Lewis S.
Sound and Vibration V.1 N.6 June 1967 pp. 15-20 26 refs.

An examination of highway noise using the systems-analysis approach. The factors are separated into source, path and receiver. The source must include the vehicle and the vehicle-road interface. The path is the radiation of the noise from source to the receiver or auditor, who can be anyone affected by the noise. Acoustical factors taking into account these interactions are considered with a concern for planning and regulation. Conclusions reached include 1) distance is most effective in reducing highway noise; and 2) cuts, barriers and buffer zones are only effective if they efficiently intercept the line of sight from source to auditor. In addition, the direct effect of highway noise is most directly measurable when interference with communications occurs. The design guides for highway noise in relation to existing communities are currently available but too often neglected by highway planners and engineers. Enforcement of existing muffler and noise regulations and the development of enforceable codes will in themselves help to reduce highway noise and will permit accurate highway design data.

8050 **ESTIMATING TRAFFIC NOISE LEVELS AND ACCEPTABILITY FOR FREEWAY DESIGN.**
Colony, David C.
University of Toledo.
in *Highway Research Record 305*
National Highway Transportation Board, Washington 1973, pp80-87 5 refs.

A description of a simple probability model for traffic noise generation. The highway designer can estimate noise levels by using the amount of traffic volume and percentage of trucks together with the mean noise level for a single truck either estimated or measured at similar location. This model can be used to predict maximum noise levels in a residential area. The need for this type of predictability is seen in the results of a survey made in the Toledo area. Results show that realtors estimate that the proximity of a freeway could reduce the sale price of a typical residential property by 20 to 30 percent. Home-owner interviews showed that of those who live immediately adjacent to an urban freeway, two out of three would not choose such a location again. Results of the home interviews are used in connection with measurements of perceived noise level in an attempt to develop an acceptability index for traffic noise. This is then incorporated into the model to give an indication of probable effect of a proposed highway project on a neighborhood. The incorporation of noise control features of highway design can then be justified financially when a specific negative value can be placed on noise.

8060 **FUNDAMENTALS AND ABATEMENT OF HIGHWAY TRAFFIC NOISE.**
Anderson, G.S., L.N. Miller and J.R. Shadley.
Bolt Beranek and Newman, Inc.
U.S. Federal Highway Administration, National Highway Institute DOT-FH-11-7976 June 1973 PB222203.

A text to aid the highway planner in noise abatement. The fundamentals of sound are covered including acoustic terminology, basic relationships of sound, outdoor sound transmission, and a brief review of certain aspects of human response to noise. Noise data of automobiles and trucks are classified into individual discrete sound sources.

The principal components of truck noise are discussed, along with a statistical descriptor of highway noise. Instrumentation and techniques for making outdoor noise measurements are detailed. Highway noise prediction, using the NCHRP Report 117 and DOT TSC procedures is explained. Noise abatement techniques are overviewed and principal concern is given to evaluation of the attenuation (noise reduction) that can be achieved with acoustic barriers alongside the road, since these treatments can fall within the design and jurisdiction of the highway engineer. Barrier designs are reviewed, from the point of view of the NCHRP Report 117 and the TSC Computer procedures, and a new nomograph is presented and discussed as a quick, useful tool for evaluating acoustic barriers for a variety of applications.

8070 **HIGHWAY NOISE ABATEMENT BY DESIGN?**

De Frain, Leo.

Michigan Dept. of State Highways.

in ***National Conference on Noise Control Engineering, 1973, Noise-Con 73*** pp.99-104.

Methods of noise control for *future* highways are discussed with reference to the role of highway engineers. After an understanding of the many variables that combine to produce highway noise, the highway engineer must know the noise-attenuation options available for treating noisy highway sites. Four distinct components of the problem's solution exist: 1) Design the roadway to minimize noise radiation; 2) Locate the highway to minimize noise impact; 3) Control land use adjacent to roadway; 4) Control vehicle noise sources. The highway engineer deals only with the first aspect. Methods of noise control for *existing* highways are limited for the engineer and usually involve the design and installation of noise barriers. Various experimental barriers have alleviated noise but the designer alone cannot be responsible for a problem which involves legislators, industry and the public.

8080 **HIGHWAY NOISE CONTROL.**

Harmelink, Milton D. and Jerry J. Hajek.

Traffic Engineering V.43 N.12 Sept. 1973 pp. 47-53.

A general review of current available noise control measures and a relative assessment of the effectiveness of each one. Several alternative methods are available, each of which provides only a partial solution. Consequently, a combination of several methods may be required to achieve effective noise control. The most beneficial measures are considered to be: 1) control of vehicular noise emissions at the source; 2) highway planning and land use controls and; 3) building layout and design. In assessing the effectiveness of noise barriers, the estimation indicates that to reach sound level reductions of 8-10 dBA, they would have to be constructed to heights of 20 to 25 feet (on level terrain). The estimated cost would be $100 per linear foot or more. Even then, they would be effective only for single story houses. Considering the high cost of barriers, their limited effectiveness and other adverse effects of high barriers (aesthetics, shadow, snow-drifting) it appears difficult to justify further barrier construction. However, possible side benefits of even low barriers (7 to 10 ft.) may be visual shielding from headlight glare, dust and water spray.

8110 **NOISE EXPOSURE FORECASTS, EVOLUTION, EVALUATION, EXTENSIONS AND LAND USE INTERPRETATIONS.**

Galloway, William J. and Dwight E. Bishop.

Bolt Beranek and Newman, Inc.

U.S. Federal Aviation Administration, Office of Noise Abatement FAA-NO-70-9 August 1970 65p. AD711131.

The report is divided into two parts. The first part describes the evolution of methods for relating aircraft noise exposure to community response in this country, starting with the original Composite Noise Rating (CNR) developed in 1952, and with applications specifically to aircraft noise in 1957 under Air Force Sponsorship. A description of CNR procedures which were developed for civil and military aircraft is given. These procedures utilized perceived noise level contours and led to the development of Noise Exposure Forecast (NEF) procedures in 1967. The CNR and NEF are related to various noise exposure indices in other countries. Cross comparison of the indices allows the results of various social surveys to be

used as verification of the numerical values and descriptors used in the CNR and NEF zones for various acceptable land uses. Part 2 interprets the noise exposure due to aircraft operations as expressed in NEF values in terms of estimated impact on land uses. Assessments of land use compatibility, based on NEF values, are given for different land uses in order to provide guidelines in land use planning, zoning, development and construction.

8120 **NOISE POLLUTION ANALYSES FOR HIGHWAY ALIGNMENT SELECTION.**
Shuster, James J. and C. Michael Kelley.
Villanova University.
in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.105-109 .

This study investigates the current and predicted levels of noise pollution on four potential alignments within an approved corridor-design location for a new expressway in suburban Philadelphia. The intention is to determine quantitatively both the current and the future impact of the proposed alignments on the noise environment, and to predict the future noise levels for the estimated time of completion plus 20 years for all alternatives. The predicted noise levels are then examined to see if they meet current standards and guidelines both Federal and state. The methodology and apparatus for field measurements is described along with the usage of a Simpson Sound Level Meter. A determination is made of the most quiet alignment as concerns its impact on the existing environment.

8130 **PLANNING FOR COMPATIBILITY OF AIRCRAFT AND ENVIRONMENT.**
Einsweiler, Robert.
in *SAE-DOT Conference on Aircraft and the Environment, 1971* pp.64-70.

A discussion of the different factors involved in ideal airport planning. Four viewpoints are suggested as being equally important in the planning process; 1) the comprehensive-functional balance in planning; 2) the federal-local balance; 3) the user and non-user considerations; 4) the goals of public and private interests. The conclusions reached from an analysis of these factors indicate that airport system and location decisions should be made by agencies specifically charged with balancing of various interests rather than by air transportation agencies which function at various levels, local, state and federal. The metropolitan level is the one where the diverse interests appear to be best balanced, and should be the level where airport planning should take place. The agency itself should be geared to a balancing of the diverse interests and not be a representative of any one factor.

8140 **SELF DEFENSE AGAINST SURFACE TRANSPORTATION NOISE.**
Veneklasen, Paul S.
in *International Conference on Noise Control Engineering, 1973, Inter-Noise 73,* pp.201-209.

An analysis of the various options to combat highway noise and ways to improve the specific methods. The three main techniques are indicated to be: 1) legal enforcement to decrease noise at the source; 2) improved highway design; and 3) building design. In the area of improved legislation, a prime need is truck noise regulation on a Federal basis, because most of the vehicles which create the most annoying noise pass freely through states with differing standards. Highway design is discussed in relation to the use of noise barriers. Surveys indicate that continuous noise barriers may raise the cost of the highway by 5 percent. The possible use of restrictive zoning is also considered. A major alternative is shown to be improved building design adjacent to highways. Innovative planning of a residential development is proposed with the use of a C shaped form, which is itself an integrated architectural noise barrier. The building itself shields the interior of the C from highway noise. The building side towards the highway must be soundproof and of adequate acoustical design. A continuous development of C shaped buildings would improve noise reduction for the community behind it. Utilizing this type of planned development, it would not be necessary to zone out residential construction or noise-sensitive buildings from the large areas adjacent to highways.

8150 **TOWN PLANNING AND TRAFFIC NOISE.**
Hewling, Michael.
Newcastle (Eng.) City Planning Dept.
Applied Acoustics V.2 1969 pp.247-257.

A discussion of traffic noise and planning for the planner and the architect who have little knowledge of the characteristics and the behavior of noise or the techniques needed for its evaluation.

In analyzing city planning problems in regard to noise, it is first necessary to determine 1) the level of the noise threshold of an area; 2) the future intensity of traffic along with the mix of vehicles, the peak periods, and the intensity of noise; and then 3) to assess the range of intensity of noise that can be expected in an individual building and the means necessary to reduce it. The philosophy of planning for noise is seen in Newcastle, England, where special attention is given to heavily used streets and along the routes of principal urban roads and motorways. The pattern of motorways takes out traffic from the central area where the emphasis is on maintaining the highest environmental standards for the pedestrian. Land use adjacent to the motorway is restricted to uses least affected by noise. The motorist on the motorway is also considered in the creation of the most beneficial environment as can be designed. Particular features of planning in new areas include the design of 5 story residential units as specific barriers against motorway noise with special floor plans and non-opening double glazed windows.

8160 **TRAFFIC NOISE.**
Sexton, Burton M.
Traffic Quarterly V.23 N.3 July 1969 pp.427-439.

A review of street and highway noise and its relationship to land use and creative planning. Planning for noise control in construction is particularly necessary when major highways are unavoidably located adjacent to quiet areas. An overview of the basic methods of physical measurement of sound is made, along with an outline of varying human reactions to sound. Noise controls incorporated into specific design features are discussed, including walls and barriers, landscaping, use of elevated highway sections, use of cut sections, and the use of filled sections. A relative assessment of the effectiveness of these features is made, with reference to the type of highway section and the type of area that the highway traverses.

8170 **TRAFFIC NOISE.**
Stephenson, R.J. and G.H. Vulkan.
Greater London Council, Scientific Branch.
Journal of Sound and Vibration V.7 N.2 1968 pp.247-262 20 refs.

A survey of some of the results of the London Noise Survey along with planning to mitigate the effects of traffic noise on the environment. The importance of lorries and buses in contributing to high noise levels is discussed, as are the effects of gradients and speed. The design of urban motorways in order to reduce noise levels is seen to be important for the future, and measurements from existing motorways are examined. The basic difference between noise from urban traffic and motorway traffic is seen to be that, in the latter case, the noise is produced by vehicles moving at a fast speed, when both tire and aerodynamic noise become important. However, in normal town traffic, engine noise predominates. Planning of future motorways should include 1) selection of the route to take account of existing physical barriers; 2) the construction of the road in a cutting or tunnel; 3) the erection of noise screens; 4) the insulation of buildings adjacent to the roadway. In existing roads, the introduction of one-way schemes and the effects of road-widening on noise levels is examined. One-way systems may spread the noise level, but will expedite the traffic, resulting in shorter exposure to noise. Road widening may also spread noise levels over a larger area, but usually results in smoother traffic with reduced stops, starts and gear changes, which account for much of the high noise levels.

8180 **URBAN PLANNING AGAINST NOISE.**
Stephenson, R.J. and G.H. Vulkan.
Official Architecture and Planning May 1967 pp.643-647.

A review of the factors of traffic noise, particularly motorway traffic noise, that must be taken into account for planning purposes. In the case of proposed motorways, a possible method of study is to draw noise contour lines along the motorways, based on available information and taking into account such factors as elevation or depression of the road, the number of lanes, the natural ground contours, shielding by buildings and present ambient levels, where known. A point-by-point assessment can then be made to decide how different areas should be treated. For example, whether barriers along the edge of the road or double windows in

houses would provide a better solution. In some cases, where two possible alternative routes are otherwise similar, the effect of noise on environment may become the deciding factor. Current noise situations needing special solutions include the problem of traffic noise effects on tall buildings. The higher levels in a tall building are further away from the vehicles immediately below, but the catchment area from which the noise comes is greater. Individual vehicle noises tend to diminish while traffic noise becomes more a steady roar. On the highest floors, the effect of wind noise, which, although it may tend to mask traffic noise, can also become very unpleasant. The design of a building can be used as a protection against traffic noise. Although the height of a building cannot be used as a protection against traffic noise, its design can be. One example is by the use of podia, which effectively shield the floors immediately above them. The particular problems caused by heliports in built-up areas are also surveyed.

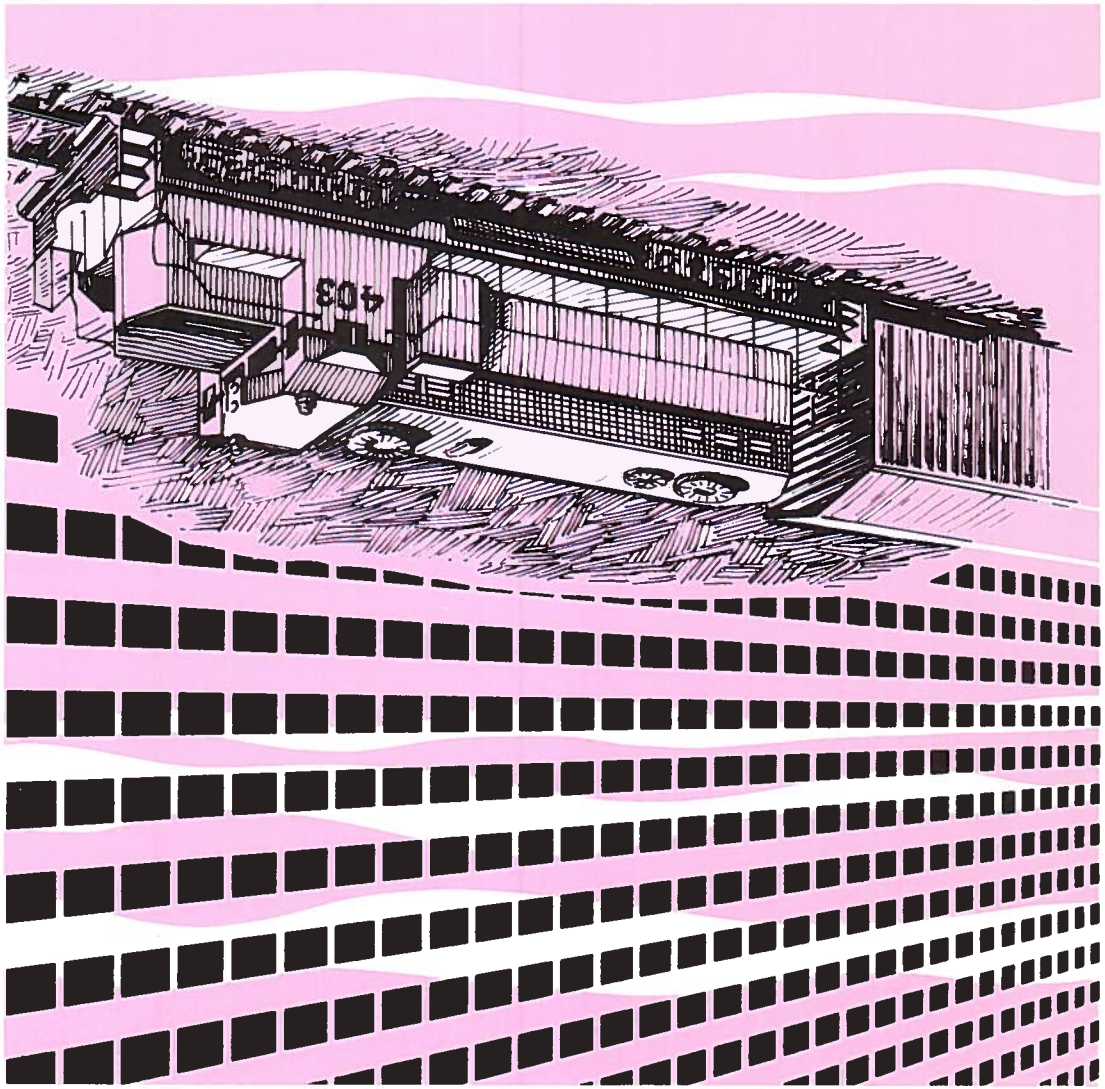
8190 **URBAN PLANNING AND NOISE CONTROL.**

Bragdon, Clifford R.

Sound and Vibration V.7 N.5 May 1973 pp. 26-32 40 refs.

An overview of land use management techniques for noise abatement. The discussion includes the use of site design analysis, environmental zoning, building codes, noise ordinances and Federal environmental legislation. The need for successful noise control by planning is highlighted by a survey of recent successful litigation by citizens or municipalities against airports. A comprehensive master plan will attempt to alleviate or avoid noise conditions that lead to litigation. The specific elements of such a plan usually include the private use of land, community facilities and transportation, along with a consideration of potential environmental impacts including noise. The specific factors regulated by zoning include: 1) Height and bulk of structures; 2) Land parcels and relative size of open spaces; 3) Density of population; 4) Use of structures and land for residential, commercial, industrial or other purposes. Zoning ordinances also can include acoustical criteria that will regulate fixed noise sources. Planning for regional transportation noise problems can be implemented by regional zoning, particularly in airport environs. Design of ground transportation systems is reviewed with regard to reduction of noise. A survey of the construction costs of alternative highway designs is given along with the construction costs of different highway noise barriers. A major element of successful planning is the continuing incorporation of noise criteria wherever possible.

XI



SUMMARY OF MAJOR APPROACHES TO TRANSPORTATION NOISE CONTROL AND ABATEMENT

IX Summary of Major Approaches to Transportation Noise Control and Abatement

This section deals with the current techniques of noise control and abatement. The control of aircraft noise at the source has been the concern of varied government research, particularly the NASA Quiet Engine program. New operational techniques for landing and take-off procedures have been developed within current technology. Current concerns in motor vehicle noise abatement include the DOT Quiet Truck program aimed at truck tire research, diesel engine research as well as training for highway enforcement personnel. Rail rapid transit is considered in relation to the noise abatement problems of older systems. The design of currently planned systems includes a variety of noise control techniques that effectively reduce existing noise levels. Other techniques for noise abatement are discussed including natural and constructed highway barriers, insulation techniques, and the use of vegetation.

A. CONTROL OF NOISE AT THE SOURCE

1. Aircraft 9010-9050

9010 **AIRPORTS AND THE COMMUNITY.**
National Industrial Pollution Control Council, Sub-Council Report Feb. 1972 35p.

An investigation of the aircraft noise problem, dealing with the effects of aircraft noise on humans, as well as with airport operations and development. The problems of airlines and aircraft and engine manufacturers are also outlined. A review of past and current efforts to reduce noise is made, including noise reduction flight procedures. Engine starting procedures and ground noise control attempts are examined, and the problems of scheduling these controls are indicated. The need for the formation of a single responsibie agency to study and develop one single noise measuring system and noise exposure method is indicated. A consistent standard for noise control developed in conjunction with various levels of state and local governments is seen to be another necessary function of such an agency. In addition, the development of a national non-profit terminal development corporation owned and controlled jointly by Federal and/or state and local governments and the airlines, is seen as a solution toward current airport management problems which hamper noise control currently.

9020 **DESIGN TRENDS FOR NOISE CONTROL FOR AIRCRAFT POWER PLANTS.**
Ciepluch, Carl C.
National Aeronautics and Space Administration in *International Conference on Noise Control Engineering 1972, Inter-Noise 72* pp.320-322 2 refs.

A survey of the NASA-initiated Quiet Engine Program, which was started to help relieve the airport community noise problem. The objective is to develop engine noise reduction technology suitable for use on subsonic, conventional takeoff and landing-type aircraft. The use of a high bypass ratio engine reduces jet velocity and jet noise, but yet retains optimum performance. In addition, design features aimed at low fan noise production are introduced into the Quiet Engines. An acoustically treated, flight-type nacelle for the engines has been designed as well. Tests indicate that substantial reduction in aircraft noise levels can be achieved by this program. When the noise level for a DC-8 aircraft is calculated with a flight weight untreated Quiet Engine, current regulation levels are met with 7 or 8 dB less than is needed. These noise levels are about 20 dB below the current DC-8 noise levels. Furthermore, if an acoustically treated nacelle is added to the Quiet Engines, the aircraft produces an additional 7 dB less noise. An estimate is made of the economic penalty due to the acoustic configurations needed for quiet engines, and it is seen that direct operating costs would be increased by 5 percent.

9030 **FLIGHT EVALUATION OF THREE-DIMENSIONAL AREA NAVIGATION FOR JET TRANSPORT NOISE ABATEMENT.**
Denery, D.G. et al.
Journal of Aircraft V.10 N.4 April 1973 pp. 226-231.

The results of NASA and American Airlines research to evaluate the operational feasibility of two-segment approaches for noise abatement. Area navigation is used to establish the upper glide slope and an Instrument Landing System (ILS) was

used to establish the lower. Using this technique, the aircraft approaches on a steeper than normal glide slope and then makes a transition to the standard approach path in time to stabilize prior to the landing. With an ILS approach for comparison, the procedure gave a noise reduction of 18 EPNdB at the outer range and 8 EPNdB, 1.1 nautical miles from touchdown. Although the program is not aimed at passenger evaluation of the procedure, the onboard observers did not express any special concern of discomfort during the two-segment approaches.

9035 **FOURTH FEDERAL AIRCRAFT NOISE ABATEMENT PROGRAM FY 1972-73**
U.S. Dept. of Transportation, Office of Noise Abatement Jan. 1973 79p.

A summary of subsonic and sonic boom research and development under the sponsorship of the Dept. of Transportation. Included is an overview of the historical background of federal involvement in aircraft noise abatement as well as references to important legislation. The problem of aircraft noise and the urban environment is examined, and the Noise Exposure Forecast (NEF), which was developed to assist land use planners in defining noise sensitive areas adjacent to airports, is explained. Prospects for future abatement of aircraft noise are examined and found to be promising as increasing numbers of older noisier aircraft are retired. The sonic boom phenomenon, sources of jet engine noise and recent noise technology are also outlined.

9040 **A PROPOSED LITTORAL AIRPORT.**
Rettinger, M. and Don W. Green.
in *International Conference on Noise Control, 1972, Inter-Noise 72* pp.344-349.

A study for an offshore airport 7.8 miles from the California mainland which would result in a 99 percent reduction in unwanted aircraft noise, in comparison with Los Angeles International Airport. The estimated cost of the seadrome being 1.4 billion has caused previous proposals to be only speculative. However, the advent of class action law suits on the grounds of nuisance, and continued emphasis on ecological and environmental protection have caused renewed interest. The total amount of suits against Los Angeles Airport in 1972, is estimated at 4.2 billion, triple the initial cost of 1.4 billion. Relative benefits to the environment are discussed along with gains from concurrent oil and natural gas drilling to augment the initial economic investment. Weather and climate conditions are seen to be manageable by present technology. A simultaneous harbor and docking facility would provide additional financial benefits while the currently noisy San Pedro Bay could revert to a quiet coastal environment.

9050 **RECENT ADVANCES IN AIRCRAFT NOISE REDUCTION.**
Skully, R.P.
U.S. Federal Aviation Administration.
in *Airports, Challenges of the Future* American Society of Civil Engineers, New York, 1973 pp. 43-53.

A discussion of current methods to lessen aircraft noise in conformance with the 1970 FAA noise level requirements for new aircraft. Progress is seen to have been made when a comparison is made between the productivity of a plane, the number of seats, and the total acreage impacted by the planes at 100 EPNdB and above, for a takeoff and an approach. For the 707 in late 1958, 84 acres were impacted per passenger seat. For the DC-10 in 1971, the combined impact of each takeoff and landing is approximately 500 acres, and the acres per seat total three. In addition to noise reduction at the source, reduction by operational procedures has been implemented. Changes in takeoff and climb as well as the approach and the landing phases have resulted in lower noise signatures. Introduced in 1972, a new approach procedure permits the pilot to commence his approach in a cleaner configuration; that is, using a lesser landing flap setting when permissible, and a lesser approach flap setting throughout the approach. But using a lower flap setting, drag is reduced, and a lower power setting is required which results in lower sound levels. In the 727, a

reduction of 7 EPNdB is possible in comparison with the old procedure. Possible new noise reduction techniques include assigning a noise index to an airline based upon the aircraft composition in its fleet. The airline would be assigned a target date for reducing its overall noise index.

2. Motor Vehicles 9310-9380

9310 ARE PRESENT HORNS, WHISTLES AND SIRENS NECESSARY FOR COMMUNICATIONS?

Eldred, K.M. and B.H. Sharp.
Wyle Laboratories.
in *International Conference on Transportation and the Environment, 1972 Proceedings* pp.277-285
9 refs.

A review of the noise-producing warning systems used on emergency vehicles and trains. The various types of existing audible warning systems and their historical development are discussed, together with an analysis of their effectiveness in warning people of imminent danger. It is concluded that such systems perform adequately in many situations, but not when the recipient of the warning signal is inside another vehicle. The historical tendency has been to increase the sound power output of warning devices to try to keep up with the distance requirements associated with higher speeds. Improved vehicle noise reduction also necessitates a louder warning noise because vehicles do not emphasize their approach. This method has not succeeded in achieving adequate warning system effectiveness for all situations, although it has succeeded in increasing the noise levels in cities. The solution is seen to be the development of alternate means for warning occupants of vehicles of immediate danger so that audible warning systems of reduced acoustic power can be used to warn the pedestrian or other persons outside vehicles.

9320 CONTROL OF ROAD NOISE BY VEHICLE.

Aspinall, D.T.
Journal of Sound and Vibration V.13 N.4 1970 pp.433-444.

A discussion of the complicated task of reducing the noise emitted by commercial vehicles. Not only are the mechano-acoustics aspects complex, but there are serious commercial limitations arising from the cost of noise reduction in a very competitive industry. Noise radiated by the engine is seen to be the principal source of noise. The principles of design of enclosures to attenuate the noise are presented, and noise reduction is achieved by exhaust silencing the various designs of engine enclosures. It is concluded that it is possible to get down to 80 dBA with the appropriate amount of engine enclosure at a weight penalty of 9 lbs. per dBA. However, space limitations on vehicles with larger engines may make the fitting of an enclosure extremely difficult, and may necessitate considerable redesign of the vehicle. 80 dBA is probably the lower limit of commercial vehicle noise and is determined by tire noise as well. These techniques can make vehicles considerably quieter, but any acoustical treatment involves penalties in weight, cost, space, etc. For this reason it is cheaper and more effective to plan noise control at the design stage than it is to modify existing vehicles.

9340 DOT'S 4 POINT PROGRAM TO REDUCE TRUCK NOISE.

Close, William H.
U.S. Dept. of Transportation.
Automotive Engineering V.81 N.2 Feb. 1973 pp.36-39.

A survey of the U.S. Department of Transportation's program to reduce noise from trucks to a maximum of 75 to 78 dBA to aid the highway noise abatement program. The truck Noise Reduction Program for controlling highway vehicle noise on a nationwide basis is divided into 1) truck tire noise research; 2) the diesel truck noise reduction demonstration project; 3) diesel truck and fan optimization; 4) highway patrol training and equipment supply. Truck tire noise research has involved 1) determining the parameters important in tire noise, and 2) identifying the variables that can be controlled for the near-term reduction of tire noises, with the ultimate goal being 3) the demonstration of quiet, long-wearing tires. The diesel truck noise reduction demonstration project is aimed at developing technology applicable to future designs that must meet very stringent future noise level controls. The research involving the diesel truck intake, and exhaust muffler and fan optimization seeks to determine ways to ultimately reduce the noise levels of most trucks by an

overall 7 dB level by a practical retrofit program. The highway patrol aspect of the program involves training highway patrolmen and state officials, and supplying equipment for each state to undertake effective roadside and certification noise enforcement programs.

9350 **ORIGINS OF DIESEL TRUCK NOISE AND ITS CONTROL.**

Waters, P.E. and T. Priede.

Great Britain, Institute of Sound and Vibration Research.

in *International Conference on Transportation and the Environment 1972, Proceedings* pp.256-272 20 refs.

A discussion of the fundamental origins of truck noise. The origins of noise radiated by engine structures are detailed and fully examined including effects of engine speed, engine size, load, and individual design. Sources of noise related to engine speed are engine intake noise, exhaust noise, cooling fan noise, and noise emitted by the engine structure and certain accessory elements. Sources of noise related to road speed include part of the transmission which is not changed by engagement of various gears, tire noise and dynamically generated noise. A method of predicting engine noise, from basic engine speed and piston diameter is given. Tire noise origins, including the effect of speed and tire size, and road surface are explained. Control of truck noise by engine shields and by changing basic principles of engine design, is compared. Recommendations for quieter trucks include an emphasis on engine redesign focusing on limitation of maximum engine rated speed, and limitation of cylinder bore diameter. This can be achieved by using engines with a larger number of cylinders, and increase of engine load, even to 4 times the values used at present in design of engine structures. None of these considerations are seen to conflict with economic considerations of design and operation.

9360 **PROGRESS IN THE REDUCTION OF DIESEL ENGINE NOISE.**

Mason, Robert L.

U.S. Dept. of Transportation.

Sound and Vibration V.8 N.2 Feb. 1974 pp. 16-19 5 refs.

An overview of the U.S. Department of Transportation program to research the noise reduction capabilities of a wide cross section of intake and exhaust components currently available for heavy duty trucks and buses. The four basic types of air intake system configurations used on diesel powered trucks include 1) exposed air cleaner with elevated (snorkel) inlet; 2) exposed air cleaner with integral inlet; 3) underhood air cleaner with elevated inlet; and 4) underhood air cleaner with front or side inlet. The noise levels of these systems range from 79 dBA to 56 dBA for currently available air cleaners. At these levels air inlet noise can be considered only a minor contributor to the sound inlet of most current diesel powered vehicles. The three basic exhaust systems used on diesel powered trucks include: 1) horizontal mufflers with vertical tail pipes; 2) horizontal mufflers with horizontal tail pipes; and 3) vertical mufflers with vertical tail pipes. The lowest sound levels range from 75 dBA to 80 dBA. The lowest maximum sound levels are obtained from systems incorporating vertical tail pipes. Horizontal tail pipe systems generally produce a 2 to 3 dB higher noise level than do vertical systems. The information is intended to aid vehicle manufacturers, owners, service organizations, operators and noise regulation and enforcement agencies on the performance and present state of development of these components. These data show the difference in data gathering and presentation between component manufacturers. The vehicle manufacturer and even more important, the replacement purchaser presently lacks an accurate method that can be related to manufacturers' tests.

9370 **TRANSPORTATION VEHICLE NOISE CONTROL.**

Franken, Peter A.

Archives of Environmental Health V.20 N.5 May 1970 pp.636-643.

A general discussion of aircraft noise, due to turbine engines, and automobile noise, due to the internal combustion engine. Possible approaches to noise control are discussed, including physical and operational modifications of the noise source, modification of the path of noise propagation, and modification (or relocation) of the receiver.

Source modifications include 1) Physical, with a need to reduce speeds, add mufflers, isolate vibrating elements, enclose source; 2) Operational, such as relocate source, and restrict source operations; 3) Path and receiver modifications with a plan to erect barriers, manage land use and modify buildings. The question of noise control acceptability is discussed in social terms as well as the costs of the solution, and whether these costs can be measurable in dollars, weight, maintenance, complexity of regulations, delays, inconveniences, or other terms.

9380 **THE TRUCK NOISE PROBLEM, AND WHAT MIGHT BE DONE ABOUT IT.**
Ringham, Rodger F.
in *International Conference on Transportation and the Environment, 1972, Proceedings* pp.154-157.

A survey of typical truck noise levels and sources along with an estimation of predictable future truck noise levels. It is hoped that today's attainable 88 dBA for heavy trucks can be reduced to 86 dBA by 1975 and 84 dBA by 1978, relying on existing technology. Improvements in engine structure, tires, mufflers and cooling systems are discussed. Efficient techniques for enforcement of noise regulations are indicated, including a method for calibration of non-standard sites for determination of noise standards. Current imposition of a 92 dBA limit on older trucks would insure at least the installation of retrofit mufflers and one of the most blatant current noise sources would be eliminated.

3. Rail Rapid Transit Systems 9610-9660

9610 **ACOUSTIC STUDIES.**
Parson, Brinckerhoff, Tudor and Bechtel, Inc.
Technical Report No. 8, San Francisco Bay Area Rapid Transit District Demonstration Project TR8 June 1968 105p. refs.

A survey of the noise and vibration studies for the Bay Area Rapid Transit District System. Several of the studies involve the investigation of new concepts of noise and vibration control, such as the use of sound barrier walls (called sound barriers or parapets) along the right-of-way, as well as wheel damping and the use of rail fasteners incorporating vibration-reduction and noise-reduction features. The rank order of the various important sources of noise produced by steel-wheel vehicles passing over steel rails is determined and various methods of noise reduction proposed.

9620 **COMMUNITY NOISE FROM SURFACE TRANSPORTATION SYSTEMS.**
Chen, Tio C.
Parsons, Brinckerhoff, Quade and Douglas, Inc.
in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.450-459.

A survey of traffic noise levels that might be generated by various forms of transit modes under consideration by the mass transit industry. A relative assessment is made of busway alternatives, light rail tunnel systems and aerial structure systems. Prediction methods for noise levels of these future transit alternatives are discussed, and abatement measures and environmental designs are suggested. Among these are: 1) improvement of new vehicle design with noise control as a major consideration; 2) transit corridor design which minimizes noise propagation; 3) a combined air and noise abatement measurement that involves a possible tradeoff between air pollution and noise pollution to yield an optimal community environment; 4) the concept of an optimal plan involving tradeoffs among traffic systems with minimum pollution impacts and energy conservation; and 5) planning of buffer zones with use of physical abatement structures as depressed highways, noise barriers, landscape plantings, improved pavements.

9630 **A METHODOLOGY FOR DETERMINING MINIMUM COST RAPID TRANSIT NOISE CONTROL.**
Lotz, Robert and Leonard C. Kurzweil.
U.S. Dept. of Transportation.
in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.175-180 11 refs.

The description of a methodology to be used as a framework for planning and designing rapid transit noise control for minimum cost. The basic elements of the method can be applied, conceptually at least, to any guided transportation system. Data is collected in three different areas: 1) Noise levels are determined in each source-path combination,

that has a noise level high enough to need reduction; 2) Noise reduction estimates are determined for specific noise abatement techniques appropriate for each situation; and 3) The cost data for these techniques is calculated. This results in the determination of the minimum cost control options available for each situation. The calculated costs are expressed in "cost units" which balance effective noise reduction against expenditure. Applications to specific Mass. Bay Transit Authority situations suggest that 15 to 20 dBA of rail transit noise reduction for wayside communities is achievable with present technology on older transit systems. Similar reductions are estimated to be achievable in the present railcar and station situation.

9640 **NEW YORK CITY TRANSIT SYSTEM NOISE.**

Gerson, R. and F.C. Hart.

New York City Bureau of Noise Abatement.

in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.171-174.

An analysis of the process by which the New York City Environmental Protection Administration hopes to set the standards for noise levels in the rapid transit system. After the sources of the noise are identified, allowable sound levels and acoustical performance, based on the largest economically feasible and available technology, will be determined. The effects of noise on subway riders is discussed, as well as the effects on people living adjacent to the system. These effects include possible hearing impairment, temporary or permanent, nervousness and fatigue. Current noise levels are seen to be frequently at 90 dBA and numerous instances at 100 dBA and above. Noise sources and solutions are 1) wheel-rail noise which can be improved by a wheeltruing program to keep wheels smooth, as well as a rail maintenance program to keep rails smoother; 2) track bed composition which can be improved for greater sound absorption; 3) curve squealing which can be designed for quieter operation; 4) car characteristics which can be redesigned for quieter operation; 5) brake squeal which can be improved by use of the slip-slide brake system; 6) door mechanisms which can be improved; 7) compressor noise, which can be improved by acoustical treatment. Cost should be balanced against the psychological and physiological tools on humans and the benefits derived by preventive maintenance.

9650 **NOISE IN TRANSIT SYSTEMS.**

Huss, Martin F. and William R. McShane.

Polytechnic Institute of Brooklyn.

Traffic Quarterly V.27 N.2 April 1973 pp.239-253 22 refs.

The article summarizes previous studies that have shown that rail rapid transit systems in the other parts of the world are quieter than those of New York City. The Hamburg (80 decibels) and Toronto (85 decibels) systems, both of which are "steel-on-steel," prove that proper design and maintenance can provide a pleasantly quiet system and, in fact, can be quieter than a rubber-tired system. The average levels in New York trains, by contrast, are between 95 and 100 decibels. Some of the techniques used successfully to reduce noise levels are: sound-absorbing concrete blocks between rails in stations; lubricated rails on curves; rubber suspensions on cars; damped and isolated car body design; continuous welded rails; special wheels, either damped or resilient; and air springs. All these techniques can be implemented now in planning stages.

9660 **RAIL MASS TRANSPORTATION SYSTEM PLANNING AND NOISE.**

Wilson, George Paul.

Wilson, Ihrig and Assoc., Inc.

in *International Conference on Transportation and the Environment 1972, Proceedings* pp.408-418 17 refs.

A discussion of new high-speed rail rapid transit system operations and the expected noise levels. The tested levels are much less than traditionally expected due to modern design concepts which include specific features for reducing noise and vibration. Testing of operational and experimental rail transit vehicles has provided data on specified noise characteristics. These can be used during the planning of transit systems to determine the ex-

pected wayside or community noise levels for various types of wayside structures, vehicles, and operations conditions. Thus, design features or system characteristics, which should be included for the control of noise, can be determined. The criteria for acceptability of transient noise from surface and aerial structure transit operations in residential areas is a complex decision, but it is generally acceptable if the peak level does not exceed 70 dBA. In general, a modern rail rapid transit system has the potential to be a mass transportation system which will create less noise and community intrusion than any alternate means of transportation currently in use or planned for the near future.

B. OTHER TECHNIQUES FOR NOISE ABATEMENT 9810-9910

9810 THE ECONOMIC AND ENVIRONMENTAL EFFECTS OF ONE WAY STREETS IN RESIDENTIAL AREAS.

Kennedy, John and Dennis Hill.
Michigan State Dept. of Highways
in *Highway Research Board No. 305*
National Highway Transportation Board, Washington 1973, pp.75-79 refs

An overview of the research done on one-way streets as they affect residential property values and general environment conditions. One-way streets are popularly characterized as being an economical and efficient method of relieving traffic congestion. Also, they can be effective in lessening the duration of overall traffic noise of a neighborhood because of the speedier flow. Accident studies, travel time studies and capacity studies agree on the practicality of the method. An analysis is made of the impact on property value, business trends and general environmental conditions. Among the factors considered are 1) theory concerning agricultural locations; 2) transportation and urban land use; 3) environmental preferences including noise levels; and 4) the role of the urban economy. Reactions of actual residents adjacent to a one-way system or systems are included. The fact that adverse environmental conditions are intensified when a residential street is converted to one-way usage to help relieve congestion on an adjacent commercial corridor is considered in reaching conclusions on one-way streets. It is noted that despite the adverse environmental impact on residential streets, property values remain constant or increase substantially. It is unfair to evaluate the cost benefit effects on the one-way conversion by just the factors of economic and environmental effects on adjacent residents without considering the benefit accruing to the thousands of motorists using the system. Much can be done to minimize or eliminate adverse effects through improved highway design.

9820 EFFECTS OF PLANTINGS ON RADIATION OF HIGHWAY NOISE.

Reethof, Gerhard.
Journal of the Air Pollution Control Association
V.23 N.3 March 1973 pp.185-189.

A discussion of the results of research to determine the effectiveness of plantings on highway noise. An attempt to attenuate automobile and particularly diesel tractor-trailer generated noise, is made by the interposition of extensive and dense plantings of all trees and underbrush between the highway and the community. It is determined that a belt of dense man-made growth of tall trees and underbrush can give as much as 5-8 dB truck or car noise reduction/100 ft. of planting depth. Natural growth of deep forests are measured to give from 3 to 5 dB attenuation per 100 ft. of planting depth. Planting depth of at least 100 ft. is required to give reliable results, with tree heights of 40-50 ft. and densities of 50-70 ft. visibility needed for good effect. A mature belt of either coniferous or deciduous forest with underbrush can be responsible for substantially more acceptable noise levels in a community which is separated by such a noise barrier from a heavily traveled highway.

9830 EUROPEAN EFFORTS TO REDUCE THE IMPACT OF TRAFFIC NOISE.

Alexandre, Ariel.
Organization for Economic Cooperation and Development.
in *International Conference on Noise Control Engineering, 1972 Inter-Noise 72* pp.205-209.

An overview of current enforcement of noise legislation and local measures to reduce the impact of traffic noise in Europe. Currently in Common Market countries, a typical vehicle type is measured by ISO standards and the requirements for

a certificate of conformity are determined. The noise limits are seen to be not sufficiently low because too many vehicles are satisfying these limits. Because Europe is highly urbanized and vehicles move more and more freely from country to country, there is a need for uniformity in regulations as well as enforcement measures. Only Switzerland has maximum noise levels for stationary vehicles, which are then easily checked by police. Several countries, including France, Switzerland, Norway, Germany and Spain, intend to use vehicle-testing centers built for compulsory periodical inspections as a means to check excessive noise as well. Lausanne is an example of an individual city with a Noise Brigade in the police department. Their special function is to subjectively decide if a vehicle is causing too much noise and to stop it for inspection. France has also instituted 37 noise squads through the country. City planning and traffic control measures are briefly discussed, including the use of experimental traffic screens in London and Paris. In France, a system of zoning is applied in new planned towns to reduce the effect of traffic noise, while in Stevenage, England, road traffic, cyclists and pedestrians are equally segregated to the betterment of residential areas. Vehicle-free zones have been instituted in some cities as well as night restrictions on through traffic in city centers. France has also started an "acoustic approval rating" for public housing which meets specific standards of internal and external soundproofing. The builder who meets specifications is eligible for larger loans to be advanced as an incentive toward quieter housing.

9840 **FREEWAY FENCING AS A COMPONENT OF NOISE ATTENUATION BARRIERS.**

Merchant, H.C. and M.R. Yantis.
University of Washington.
in *National Conference on Noise Control Engineering, 1973, Noise-Con 73* pp.110-113 15 refs.

A study of the modification of chain-link freeway fencing into an acoustic barrier. The various situations under which the modifications would be feasible are determined by suitable topography and the height of the existing fence. Tests show that when an effective barrier height for a particular site is close to the height of the existing fence, a minimum amount of treatment would be needed. A marginal (3 dBA) attenuation of highway noise could be justified if the treatment is simple and inexpensive enough. Plywood is suggested as a possible treatment that could be attached to the fencing, as it is the least expensive and comes in a continuous range of thicknesses. In some highway noise situations, very thin plywood would be effective with a savings in cost and an ease in installation and repair. However, when the proposed barrier height substantially exceeds the height of the existing fence, the thickness of plywood would be determined by acoustic considerations which would dominate the design.

9850 **INDEPENDENT VERSUS NARROW-MEDIAN ALIGNMENT, COMPARATIVE ECONOMY, SAFETY AND AESTHETICS.**

Peet, James S. and Dennis Neuzil.
in *Highway Research Record No. 390*
National Highway Research Board, Washington 1973. pp.1-14 refs.

A review of the relative merits of independent alignments vs. constant median alignment for a high type of roadway design. Independent alignments and other wide median designs are seen to be generally superior to narrow median design from the standpoint of safety and aesthetics as well as noise control. A wide median will reduce the intensity of noise adjacent to the roadways because traffic density is reduced. It also permits the planting of trees and shrubs that tend to reduce perceived noise levels. Economic analysis proves that within certain limits, independent alignment can often be built and maintained at less total annual cost than some narrow median designs.

9860 **INSULATING HOUSES AGAINST AIRCRAFT NOISE.**

Donato, R.J.
National Research Council of Canada.
Journal of the Acoustical Society of America
V.53 N.4 April 1973 pp.1025-1027.

A research study to establish guidelines by which structures can be designed so that outside noise is reduced to recommended internal levels.

A series of calculations is made to establish construction guidelines for the financing of housing near airports. The aim is to produce tables of various types of building components that could be used to produce the kind of insulation required. The components are chosen for their acoustical properties, their relative areas, the degree of intrusive sound that may be tolerated and the noise exposure forecast contours (NEF). The estimate of performance of these components has been obtained from laboratory tests and a need exists to put these ideas to the test. The next stage is to build experimental houses, subject them to aircraft flyovers and measure the indoor level produced by various combinations and types of components.

9870 **NOISE ABATEMENT AND CONTROL.**
Highway Research Record, No. 448 68p.
National Highway Research Board, Washington, 1973.

Seven studies dealing with the problem of traffic noise control. One report gives a broad overview of traffic noise and its effect on people by indicating the basic variables of sound that must be considered. An emphasis is made on the distinction between traffic noise effects that are comparatively easy to quantify, such as speed interference, and traffic noise effects that are comparatively difficult to quantify, such as sleep interference and general annoyance. A second report discusses the four categories of noise (intake, exhaust, engines and chain noise) for four types of vehicles (automobiles, trucks, motorcycles and buses). Other reports deal with the construction of noise barriers at critical points along major highways. Data is presented on the noise reduction effectiveness of specific highway noise barriers. In addition, the newest concept in highway noise barrier design, the Kinematic Sound Screen, is described. The special feature of this barrier is that the spacing between the columns that make up the sound screen permits the motorist to "see through" the barrier at highway speed.

9880 **NOISE REDUCTION BY VEGETATION AND GROUND**
Aylor, D.
Journal of the Acoustical Society of America, V.51 N.1 Jan. 1972.

A research study comparing the transmission of random noise through various forms of vegetation. Transmission through dense corn, a dense hemlock plantation, an open pine stand, dense hardwood brush, and over cultivated soil, was measured. The relation between attenuation and frequency in those diverse cases suggests the degree of noise reduction in any configuration of vegetation and soil. The corn is seen to effect the greatest attenuation of noise of all the vegetation, while the natural vegetation is not as effective. Where bare ground is concerned, the frequency of maximum attenuation depends on the soil permeability to air. Tilling the soil is seen to increase maximum reduction of the transmitted noise. Furthermore, earlier conflicting reports of noise reduction by vegetation appear reconciled if ground attenuation is taken into account. Scattering and ground attenuation are the principal factors in sound reduction by vegetation. Both factors attenuate relatively less sound as distance from the sound source increases. Measurements taken far from the sound source may give an underestimation of the real effectiveness of a narrow band of vegetation or soil.

9890 **THE INSULATION OF HOUSES AGAINST NOISE FROM AIRCRAFT IN FLIGHT.**
Scholes, W.E. and P.H. Parkin.
Great Britain, Building Research Station.
Applied Acoustics V.1 N.1 1968 pp.37-46 3 refs.

The results of a pilot project in which three groups of existing two story traditional houses are insulated against aircraft noise. The insulation measures include 1) the addition of inner windows placed within existing window frames, and 2) the installation of a sound-attenuating ventilator unit in each insulated room. In addition, rooms on the upper floors have additional ceiling insulation and blocked fireplace flues. Tests are then made with a helicopter noise source which effectively represents the range of broad band noise spectra. Results indicate that external noise is lessened by 35 to 40 dB without loss of ventilation. The cost of insulating three rooms per house is estimated at $450 (U.S.) per house, if large numbers of houses are treated.

9900 **TRAFFIC NOISE REDUCTION BY EARTH BERMS.**

Reeder, H.C.

Public Works V.103 N.4 April 1972 pp.84-85

A research study of the effectiveness of earth berms (barriers) as noise barriers on highways. Natural earth berms that were short in length and irregular in shape were used to provide theoretical formulas for noise reduction by barriers. Measurements were made along existing highways which had natural berms, and were compared with noise levels that would exist if no barrier was present. Trucks were used as an uncontrolled noise source. The results indicated that as high as 25 dBA attenuation can be obtained using earth barriers. Other studies have shown berms to cause less attenuation, but there is reason to believe that the amount of foliage on the individual berm is a factor in effectiveness.

9910 **WINDOWS, THE WEAK LINK.**

Yerges, L.F.

Sound and Vibration V.5 N.6 June 1971 pp. 19-21.

A systematic design approach to windows in exterior walls of buildings near airports. First the noise exposure must be forecast, then the required insulation determined, and finally the choice of adequate materials and construction details. Construction providing adequate noise protection near airports is 15-20 percent more expensive than standard construction and windows if they are included usually are the weak link. To determine the probable external noise exposure from aircraft, the straight line distance to the nearest airport apron position (not just to the edge of the airport) must be measured. Suitable noise levels for different categories of buildings are predecided. The acceptable interior level is subtracted from the anticipated exterior level to determine the external wall insulation needed. Single, double or triple glazed panes of varying construction and design are among the available choices.

AUTHOR INDEX

SUBJECT INDEX

GLOSSARY

A-SCALE SOUND LEVEL (dBA) - The A-scale sound level is a quantity, in decibels, read from a standard sound-level meter that is switched to the weighting scale labeled "A." The A-scale sound level emphasizes middle frequencies.

ABSORPTION - Absorption is the ability of material to absorb sound energy.

ACOUSTICS - Acoustics is the science of sound, including its production, transmission, and effects.

AMBIENT NOISE - Ambient noise is the background noise or prevailing general noise, that has a measurable intensity, in a given environment.

ANALYSIS - The analysis of a noise refers to the composition of the noise into various frequency bands.

AUDIOGRAM - An audiogram is a graph or a chart showing response or loss of hearing as a function of frequency. The audiogram is usually plotted by an audiometer.

AUDIOMETER - An audiometer is an instrument for measuring the threshold or sensitivity of hearing. It produces audiograms by plotting the levels at which the subject can or cannot hear.

BACKGROUND NOISE - Background noise is the total of all noise in a system or situation, independent of the presence of the desired signal. Usually it is used with the same meaning as "residual noise."

C-SCALE SOUND LEVEL (dB-C) - The C-scale sound level is a quantity, in decibels, read from a standard sound-level meter that is switched to the weighting scale labeled "C." C-scale measurements are essentially the same as overall sound-pressure levels, which require no discrimination at any frequency.

COMMUNITY NOISE EQUIVALENT LEVEL (CNEL) - The Community Noise Equivalent Level (CNEL) is a cumulative measure of community noise. The A-weighted sound level is used, and the weighting factors place greater importance on noise occurring during the evening and even greater importance on night noise.

COMPOSITE NOISE RATING (CNR) - Composite Noise Rating (CNR) is a noise exposure used for evaluating land use around airports.

CUMULATIVE DISTRIBUTION - Cumulative distribution is usually described by a table or graph showing the percentage of a given test sample or a time period during which the varying sound level equals or exceeds stated levels. The levels, such as 50, 60, 70, 80, 90 and 100 decibels are equally spaced at intervals not greater than 10 decibels.

DAMAGE-RISK CRITERIA (HEARING-CONSERVATION CRITERIA) - Damage-risk criteria are recommended maximum noise levels that for a given pattern of exposure, if not exceeded, should minimize the risk of damage to the ears of persons exposed to the noise.

DAMPING - Damping is the dissipation of energy with time or distance or conversion of energy. It is applied to the attenuation of sound in a structure or owing to the addition of sound-dissipative materials.

DECIBEL - The decibel is a logarithmic unit of measure of sound pressure (or power) calculated according to a formula. Zero on the decibel scale corresponds to a standardized reference pressure (0.0002 microbar) or sound power (10^{-12} watt). Decibel is abbreviated dB.

DOSIMETER - A dosimeter is an instrument which registers the occurrence and cumulative duration of noise exceeding a predetermined level at a chosen point in the environment.

EFFECTIVE PERCEIVED NOISE LEVEL (EPNL) - A measure which evaluates the level of a single noise event, usually from an aircraft source. It is derived from Perceived Noise Level (PNL) which is tone-corrected and calculated at 0.5-second intervals.

FILTER - A filter is a device that transmits certain frequency components of the signal (sound or electrical) incident upon it, and rejects other frequency components of the incident signal.

FREQUENCY - The frequency of a sine wave of sound is the number of times it repeats itself in each second. In acoustics, the unit of frequency is the cycle per second. In most European countries the cycle per second is called hertz (Hz), and this term has recently been adopted in the United States.

HEARING LOSS (HEARING LEVEL, HEARING THRESHOLD LEVEL) - The hearing loss of an ear at a specified frequency is the amount, in decibels, by which the threshold of audibility for that ear exceeds a standard audiometric threshold.

HERTZ - A hertz is a unit of frequency equal to one cycle per second.

HOURLY NOISE LEVEL - The average noise level during the hour. For sound it is the mean-square A-weighted sound pressure level over the hour.

JET NOISE - Jet noise is the noise produced by the exhaust of a jet into its surrounding atmosphere. It is associated with the turbulence generated along the interface between the jet stream and the atmosphere.

LEVEL - In acoustics, the level of a quantity is the logarithm of the ratio of that quantity to a reference quantity of the same kind. The base of the logarithm, the reference quantity, and the kind of level must be indicated. The unit of the level, such as the decibel, serves to identify the base of the logarithm including any constant of proportionality.

LOUDNESS - Loudness is the judgment of intensity of a sound by a human being, or just the ear. It is dependent on sound pressure and frequency. Over much of the range, a threefold increase in sound pressure is considered a doubling of loudness.

MASKING - Masking is the process by which the threshold of audibility for one sound is raised by the presence of another, or masking, sound.

MICROPHONE - A microphone is an acoustic transducer that responds to sound waves and delivers equivalent electric waves.

NOISE - Noise is any unwanted sound. It can be any unwanted disturbance within a useful frequency band.

NOISE CONTROL - Noise control is the technology of establishing appropriate acoustical criteria to minimize noise, and of modifying sources, transmission paths, and receivers of noise for the purpose of satisfying these criteria.

NOISE EXPOSURE FORECAST - The noise exposure forecast is a method used for making noise exposure forecasts of aircraft noise utilizing a perceived noise level scale with additional corrections for the presence of pure tones.

NOISE AND NUMBER INDEX (NNI) - The Noise and Number Index is a measure based on perceived noise level and with a weighting scale accounting for specific noise sources. Used in Europe for airport noise measurement.

NOISE POLLUTION LEVEL (LNP or NPL) - The noise pollution level is a measure of the total community noise, which can include both traffic noise and aircraft noise. It is usually computed from the average sound level of a sample of noise along with 2.56 times the standard deviation of the sound level.

NOISE RATING CURVES OR NUMBERS - Noise rating curves are sets of curves relating levels of sound in octave bands to acceptability for particular applications, from factory noise to noise in homes. When an octave-band analysis is plotted on a graph of NR curves, the number of the curve which is reached by the level in one or more bands is the Noise Rating Number (NRN) of the noise. In general application dBA tends to be more popular and useful than NRN.

OCTAVE - An octave is the interval between two sounds one of which has a frequency twice that of another.

OVERALL SOUND-PRESSURE LEVEL - The overall sound-pressure level is the sound-pressure level measured in a broad frequency band covering the frequency range of interest.

PHON - The phon is the unit of loudness level.

PITCH - Pitch is an attribute of the auditory sensation. Sounds may be ranked on a scale extending from low to high pitch. Pitch depends primarily upon the frequency of the sound stimulus, but it also depends upon the frequency of the sound pressure and the wave form of the stimulus.

PRESBYCUSIS - Presbycusis is a condition of hearing loss that normally occurs as a person grows older.

RANDOM NOISE - Random noise is an oscillation whose instantaneous magnitude is not specified for any given instant of time.

REVERBERATION - Reverberation is the persistence of sound in an enclosed space as a result of multiple reflections after the sound source has stopped.

SAMPLE TIME - The sample time is the total time during which a varying sound pressure level is measured.

SHIELDING - Shielding is the process of providing attenuation of sound by interposing a wall, building, or other barrier between an acoustic source and a receiver.

SOCIOCUSIS - Sociocusis is a condition of hearing loss resulting or ascribed to non-occupational noise exposure associated with environmental noise and exclusive of hearing loss associated with aging.

SONIC BOOM - The sonic boom is the pressure transient produced at an observing point by a vehicle that is moving past it faster than the speed of sound.

SOUND - Sound is an oscillation in pressure, stress, particle velocity, etc. in an elastic medium, or the combination of such oscillations.

SOUND ABSORPTION - Sound absorption is the conversion of sound energy into some other form, usually heat, in passing through a medium or on striking a surface.

SOUND INTENSITY - The sound intensity in a specified direction at a point is the average rate of sound energy transmitted in the specified direction through a unit area whose surface is perpendicular to this direction at the point considered. The unit is generally watts per square centimeter or per square meter.

SOUND LEVEL - Sound level is the frequency-weighted sound pressure level obtained with the standardized dynamic characteristic "fast" or "slow" and weighting A, B, or C; unless indicated otherwise, the A-weighting is understood.

SOUND-LEVEL METER - A sound-level meter is an instrument–comprising a microphone, an amplifier, an output meter, and frequency-weighting networks–that is used for the measurement of noise and sound levels in a specified manner.

SOUND PRESSURE - The sound pressure at a point in a medium is the instantaneous pressure at that point in the presence of a sound wave, minus the static pressure at that point.

SPEECH-INTERFERENCE LEVEL (SIL) - The speech-interference level of a noise is a calculated quantity providing a guide to the interfacing effect of a noise on speech. The speech-interference level is the arithmetic average of the octave-band sound-pressure levels of the noise in the most important part of the speech-frequency range. The levels in the three octave-frequency bands of 600-1200 Hz are commonly averaged to determine the speech-interference level.

WAVELENGTH - The wavelength of a periodic wave (such as sound in air) is the perpendicular distance between analogous points on any two successive waves. The wavelength of sound on air or in water is inversely proportional to the frequency of the sound. Thus the lower the frequency, the longer the wavelength.

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