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GUIDELINES FOR DEVELOPING A TRAINING PROGRAM IN NOISE SURVEY TECHNIQUES

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The report contains guidelines for the content, format, organization, and administration of a training program for noise survey technicians. It is intented to provide assistance to State and local governments in setting up a training program with the following objective: the training of technicians to assist in the enforcement of noise ordinances and investigation of noise complaints. The program is directed toward trainees with a minimum of a high school education and no previous experience in acoustics. The report outlines and explains material to be covered in a 4 1/2 day training program.

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JULY 1975

Report of Working Group 70
NAS/NRC Committee on Hearing,
Bioacoustics and Biomechanics
John Shadley, Chairman
William Gately
George W. Kamperman
Paul L. Michael

Under Office of Naval Research Contract
No. N00014-67-A-0244-0021

THE U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF NOISE ABATEMENT AND CONTROL

FOREWORD

The Noise Control Act of 1972 (Public Law 92-574) authorizes the Environmental Protection Agency to provide technical assistance to State and local governments including advice on the training of noise-control personnel. This report is intended to assist State and local governments in developing a training program for noise survey technicians. It provides guidelines for the content, format, organization, and administration of a program designed to train technicians to make reliable measurements of simple noise problems encountered in the community. These recommendations should be useful in training technicians to assist in the enforcement of noise ordinances and investigation of noise complaints.

The guidelines were prepared by Working Group 70, NAS/NRC Committee on Hearing, Bioacoustics and Biomechanics.

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GUIDELINES FOR DEVELOPING A TRAINING PROGRAM IN NOISE SURVEY TECHNIQUES

The guidelines contained in this report are recommendations regarding the content, format, organization, and administration of a training program for noise survey technicians. They are intended to provide assistance to State and local governments and do not constitute standards, specifications, or regulations.

GENERAL

TRAINING PROGRAM OBJECTIVE

The purpose of the training program is two-fold:

1. To train the technician to make sound measurements and interpret the resulting data in both a sampling and an enforcing capacity as related to noise in the community. The scope of the trainee's technical jurisdiction will be limited to a relatively simple class of community noise problems comprising perhaps as much as 75 percent of the commonly encountered noise problems investigated as a result of complaint. The role of the technician so trained is to relieve the more experienced and highly trained acoustic specialists of a significant portion of the noise monitoring and data collection burden, and
2. To serve as an introduction to acoustic field measurement and analysis for those trainees requiring advanced or otherwise more specialized skills related to acoustic measurement.

The program is directed toward trainees with a high school education, and perhaps, 1 or 2 years of college, but with no previous experience or education in acoustics. Trainees can be expected to represent departments of environmental protection and enforcing agencies at various levels of government.

At the conclusion of the training program, all trainees will be expected to have gained a working facility in the use of the sound level meter and the interpretation of the sound measurement results. The trainees should also have gained a familiarity with the basics of the more advanced sound measurement and data reduction techniques.

ORGANIZATION AND FORMAT

The program should be conducted in a classroom format with trainees seated at tables providing ample room for instruments, work sheets, and reference material. The class size should be limited to approximately twenty students. The classroom sessions can be conducted by a single lecturer; however, during the laboratory and workshop sessions, assistants should be available to answer particular questions and lend aid to trainees as the need arises.

The program should be designed for 4-1/2 days in length. The first three days will be devoted to intensive training in the physics of sound and hearing, use of the sound level meter, noise survey techniques, limitations and calibration of the meter, and community noise response. The remaining 1-1/2 days will be used for review and discussion of the supplementary topics involving the more advanced techniques of sound measurement and analysis.

The class day should include 6-1/2 to 7 hours of lecture and laboratory time with 15 to 20 minutes for coffee breaks morning and afternoon and 1 or 1-1/2 hours for lunch. The program is scheduled to end at noon on the fifth day.

Visual and audio aids should be used generously throughout the program. Laboratory sessions can be integrated into the lecture periods or can be separate entities, depending upon the topic. For sound measurement laboratory sessions, a sound level meter should be issued each pair of students.

Manuals for the instructor and each student should be provided. The student manual should be a self-contained text covering the lecture material presented in the first three days of the course, complete with figures, charts and tables, but should serve as a complete handbook on the measurement of sound using the sound level meter and the interpretation of the measurement results. Text material on the last 1-1/2 days should be contained in the student manual also, but in less detail and with reference to the more technical literature available for in-depth study. The teacher's manual should contain instructions on the presentation of the program, e.g., length of time to devote to the various topics, desired emphasis, and sequence of audio and visual aids.

Before the first offering of the course, the instruction materials should be pretested as to correctness, continuity, and effectiveness of the content and style of the manuals, audio-visual aids, demonstration and measurement programs, and examination. This pretesting could be accomplished in any of several ways, including reviews by other professionals and by students, or through a full pilot course to a collection of students and critics.

Satisfactory completion of a standardized written examination on the third day will serve as evidence of successful completion of the training program. A diploma recognizing completion of the course and examination should be issued each trainee at the conclusion of the training program. The term "certification" should be avoided because of the implication of endorsement by some official agency. After successful completion of the course,

the trainee can be described as, "technically trained in the current techniques of outdoor sound measurement using the sound level meter."

CURRICULUM

The suggested curriculum for the training program has been outlined and is included as part of these guidelines. The outline includes titles and descriptions of major topics, order of coverage, length of time to be devoted to each topic, and comments indicating desired emphasis and precautions.

For the first three days, the program has been designed to place emphasis on those topics leading directly to an understanding of sound level and its measurement, and the interpretation of the measurement data. The training program conceivably could conclude at the end of the three day session. The 1-1/2 day, somewhat more advanced, extension of the program is recommended, however, to give the trainee a broader technical base. While the material presented in the first three days of the program should be rather well defined, the program in the last 1-1/2 days should be tailored somewhat to the needs and backgrounds of the trainees in attendance.

Handbooks, standards, ordinances, and reports that should be used as reference material in the presentation, and included as a part of the student manual are the following:

1. American National Standards Institute (ANSI) S1.1 - 1960 (R1971), "Acoustical Terminology."
2. Handbook of Noise Measurement by Arnold P. G. Peterson and Ervin E. Gross, Jr., Seventh Ed., General Radio Company, Concord, Mass. (1972).

3. Acoustic Noise Measurements by Jens Trampe Broch, Second Ed., Bruel and Kjaer, Nairum, Denmark, (January, 1971).

4. Instruction manuals for all sound level meter types used in the course, available from the instrument manufacturer.

5. American National Standards Institute (ANSI) S1.4 - 1971, "Sound Level Meters."

6. International Standards Organization (ISO) Recommendation R 1996, "Assessment of Noise with Respect to Community Response."

7. EPA Document 550/9-75-020 "Noise Source Regulation in State and Local Noise Ordinances," National Technical Information Service, Springfield, Virginia 22161.

8. City of Chicago Noise Ordinance as amended, Dept. of Environmental Control, 320 N. Clark St. (Rm. 500), Chicago, Illinois 60610.

9. Noise and Vibration Control, by L. L. Beranek, McGraw-Hill Publishing Co., 1971.

Films that may be considered for part of the lecture material include:

1. The National Bureau of Standards film for general information, available from National Audio-Visual Center, Washington, D.C. 20409.

2. The English film, "Dangerous Noise," Films Division, Rm. 507, Central Office Information, Hercules Road, London SE1, England.

3. The American Broadcasting Company film, "Death Be Not Loud." Available from McGraw-Hill Publishing Company, Box 404, Heightstown, N. J.

4. "The Sound of Sound" on hearing conservation. Available from American Optical Corporation, Safety Product Division, Southbridge, Massachusetts 01550.

There are many other books, reports, standards and other documents that should be referenced in the student manual. It is suggested that one set of these be available to the trainees for reference throughout the week-long training program. A list of additional recommended reference literature is provided in Appendix A.

IMPLEMENTATION AND ADMINISTRATION

The course material, teacher's and student's manuals, and audio and visual aids, should all be prepared by the same organization or closely coordinated group of organizations to insure uniformity and continuity among the instruction materials. Necessary qualifications for the organization(s) preparing the material include experience in indoor sound measurement and in conducting short courses on technical topics. Desirable qualifications should include a working familiarity with the major topics to be discussed in the program, especially the physics of sound, community response to noise, sound measurement, and instrumentation.

The selection and qualifications of course administrators should be carefully considered. Several choices for course administrators are available, including:

1. The State government may develop its own staff and administer the course in a single location or in various local jurisdictions.
2. The local government may develop its own staff and administer the course.

3. State or local governments may contract with a single university, college, community college, technical institute, or private business to administer the course at either single or various locations.

4. The State government may contract with several educational institutions and/or private businesses and administer the course in various local jurisdictions.

A primary constraint in selecting an administrator is that the organization selected should have approximately the same qualifications as those previously stated for the preparers of the course material. An official certification of the course administrator appears undesirable at this time because of the difficulty in establishing firm qualification requirements accepted by existing professional organizations and by the acoustical profession at large. It is recommended that each applicant be considered individually using the recommended qualifications as guidelines.

Participation is likely to be more enthusiastic if trainee travel is minimized. Lecture material and equipment will have to be available at the lecture site. All manuals and presentation material should be on location in advance of the program. Depending on the course administrator, some equipment will be available and other equipment can be rented or borrowed. However, for the sake of uniformity of quality and state of repair, and to assure availability when needed, it would be advantageous to purchase and maintain the required equipment. An approximate list of required equipment includes the following:

1. Slide projector

2. Movie projector with sound equipment

3. Overhead transparency projector

4. Sound level meter, calibrator, microphone, windscreen, and headphones for each pair of students

5. Tape recorder and playback amplifier and speakers

6. Several items of SLM test equipment including:

   - Variable frequency oscillator and step attenuator
   - Tripod
   - VOM meter
   - Graphic level recorder
   - Microphone cables, dummy microphones, windscreens.

7. Octave, and/or 1/3 and/or 1/10 octave band sound measurement and analysis equipment

8. Statistical sampling equipment (optional)

The exact instrumentation requirements should be developed along with the development of the course material.

The alternatives to purchasing, maintaining, and transporting the equipment are to simplify the course, or to place the burden of supplying equipment on the contractor each time the course is given. The latter alternative would further limit the course administrators to organizations that have access to the required equipment.

COURSE OUTLINE

FIRST DAY

The topics to be discussed in the first day have been selected to give the trainee a broad understanding of the basic principles and concepts of sound, hearing, and sound measurement. Text material should provide discussion of the fundamental acoustic terms, concepts, and relationships. However, in the limited lecture time available, discussion of some of the items of special interest have been postponed to the last day of the course in order to provide adequate coverage of those topics leading directly to an understanding of sound level and its measurement.

INTRODUCTION (30 Minutes)

Discuss the objectives of the course with particular emphasis on the areas of responsibility of the trainee. From this discussion the trainee should have a clear definition of what is expected of him and of the limitations of the training provided.

THE PHYSICS OF SOUND (2 Hours, 30 Minutes)

1. Basic Principles and Terminology
    a. Amplitude
    b. Directivity
    c. Far Field
    d. Free Field
    e. Frequency
    f. Loudness

g. Pitch

h. Pressure (atmospheric, peak, root-mean square) little detail

i. Propagation

j. Pure Tone

k. Reverberation

2. Noise Measuring Units and Calculations

a. The Decibel (dB)

b. Sound Pressure, Sound Pressure Level, and Intensity

c. Adding Decibels (random and pitched noises)

d. Frequency Bandwidths

e. Noise Propagation Characteristics

- Noise source in free field
- Noise source in reverberant field
- Sound absorption

f. Frequency Weighting Networks; A, B, C

INTRODUCTORY COMMENTS ON THE PHYSIOLOGY OF HEARING (30 Minutes)

1. How Sound is Heard

2. Problems Related to the Ear and Hearing

a. Noise - Induced Hearing Loss

b. Federal Standards Governing Noise Exposure

c. Other Causes of Hearing Loss

NOISE MEASUREMENT (1 Hour, 15 Minutes)

1. The Sound Level Meter

   a. Function, Operation, and Limitations

   b. Microphones

      - Characteristics of ceramic condenser, and dynamic types

        -Frequency response

        -Sensitivity

        -Range

        -Directivity

        -Environmental limitations

      - Calibration

        -Pressure

        -Free-field

        -Laboratory

        -Field

   c. Indicating Meter

      - Response speed (fast and slow)
      - Characteristics (root-mean square, average, peak)

   d. Frequency Weighting Networks

   e. Overall Standards on Operation

LABORATORY EXERCISES WITH THE SOUND LEVEL METER (2 Hours)

One sound level meter should be provided for every two trainees so that they can work together measuring sound levels of various noise spectra

provided from tapes or other demonstration equipment. Each trainee must make sound pressure level measurements of at least five different noise spectra that include rising, falling, peaked, and flat frequency characteristics while his partner records the data. Measurements must be made with the A, B, and C frequency weightings, with both the fast and slow meter responses, on each of the five noise spectra. The trainee should be instructed in the proper selection and orientation of the microphone. One qualified instructor for every six trainees must be available to guide individual trainees during the laboratory exercises.

SECOND DAY

The topics to be discussed in the second day have been selected to give the trainee experience in making and interpreting measurements of a variety of common out-of-doors noises in a variety of situations.

SOURCES OF COMMUNITY NOISE (45 Minutes)

Taped samples of common industrial and transportation noise are to be played through an amplification system while the trainees practice using the sound level meter. The instructor may identify the source and point out the features of the sound having special interest. The sound sources should be selected to provide a variety of measurement experiences. For example, the taped samples may include the following:

1. Familiar community noises with which the trainee can begin to associate levels of sound.
2. Tones superimposed on broad-band noise, e.g., transformer or fan tones, to illustrate the range in measured values due to standing waves-space averaging.

3. Intermittent, impact, or fluctuating noises to illustrate slow and and fast meter response, time averaging.

4. Insect noise to illustrate the measurement technique.

FACTORS THAT AFFECT OUTDOOR SOUND PROPAGATION AND MEASUREMENT (1 Hour, 30 Minutes)

This presentation includes guidelines for assessing the influence of each factor; as well as charts, graphs, and tables defining corrections to account for each factor.

1. Identification and frequency spectrum of source(s)--significance for accurate measurements; effect of discrete tones; procedure for space/time averaging.

2. Distance from source--spherical, hemispherical spreading of sound waves from source; absorption of sound in air.

3. Effect of terrain and surface between source and measurement location.

4. Effects of shielding and reflection of sound by nearby objects--geometric interpretation; significance of frequency spectrum of source.

5. Effects of wind, thermal gradients, and relative humidity on absorption and/or refraction of sound waves. Effects of adverse weather conditions on the equipment.

NOISE SURVEY TECHNIQUES (1 Hour, 15 Minutes)

The purpose of this topic is to teach the trainee the special techniques involved in making meaningful and thorough sound measurements in an outdoor environment.

1. Use and limitations of the windscreen.

2. Check list for equipment calibration and check-out.

3. Check list for observations to be recorded on data sheets.

4. The importance of listening--with the unaided ear and with earphones.

WORKSHOP--FIELD MEASUREMENT AND EVALUATION OF COMMUNITY NOISE
(3 Hours, 30 Minutes)

1. Review calibration and measurement procedures.

2. Demonstrate sound level measurement procedure in representative setting, including interpretation of indicated values relative to compliance or noncompliance with statutory limits.

3. Divide students into groups of three or four and have them assess compliance or noncompliance of various sources--stationary and moving--with measured levels, at two or three predetermined and representative locations. Also, tape record events at these locations for later discussion. (Note: Noise measurement locations should be carefully selected and evaluated in advance, to illustrate as many representative situations as possible.) Include traffic driveby measurement; certification test (for comparison), stationary source measurement at property line. Effects of nearby barriers or obstacles and possible contributions from other sources should be discussed and included if possible.

4. Following field measurements, discuss results obtained by various groups relative to compliance or noncompliance, effects of measurement location, and corrections (if any) required for shielding, reflections, wind or terrain. Ample time should be alloted for individual questions and answers.

THIRD DAY

LABORATORY DISCUSSION OF INSTRUMENTATION (2 Hours, 15 Minutes)

The purpose of this topic is to give the trainees a more detailed understanding of the technical aspects of sound level measuring instruments--limitations of the sound level meter, how to recognize common malfunctions and how to avoid common errors in calibration and field measurement.

1. Diagnosis of Equipment Malfunctions

   a. Off-calibration
   b. Defective calibrator
   c. Dead batteries/reversed polarity
   d. Low batteries
   e. Intermittent or shorted microphone cables
   f. Condensation on microphones
   g. Faulty microphone
   h. Low impedance connection at meter output

Tests required for the above diagnoses include:

   a. Calibration by a second calibrator
   b. Exchange of microphones
   c. Battery check/inspection
   d. Check instrument noise floor by use of dummy microphone (series capacitor in place of microphone)
   e. Frequency response of instrument by use of variable frequency oscillator
   f. Listening with headphones for sounds of intermittency when the sound level meter is impacted and twisted

2. Limitations of the Survey Meter and Errors to Avoid

   Some of this material can be presented in lecture form. Where possible, however, the lecture material should be supplemented with appropriate demonstrations. Concepts to be emphasized include:

   a. Noise floor of the instrument
   b. Characteristics and limitations of various microphones
   c. Inability of the meter to distinguish sounds of different origin, e.g., plant noise from insect noise
   d. Inability of the meter to distinguish between airborne sound and wind pressure fluctuations on the microphone
   e. Limited battery usefulness in conditions of extreme cold
   f. Effect of the observer on the sound measurement

3. Simple Demonstrations to Perform Include:

   a. The erroneous signal produced by wind and vibration on standard microphone cable
   b. The loading effect of headphones connected to the output of the sound level meter
   c. Effects of wind on microphone signal with and without a windscreen

REVIEW (1 Hour, 15 Minutes)

Highlights of all material should be reviewed in preparation for the examination to follow in the afternoon. Format can be question and answers, but discussion should be covered in the examination.

WRITTEN EXAMINATION (1 Hour)

A standardized examination covering the first 2-1/2 days of the course should be given all students. The questions should be of the objective type, perhaps with multiple choice answers, and should emphasize fundamentals of sound, outdoor sound propagation, field measurement techniques, and instrumentation. As reference material during the test, the students should be permitted access to their basic set of notes provided as written test material at the beginning of the course.

COMMUNITY RESPONSE TO NOISE (1 Hour)

The purpose of this topic is not so much to teach the trainee how to predict community response, but rather to recognize the characteristics of noise that are thought to disturb people. When investigating a complaint about noise, the trainee in the field should be able to identify the cause for complaint and tailor his investigation and measurements accordingly. Subjects to be discussed include the following:

1. The "Community Noise Problem"--definition and historical review; types of sources--social survey results.
2. Review of factors that have contributed to "the Community Noise Problem"--mechanization, population density, urban design, land use planning.
3. Effects of noise on people
    a. Physiological effects of noise and associated sound levels
        - Hearing damage review
        - Other physiological effects

b. Sociological and psychological effects

- Interference with speech and speech related activities
- Interference with sleep
- Annoyance, unspecified--variations in sensitivity to noise

c. Factors and prediction schemes employed to assess community noise

- Characteristics of noise related to annoyance, including level, duration, frequency, narrow band noise, fluctuations, modulations
- Factors, not properties of the noise, e.g., time of day; community attitudes; social, political, and economic considerations
- Schemes used to predict community reaction to noise, e.g., noise level rank, noise pollution level, ISO recommendation 1996, etc. This material should be introduced only for the purpose of emphasizing the factors related to annoyance and the uncertainty in community reaction prediction methods.

EXAMINATION REVIEW AND DISCUSSION PERIOD (1 Hour, 30 Minutes)

1. Review of Examination Questions and Results

The previous 1-hour lecture period should allow ample time for an assistant to check the answers to the objective examination questions and tabulate the results. Because a review of the examination questions and results will be of substantial benefit to both the trainees and the instructor in determining where remedial study is needed, this review should be conducted on the third day leaving ample time for the required shift in emphasis on the fourth and fifth days.

2. Discussion Period

Following the examination the class may benefit from a more relaxed, class participation period for questions and discussion. The discussion should be focused on the anticipated roles of the trainees in regulation, measurement and enforcement capacities. Emphasis should be placed on application of the newly acquired skills to these functions, and on definition of the class of problems the trainee should expect to solve.

FOURTH DAY

COMMUNITY NOISE REGULATIONS (1 Hour, 30 Minutes)

The trainee should be made familiar with some existing noise regulations--the language used, the inherent limitations, problems of enforcement, and the responsibilities of the measurement technician.

1. Qualitative versus Quantitative Noise Regulations
   a. Examples of qualitative regulations
   b. Limitations of qualitative regulations
2. Quantitative Noise Regulations
   a. Examples of quantitative noise regulations (ref. EPA Document 550/9-75-020)
      - Cross-section of types of quantitative regulations
      - Detailed discussion of one or two regulations covering:

-Stationary noise source regulations, e.g., City of Chicago Noise Ordinance

-Vehicle noise emission regulations, e.g., EPA Interstate Motor Carrier Regulation, State of California noise regulations for highway vehicles, or State of Minnesota regulations for snowmobile noise.

3. Summaries of community noise regulations and policies most widely applied or frequently encountered.

   a. EPA Interstate Carrier Regulations and new product regulations as promulgated
   b. HUD Departmental Circular 1390.2
   c. FHWA Policy and Procedures Memorandum 90-2
   d. State of Oregon regulations
   e. Noise regulations of the City of Chicago
   f. State of California vehicle noise regulations

4. Model legislation--adaptation and application to individual jurisdictions.

The remaining topics discussed in the fourth and fifth days are intended to give the trainee an introduction to some of the more advanced and technically more complex aspects of noise, its measurement, and control. Since the backgrounds of the groups attending the course may vary widely, the instructor should exercise his own judgment in selecting an appropriate technical level and pace for the fourth and fifth day lectures. For this reason, the course outline suggested here includes broad lecture categories only.

SPECIAL ANALYSIS TECHNIQUES (2 Hours)

Comprehensive instruction in these topics cannot be given in the limited time available; however, the trainee can be introduced to the techniques, their uses and limitations. References to published material giving detailed instruction should be included in the written text.

1. Narrow Band Analysis--octave, 1/3 and 1/10 octave, 1 percent band analysis
2. Impact Noise Measurement
3. Statistical Distribution Analysis
4. Tape Recording Techniques
5. Real-time Analysis

The use of some of these instruments and techniques can be demonstrated in conjunction with the recorded tape samples used in the second day of the course. Octave and narrow band analyzers should be made available for demonstration. Other equipment should be used if available.

WORKSHOP--FIELD MEASUREMENT AND EVALUATION OF COMMUNITY NOISE (3 Hours, 30 Minutes)

This topic is to parallel topic D of the second day. Trainees should gain actual field experience at outdoor sound measurement in new noise situations. The purpose of the exercise is to:

1. Allow the trainee to gain a new level of confidence in the use of the sound level meter

2. Allow the trainee to apply the skills and understanding acquired since the previous field measurement exercise

3. Provide for a break in the monotony of the classroom instruction

FIFTH DAY

PHYSICS OF SOUND (1 Hour, 15 Minutes)

Some items within this general topic were introduced on the first day of the course. In order to avoid confusing the beginning student in his first introduction to sound, some of the peripheral and more difficult subjects had been deferred for discussion on the last day.

1. Basic Concepts and Terminology

   a. Amplitude
   b. Intensity
   c. Period
   d. Pink noise
   e. Power
   f. Random noise
   g. Resonance
   h. Velocity
   i. Wavelength
   j. White noise

2. Mathematical Relationships in Sound

   a. Sound power level and sound pressure level relationships

b. Spherical, hemispherical, cylindrical, plane wave propagation

c. Point source, line source, distributed plane source

PHYSIOLOGY OF HEARING (Expansion of Topics Introduced on the First Day) (1 Hour)

1. Anatomy of the Ear

   a. External ear

   b. Middle ear

   c. Inner ear

2. Problems related to the Ear and Hearing

   a. Noise-induced hearing loss

      - Sustained noise exposure
      - Interrupted noise exposure
      - Impact noise exposure

   b. Rules, regulations and standards governing noise exposure

      - Federal
      - State
      - Local
      - Other

   c. Other causes of hearing loss

      - Aging effects
      - Hereditary effects
      - Acoustic trauma
      - Effects of drugs
      - Allergy effects
      - Meniere's disease

INTRODUCTORY COMMENTS ON METHODS OF NOISE REDUCTION
(1 Hour, 15 Minutes)

The trainee should acquire an understanding of some of the elementary concepts of noise control. He should be prepared to distinguish between the noise problems that clearly have simple solutions and those that are clearly complex. He should be equipped to report on his assessment of a noise problem in the light of basic noise control possibilities. General guidelines should be given on the applications of the following items:

1. Sound Absorption Materials
2. Sound Transmission Loss Materials
3. Enclosures
4. Silencers
5. Noise Barriers
6. Vibration Isolators
7. Damping Materials
8. Fundamental Redesign of the Sound Generation Mechanism
9. Administrative Methods of Noise Reduction
10. Maintenance Programs of Noise Reduction

APPENDIX A

RECOMMENDED REFERENCE LITERATURE

It is suggested that the following documents be referenced in the student manual and that one set be available to the trainees for reference throughout the course.

GENERAL INTEREST BOOKS

* Report to the President and Congress on Noise, NRC 500.1, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, December 31, 1971. (NTIS # PB-206716).

Harris, C. H., ed., Handbook of Noise Control, McGraw-Hill Book Co., 1957.

* Noise Facts Digest, June 1972 (NTIS # PB-228345).

EPA MANDATED DOCUMENTS

* Public Health and Welfare Criteria, EPA 550/9-73-002, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, July 27, 1973. (GPO # 5500-00103).

* Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety, EPA 550/9-74-004, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, March 1974. (GPO # 5500-00120).

* Volume 1 of First Report on Status and Progress of Noise Research and Control Programs in the Federal Government, EPA 550/9-75-023, U.S. Environmental Protection Agency, Office of Noise Abatement and Control, June 1975.

STANDARDS**

American National Standards Institute (ANSI) Standards:

S1.2-1962 (R1971) - "Method for the Physical Measurement of Sound"

S1.6-1967 (R1971) - "Preferred Frequencies and Band Numbers for Acoustical Measurements"

S1.8-1969 - "Preferred Reference Quantities for Acoustical Levels"

S1.10-1966 (R1971) - "Methods for the Calibration of Microphones"

S1.11-1966 (R1971) - "Specification for Octave, Half-Octave, and Third-Octave Band Filter Sets"

S1.12-1967 (R1972) - "Specifications for Laboratory Standard Microphones"

S1.13-1971 - "Methods for the Measurement of Sound Pressure Levels"

S3.4-1968 (R1972) - "Procedure for the Computation of Loudness of Noise"

S3.5-1969 - "Methods for the Calculation of the Articulation Index"

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 36-72 "Methods of Testing for Sound Rating Heating, Refrigerating, and Air-Conditioning Equipment"

Society of Automotive Engineers (SAE) Standards:

SAE Recommended Practice J192 - Exterior Sound Level for Snowmobiles (1970)

SAE Standard J366a - Exterior Sound Level for Heavy Trucks and Buses (1971)

SAE Standard J377 - Performance of Vehicle Traffic Horns (1969)

SAE Standard J672a - Exterior Loudness Evaluation of Heavy Trucks and Buses (1970)

SAE Standard J952b - Sound Levels for Engine Powered Equipment (1969)

SAE Standard J986a - Sound Level for Passenger Cars and Light Trucks (1970)

SAE Aerospace Recommended Practice ARP 796 - Measurement of Aircraft Exterior Noise in the Field (1965)

*Standards on Noise Measurements, Rating Schemes, and Definitions: A Compilation, NBS Special Publication 386, U.S. Department of Commerce, National Bureau of Standards, November 1973. (GPO # C13.10:386).

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Sound and Vibration, Sound and Vibration Acoustical Publications, Inc., 27101 E. Oviatt Road, Bay Village, Ohio 44140. (published monthly).

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*Available from Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402; or the National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Va. 22161.

**Available from the American National Standards Institute (ANSI), 1430 Broadway, New York, N. Y. 10018.

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