ANALYSES OF NOISE IN SELECTED AGRICULTURAL MECHANICS FACILITIES

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TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

All components of an educational environment influence the behavior of people and thus the learning of all those in that environment. A large part of the teaching-learning process consists of verbal communication, which is readily recognized as a form of desirable sound. However, noise or unwanted sound is also present in most environments. Any time noise or other environmental components interfere with desired sound audio-communication, the environment is less conducive to the teaching-learning process.

"Communication lies at the heart of the teaching process, and a large part of communication in a school is through the medium of sound; a school which hampers audio-communication has failed in a primary purpose." (9)

The aural environment to which a group of learners is exposed is influenced to a great extent by facilities which surround it. When the many facets of sound or noises are analyzed through such techniques as the determination of sound level and the identification of sound characteristics which cause it to be noise, therefore annoying, definite steps can be taken to alleviate some of the more critical noise interferences in the facility.

Statement of the Problem

Good audio-communication is necessary for an environment that is conducive to the teaching-learning process. However, it may be that sounds produced by normal activities carried on in agricultural mechanics programs interfere with and impede the desired verbal communication necessary for an effective teaching-learning process.

Purpose of the Study

The primary purpose of the study was to analyze the different noises that are emitted by machines and activities in four selected agricultural mechanics facilities during periods of normal usage. Facilities were selected as being representative of those commonly in use in terms of (a) construction types, (b) size of building, (c) number, size, and type of equipment, (d) number of students, and (3) type of instructional program housed. Data obtained were used to analyze noise levels for impairment to audio-communications. The maximum tolerable conflicting noise level was found through determining speech interference levels at each facility.

The study also analyzed those sounds in the selected laboratories or shops that were annoying to students.

Objectives of the Study

The types of building construction and instructional programs investigated were as follows:

A. Predominantly block and/or brick without dropped ceiling

1. Laboratory skills oriented instructional program (LSO)
2. Project construction oriented instructional program (PCO)

B. Predominantly steel construction without dropped ceiling

1. Laboratory skills oriented instructional program (PCO)

2. Project construction oriented instructional program (LSO)

Given these types of structures and programs and the major purpose described above, this study was made to attempt to accomplish the following specific objectives:

1. To identify the sound levels and speech interference levels created by types of educational programs in each category of facilities selected as representative of those used in Oklahoma for vocational agricultural mechanics programs.

2. To identify the most annoying sounds perceived by students in the selected facilities during normal use.

3. To assess the annoying characteristics of sounds (intensity, frequency, abruptness, consistency, appropriateness, localization, necessity, and movement of source) as perceived by students and to measure certain of these characteristics with a sound level meter.

4. To determine in which of a selected group of mental and physical activities students are susceptible to the most annoying sound.

5. To analyze noise created by selected equipment in facilities for sound level, frequency, speech interference level, and degree of annoyance.

6. To determine the degree of impairment to the desired aural environment for each selected facility as perceived by the respective students and as measured with a sound level meter.

7. To determine if sound levels exist in the selected agricultural mechanics facilities for prescribed lengths of time that are harmful to the individual's health as described in the Walsh-Healey Act.

Need of the Study

Agricultural mechanics facilities because of their nature, house programs and activities involving students operating machinery and equipment, create sound levels which are higher than experienced in most teaching-learning situations where audio-communication is necessary. With the trend toward new facilities being constructed primarily of steel and other hard materials, along with larger and more sophisticated equipment being placed in these facilities which more nearly emulate that of industries, sound environments are becoming more critical in these types of educational settings.

Contributions and implications that might be derived from information to be found in this study are:

1. Laboratory layout. If the equipment emitted sound levels and persistence are known, implications are that equipment which produces the highest sound level over long time periods be placed at locations in the facility where interference with a desired activity would be at a minimum. Those areas of the laboratory where communication is most necessary should be kept relatively free from sound levels above 60 decibels on the "A" scale for periods longer than five minutes. When the laboratory oriented instructional program is utilized, proper placement of equipment in consideration of noise is very significant because a student is usually confined to a specific station for a longer period of time, therefore, being vulnerable to adjacent equipment noise.

2. Mounting of equipment. Different types of mounting for that large equipment which is attached to the floor (usually concrete) and produces high sound levels could be considered.

3. Building design. Considerations for the alleviation of unacceptable noise level for various building designs might be use of inside exposed insulation with accoustical qualities or dropped ceilings. Other considerations are partition arrangement, floor material, etc.

4. Annoyance. Those sounds causing annoyance could be identified and possible rectifications suggested.

5. Instructional programs or activities. Instructional programs exhibiting undesirable sound environments might be altered or changed.

6. Hearing damage risk. Critical sound level measurements made by the study can be used to identify those sound levels present for long enough durations in typical agricultural mechanics facilities under average or normal operating conditions that may be harmful to the hearing of those subjected to it.

It is believed by this writer that a study is needed that will focus more attention on and help people to become more cognizant of what is referred to as the third pollution, noise, as it applies to the educational environment.

Definition of Terms

Speech Interference Level (S.I.L.): The arithmetic average of the sound-pressure levels in the octave bands centered on 500, 1,000 and 2,000 Hz (cycles per second).

Octave: The interval between two sounds having a basic frequency ratio of two. The interval in octaves between any two frequencies is the logarithm to the base 2 (or 3.322 times the base logarithm to the base 10) of the frequency ratio. (13)

Microphone Orientation (M.O.): The location and position of the microphone with respect to the sound source and surrounding environment.

Environmental Sound Level: The total or overall sound level measurement taken in the far or diffuse field with the microphone on a tripod positioned in a specific manner as specified on floor plans. Microphone location is identified by letter code on each facility floor plan. Total sound measurement radiated in the facility is the intent.

Equipment Sound Level: The measurement taken of one specific piece of equipment or machine with a specified microphone orientation.

Standard Position (S.P.): A type of microphone orientation used for sound level measurements taken in the near field. In this study, the standard position was for the microphone to be 5 ft 4 in. vertical distance from the floor and 4 ft. horizontal distance from where the sound being measured (usually equipment noise) was emanated. Random incidence was assumed and the microphone was positioned perpendicular to the sound path being measured.

Near Field: The area in which sound level measurements were taken to determine the dominant sound produced.

Background (Bkgd.): Environmental sounds in the background. Background sound levels are far field measurements (M.O. may be S.P.) and are taken with the intent of finding the overall Bkgd. or ambient noise level of the total environment prior to measurement of the sound level of one specific piece of equipment or machine.

Conversing: An activity the student may be engaged in while in the agricultural mechanics laboratory. Conversing implies in this study that a person involved in this activity is talking to another person with normally only two people involved, the person doing the talking or conversing and the person listening.

Discussing: An activity the student might be engaged in while in the shop. Discussing implies in this study that more than two people are involved and the student involved in the activity of discussing may or may not be doing the talking.

Laboratory-Skills-Oriented Instructional Program (LSO): That type of instructional program in which a major portion of the laboratory time is spent with the student performing specific well-defined skills utilizing basically one station or location in the laboratory. The skill performed or object constructed may have no practical purpose other than to provide a situation for the student to accomplish a specific objective.

Project-Construction-Oriented Instructional Program (PCO): That type of instructional program in which a majority of the student laboratory time is spent constructing a project which probably will have some useful application when it is finished. The student will not be performing specific tasks at one location but will be involved in a large number of tasks requiring him to utilize many different pieces of equipment at many different locations.

Agricultural Mechanics Facility: The structure or building or portion thereof which is utilized for conducting the agricultural mechanics program. The term facility also includes all of the equipment and accessories that are housed in the described structure.

Predominantly Steel Building: A building that is constructed utilizing steel framing and with at least three major inside walls of the laboratory consisting of painted exposed steel of standard guage.

The underneath side of the roof may be exposed insulation. The roof may be gabled or flat decked.

Predominantly Concrete (Cinder) Block and/or Brick Building: A building in which at least the three major inside exposed walls consist of brick or cinder block painted or unpainted. Exposed roofing members may be of either wood or steel but will be exposed with no dropped ceiling. Exposed insulation may be exhibited on underneath side of roof sheeting and inside wall.

Normal Usage: The normal or average operation of an agricultural mechanics facility infers that the educational activities being carried on in that specific facility are representative of what is average or normal for that facility during a considered normal week. Normal or average usage is that period of time when an average number of students per class period are operating an average number of machines in a normal manner and performing what is considered to be normal activities by the respective instructors.

Sound: An oscillation in pressure, stress, particle displacement, particle velocity, etc., in a medium with internal forces or the superposition of such propagated alterations. (13)

Noise: Any undesired sound.

Sound Pressure: The "root-mean-square deviation of atmospheric pressure from its static value due to a sound wave. It is measured in dynes per square centimeter. A sound pressure of one dyne per square centimeter. . . is equal to approximately one millionth of atmospheric pressure." (13)

Sound Pressure Level (S.P.L.): Sound pressure when measured on the decibel (dB) scale.

$$\text{S.P.L.} = \text{Log} \frac{P}{0.0002} \text{ dB } \underline{\text{re}} \text{ 0.0002 MICROBAR}$$

Decibel (dB): One-tenth of a bel. Thus, the decibel is a unit of level when the base of the logarithm is the tenth root of ten, and quantities concerned are proportional to the power. (13)

Decibel Scale: "A relative scale expressing only fractional or percentage changes in sound pressure or energy." (13)

Sound Level Meter: An instrument including a microphone, an amplifier, an output meter, and frequency weighting networks for the measurements of noise and sound levels in a specified manner.

Annoyance Rank: Based on the percentage of student responses indicating that equipment was causing most annoyed sound; "none" is not to imply that students were not annoyed by such equipment or noise, but no student felt it caused him the most annoyance as compared to other noises in the shop.

Limitations of the Study

The investigator realizes that the study was subject to certain limitations and/or delimitations among which are at least the following:

1. The study was delimited to four facilities selected as being representative of the different groups.

2. All variables that influence sound could not be held constant when comparing facilties.

3. No effort was made to determine the behavioral effects sound or noise had on a learner; however, sound levels that were found to be hazardous to the individiual as defined by the Walsh-Healey Act were identified.

4. The study was limited to those measurements which could be taken in limited time intervals with one microphone. Time intervals were limited due to the number of measurements that were necessary during

each class session in the sound analysis. More sophisticated instrumentation with multiple microphones being used simultaneously may have given more valid environmental measurements, but such was not available to the researcher.

Assumptions

1. The selected agricultural mechanics facilities are typical of those predominantly steel or concrete block buildings housing laboratory oriented or project construction oriented instructional programs.

2. The sound analyses were recorded during normal shop operation.

3. Instruments and procedures were adequate for measuring the data that was necessary for the study.

CHAPTER II

THEORETICAL BACKGROUND

Introduction

The purpose of this chapter is to present findings in the literature that the investigator used in developing the rationale for conducting the study.

No literature found concerned itself directly with the analysis of noise in school laboratories; therefore, it was necessary to draw from related literature that dealt with noise problems in other areas. An attempt was made to discern what materials were relevant to the basic purpose of the study, to analyze sounds in the typical agricultural mechanics laboratories for the conditions that exist with regard to noise interference.

Selected literature reviewed that was relevant to the study is presented under major topic headings to facilitate clarity and organization.

Sound

Peterson and Gross (13) define sound in general terms. ". . . sound in the physical sense is a vibration of particles either in a gas, a liquid, or a solid."

A more specific Peterson and Gross (13) definition is presented in the definition section of Chapter I. They also offer an alternate definition which includes the sensation of hearing. This investigator has no desire to defend or repudiate the philosophical debate regarding the age old argumemt, whether or not one has to hear the crash of a tree in the forest before a sound is produced, except that an eclectic view is taken in this study in that an objective measurement is being taken of noises which effect the sensation of hearing.

All literature reviewed agreed basically on the definition of sound but used different terminology.

BRUEL & KJAER (4) said that "Sound may be defined as the auditory sensation evoked when such vibrations," referring to transmission of energy in the form of vibrations which constitute variations in pressure or position of the particles in the medium, "normally in air, impinge upon the ear. As an auditory sensation sound is limited to frequencies in the range from about 20 Hz to 20,000 Hz."

According to the Hewlett-Packard Accoustics Handbook (10) sound is an undulatory motion of air or other elastic medium which can produce the sensation of hearing when incident upon the ear.

Hewlett-Packard also explain that a medium for propagation must be present such as air. Sound waves cannot travel through a vacuum.

Sound at a particular point is a rapid variation in the pressure of the medium at that point around a steady-state pressure. In air the steady-state pressure is atmospheric pressure. Of course, the average atmospheric pressure changes, but this change is slow enough to be considered constant compared to the rapid pressure variations of sound. (10)

Loudness

Loudness is a subjective quantity indicating the magnitude of the hearing sensation. Loudness is determined principally by sound pressure and to some extent by frequency. The relation of loudness to sound pressure has been established by extensive psychological testing and has been the subject of long efforts toward standardization. (13)

Because of the dynamic range of the ear, decibel units are used to avoid working with unwieldy numbers. Hearing in the decibel scale ranges from 0 dB, the reference point (re 20 μ N/M^2) which is the threshold of hearing up to 140 dB where the sound actually causes pain.

The following table is presented to illustrate where common sounds fall on the continuum. (1)

TABLE I

SOUND PRESSURE LEVELS IN TERMS OF DECIBELS FOR COMMON NOISES

SOUND QUALITY	DECIBELS	SOUND SOURCE
		Rocket engine
Threshold of		Ram jet
Feeling/Pain	120	Turbojet: 7,000 lbs. thrust
		Propeller aircraft
		Boiler factory
Deafening	110	Nearby riveter, drop hammer
	100	Thunder
		Woodsaw
	90	Loud street noises
		Noisy factory, screw machine,
Very Loud		Loud television
	80	Police whistle, portable sander
		Noisy office
Loud		Average traffic
	70	Normal radio or television
		Average factory
	60	

TABLE I (Continued)

SOUND QUALITY	DECIBELS	SOUND SOURCE
		Noisy home
	50	Average office
Moderate		Ordinary conversation
		Quiet radio
	40	
		Quiet home
	30	Private office
Faint		Average auditorium
		Quiet conversation
	20	
	10	Rustle of leaves
Very Faint --		Whisper
Threshold of		Soundproof room
Audibility	0	

The instrument that measures loudness level does not deal with purely physical quantities only but must imitate to some degree the properties of the human ear which involve complicated physiological and psychological mechanisms.

It was beyond the purpose and scope of this study to explain all of the different methods which have been devised and units of measurement that have evolved in measuring loudness or loudness levels.

These units of measurement include sones, phons, noys, PNL, etc.

The precision impulse sound level meter used in this study takes into consideration the complexities of the sensation of loudness which is a function of frequency band width and the proximity of sounds in terms of frequency. (4)

These effects, to some extent, are taken into account by weighting networks which conform to standards established by the International

Electrotechnical Commission (IEC) for sound level meters. The IEC has set specifications which standardize an apparatus by which sound pressure can be measured under closely defined conditions so that results obtained can be compared universally.

Responses were obtained in the study with three of the four weighting networks designated as A, B, C, and D. Responses from these networks selectively discriminate against low and high frequencies. The D network is relatively new and was designed originally for jet aircraft noise. Although all environmental readings were recorded in A, B, and C networks in the study, only the A and C network data are shown.

> The difference in reading of level with the C-weighting and A-weighting networks (L_C-L_A) is frequently noted. This difference in decibels is called the "harmonic index." It gives some idea of the frequency distribution of the noise. (13)
>
> For simple ratings or screenings of similar devices the A-weighted sound level at a specific distance is now widely used . . . It is also useful in preliminary ratings of similar ambient noises for the human reaction that may occur.

Frequency distribution is determined by comparing the readings in the different scales.

> If the level is essentially the same on all three networks (A, B, and C) the sound probably predominates in frequencies above 600 Hz. If the level is greater on the C network than on A and B networks by several decibels, much of the noise is probably below 600 Hz. (13)

Effects of Noise on Behavior

A considerable amount of research has been carried on in the area of sound and its effects on people. Broadbent (2) alluded to over twenty studies which attempted to measure different effects noise has on people.

> Behavior in response to noise can normally be measured in three ways. (1) A man can be asked to report on his own feelings or sensations which means inquiring about the annoyance which the noise is causing the man. (2) Physiological measurement may be applied such as metabolism, rate of breathing, tension in the muscles . . . (3) The man may be required to perform some task, and his efficiency on that task measured. (2)

Annoyance of Sound

According to Broadbent (2) determining the annoyance of a sound is rather subjective and "that some noises are annoying to almost all people, and probably any particular noise is annoying to some person."

According to Gilliland: (9)

> The sound of a saw in the shop, or the shuffle of feet passing through the hallway, or the roar of a jet plane landing at a nearby airport are disturbing sounds to everyone except the boy running the saw, the student passing to another class, or the pilot landing the airliner.

Broadbent suggests that noise levels which interfere with speech to the degree that it is barely understood cause an appreciable amount of annoyance.

Factors that have been found to cause sound to be annoying are (1) loudness, (2) pitch, (3) intermittent and irregular noise, (4) localization of sound production, (5) avoidable or unnecessary sounds and (6) inappropriateness to ones own activity. (2)

Physiological Responses to Sound

Most of the sources reviewed suggest that there are no significant physiological effects of sound in the decibel ranges that are commonly found in the school setting.

Tests have shown that persons become accustomed to high noise levels when exposed for long periods of time. One thorough test found little or no effect on respiration rate, blood pressure, metabolism, acuity of vision, heartbeat, and pulse rate after hours of exposure to jet engine noise.

Noise Effects on Efficiency

A great deal of research effort has attuned itself to measuring the effects of sound on human performance. A few of the simple tasks, sensory and motor functions that have been measured in attempting to ascertain the varying effects of sound are: (1) reaction time, (2) judge of distance, (3) reversible perspective, (4) identification of light intensity, and (5) squeezing of hand dynamometer, etc. Of all those studies reviewed regarding simple tasks, none or little significance was shown.

Broadbent (2) reviewed a number of studies involving complex tasks or intellectual tasks, solving (1) arithmetic problems, (2) vocabulary tests, and (3) form board tests, and concluded that most were unaffected to any appreciable degree by noise. "These studies and certain others using similar types of problems suggest that paper and pencil work of this type of problem will not be likely to show effects of noise." (2)

Slater (15) tested the effects of noise on seventh graders. She used three levels of noise and tested for results on the STEP reading test. Questionnaires were used to determine perception of noise and anxieties. Analysis of variance showed no difference.

Because of the insignificant differences shown in most of the research reviewed regarding the effects of sound on individuals, this researcher decided not to encompass this aspect of sound on learning.

Consideration of Studies in Industry

Most of those studies in industry reviewed pertaining to the effects of sound levels were concerned basically with the productivity aspects. This situation causes many of them to be irrelevent to this study.

According to Gilliland (9) when considering the educational aspects of sound and utilizing research concerned with:

> . . . the medical consequences of exceptional exposure to physiologically damaging sonic conditions, with inherent psychological and neurological implications or industrial concern with operation procedures, which ultimately cost industry money . . . are gross instruments of comparison. It takes far less sound to disrupt and prohibit learning than it does to damange the human organism or to seriously impair his adjustment processes.

Many of the industrial studies contained definite weaknesses due to lack of control of other conditions besides the noise which was being investigated.

Techniques that resulted in weaknesses were the use of only a few subjects over short periods of time, experiments encompassed short testing periods, carry-over effects were not considered, tasks used were to some extent practiced, and noises were familiar. It is almost impossible to generalize or transfer information gathered to the agricultural mechanics facility environment since these weaknesses were found in both industrial and laboratory research.

Sound Levels in Two Types of Classrooms

Fitzroy and Reid (7) conducted a study involving the sound levels of closed space type classrooms versus open space type classrooms. They showed average noise reduction, class in session, class silent, speech interference levels, and articulation indexes for each of the types.

The study involved thirty-seven schools throughout the United States. Average sound levels recorded for classrooms were in the 66 and 67 dB range. Laboratories similar to agricultural mechanics were not included.

Critical Factors Identified in Literature

After reviewing and summarizing the literature that seemed relevant to sound levels and noises, it was decided to investigate the following factors: (1) Noise interference with conversation, (2) annoyance, and (3) hearing damage risk.

The decision was based on the following facts:

(1) Because the main interest was to discern what influence noise had on the educational environment and because it was a basic assumption that verbal communication is paramount in the teaching-learning process, speech interference became a basic factor to consider.

(2) Because the most valid research suggested that annoyance seemed to inhibit learning, it became a basic issue for consideration in the study.

(3) Because of the new concern of the public in the third pollution and its hearing damage risk, it became a factor for consideration.

Microphone Orientation

Environmental sound levels were measured with microphone orientation in the far field at zero degrees incident to major activity with measurements taken in a diffuse field using an omni-directional microphone and a random incidence corrector.

> The omni-directionality of the instrument becomes more important when the sound is incident from all directions. Such examples are noise from several sources in a machine shop or noise from a single

> source in a room but reflected by hard boundaries so the field is more or less diffuse. (14)
>
> The orientation of the microphone is immaterial in a diffuse field. However, even omni-directional microphones exhibit some directional qualities, so orientation is important in a field which is wholly or partly directional. In that case the microphone should be oriented so that the directional part of the field is frontally incident because microphone frequency response is flattest for such incidence. (10)

The methods used in determining if measurements were taken in the near field were:

1. Determine the critical radius.

2. Measure a distance three to four times the largest dimensions of the radiating source.

3. Double the distance of microphone from sound source and see if 6 dB reduction is made in reading.

> The transition from a directional sound field to a diffuse sound field, in a room is characterized by a critical radius, which can be estimated as follows:
>
> $$r_G = 0.14 \sqrt{\bar{a}A}$$
>
> where $\bar{a}$ is the absorption coefficient of the walls and A is the surface area of the wall, floor and ceiling. (10)
>
> At a distance of several (three to four) times the largest dimension of the radiating source, "spherical spreading" is said to exist, and the behavior is then essentially independent of the size of the source. (13)

Measurements taken in the near field were with microphone orientation (M.O.) 90 degrees incident to the radiating source because it was the desire to measure the sound level in the area around the dominating machine and not just the sound emitted from the machine.

In determining speech interference two methods were considered:

Determine the noise rating number, N, for the three octave bands with centre frequencies, 500, 1,000, and 2,000 Hz, then use a standardized table to determine if the noise rating number is permissible for the case considered. (4)

The table consists of a noise rating number column, a distance at which everyday speech of conversational voice level is considered to be intelligible column, and a distance at which everyday speech of raised voice level is considered to be intelligible column.

Noise number is determined by the formula, $N = \frac{L - a}{b}$. L is the octave band sound pressure level in decibels. The a and b are constants given for the most important octave bands. (4)

The latter method in determining speech interference, and the one adopted, was to acertain the speech interference level by finding the mean dB measured at the 500, 1K and 2K midfrequency of octave bands. It was chosen because of its ease of computation, and it is the one more commonly used. Readings derived from computations using both methods are similar.

> Because of the annoyance of interference with speech and also because noise interferes with work where speech communication is necessary, a noise rating based on the speech-interference level is frequently useful. We should know how to improve speech communication in a noisy place.
>
> Even direct discussion can be difficult and tiring because of excessive noise. Excessive noise may make it impossible to give danger warnings by shouting or to give directions to workers.(13)

The three octave bands used in determining speech interference level, 500, 1K, and 2K are used because "a number of experimenters have shown that nearly all the information in speech is contained in the frequency region from 200 to 6,000 Hz." (13)

CHAPTER III

DESIGN AND METHODOLOGY

Introduction

The purpose of the study was to analyze noise in representative agricultural mechanics facilities. In order to perform this analysis, a method had to be chosen for selecting these facilities. To accomplish this objective it was necessary to select variables that could be easily identified and that were most crucial in regard to what was to be measured.

In determining those variables that are critical to noise analysis, some decision had to be made as to what objectives were to be met regarding the analysis. The variables identified in the objectives of this study suggested the criteria used in selection of the facilities and procedures used in analysis of noises within the facilities.

Purposes of the Chapter

The purposes of this chapter are to explain:

1. Procedures used in selecting and equating representative facilities used in the study.

2. Methods used in identifying and analyzing the sounds for annoyance and degree of speech inhibition.

3. Procedures used in determining machine-time-use patterns.

4. Methods used in measuring sound levels.

5. Procedures used in determining microphone orientation for environmental sound analyses.

6. Procedure for graphically recording sound levels.

7. Method used in determining mean decibel from strip chart recorder.

8. Procedure used in calibrating sound level meter.

9. Method used in calibrating graphic recorder.

Procedures Used in Selecting and Equating Representative Facilities

Criteria used in selecting facilities were:

1. Types of buildings housing vocational agricultural mechanics programs.

2. Type of instructional program housed in the structure.

Buildings utilized in conducting agricultural mechanics programs can be categorized into basic groups according to the predominant material from which the buildings are fabricated. Buildings constructed primarily of concrete (cinder) block and/or brick without a dropped ceiling and those predominantly of steel seem to represent the most typical and were selected for investigation.

The four facilities selected to represent the steel and concrete block and/or brick buildings were chosen from agricultural mechanics facilities in Oklahoma by this researcher in collaboration with Mr. Hallard Randell, Agricultural Mechanics Specialist for the Oklahoma Vocational Agriculture Division of the State Department of Vocational-Technical Education. Mr. Randell in turn counseled with and was advised by vocational agriculture district supervisors as to what existing facilities would meet the suggested criteria. A copy of the letter written to

Mr. Randell is in Appendix C.

Criteria used in selecting and equating these facilities were:

1. Square feet
2. Number and size of windows
3. Insulation
4. No sealed ceiling
5. Number, size, and type of machines
6. Number of students in shop
7. Age of facility
8. Type of instructional program

The type of instructional program carried out in the facility was considered an important variable in the selection of facilities. The two main types of instructional programs considered as typical in the state are laboratory skill oriented (LSO) and project construction oriented (PCO). These are explained in the definitions offered in the first chapter.

Categorizing or classifying that type of instructional program being carried out in each of the four facilities selected was accomplished by presenting those helping in the selection of the facilities a copy of the definitions and from their concensus categorizing the program simultaneously with the facility. Such considerations as skill assignments, amount of time spent at each work station, and objectives of the course were used in identifying the type of program.

Using the procedure just explained twelve facilities were suggested for consideration. From these twelve, the four facilities that best met the criteria for use in the study were chosen. The delimiting process was accomplished by telephoning each respective vocational agriculture instructor at the school where the facility was located and asking him if he and his school administrator would be willing to cooperate in such an endeavor.

Every instructor indicated that he would be receptive to such a study. The criteria were reviewed and the instructor's responses were marked on a checklist as he gave them. A copy of the criteria checklist is in Appendix C. Weighing information gathered from both sources, the state staff and the respective instructors, the four sites used in the study were chosen and possessed the following characteristics.

Site 1:	Predominantly Concrete Block	Laboratory Skills Oriented (LSO)
Site 2:	Predominantly Steel	Laboratory Skills Oriented (LSO)
Site 3:	Predominantly Steel	Project Construction Oriented (PCO)
Site 4:	Predominantly Concrete Block	Project Construction Oriented (PCO)

When actual testing was conducted, it was found that, although programs being conducted in Sites 1 and 2 were predominantly laboratory skills oriented, there were project construction oriented instructional programs in the more advanced classes. Because of this fact the environmental data presented in the following chapters will be identified by instructional programs in progress when the sound levels were measured. All environmental analyses made at Sites 3 and 4 were conducted with PCO instructional programs ongoing.

Methods Used in Identifying and Analyzing Sounds

A questionnaire was administered by the researcher at each study site during the same day the sound level measurements were recorded except in the case of one site where the instrument was administered a week later to one of the classes. A copy of this questionnaire is in Appendix A.

Dates of the site visitations were as follows:

Site 1: Friday, April 9, 1971

Site 2: Wednesday, April 14, 1971

Site 3: Friday, April 16, 1971

Site 4: Wednesday, April 28, 1971

Types of activities to be performed in the agricultural mechanics facility and the keeping of the visitations as close together as possible were the basic considerations in selection of dates. The questionnaires were administered to students who were or had been utilizing the agricultural mechanics facility for at least three weeks of the semester.

A preliminary draft of the questionnaire had been previously administered to 32 C.E. Donart High School vocational agriculture students at Stillwater, Oklahoma, who were or had been utilizing their agricultural mechanics laboratory during the spring semester of 1971. Their responses and comments were used in the refinement and/or revision of the final draft of the questionnaire.

The questionnaire was designed to accomplish the following:

1. Identify the sounds in the agricultural mechanics facility during periods of normal use that annoyed the student most as perceived by the student.

2. Select characteristics of this most annoying sound which caused it to be annoying as perceived by the students.

3. Determine the degree to which the students were susceptible to annoyance while engaged in five suggested activities.

4. Determine the frequency with which the sound environment

of the respective facilities, during periods of normal use, interfered with or inhibited desired audio-communication as perceived by the student.

In identifying which sound in the shop during periods of normal use most annoyed the student, the student was simply asked to respond to the question: Is there a specific (one) noise or sound in the agricultural mechanics shop which annoys or bothers you? If so, name what causes that noise . . . Identify the one that bothers you most.

Data obtained from the student questionnaire were analyzed to obtain item counts, percentages, and in some cases the rank order of items. This procedure allowed the investigator to make comparisons across study sites.

Procedure Used in Determining Machine-Time-Use Patterns

Machine-time-use refers to the amount of time noise producing machines or equipment were used in each session.

The time pattern refers to the amount of time (given by percentage) a machine or piece of equipment was utilized in the first, middle, and last portion of the class session.

It is believed that this information lends to and augments that data regarding noises that are annoying. Also time pattern portions of the session, first part, middle, or last portion, during which the machine was in use are indicative of work patterns and may indicate where adequate audio-communications are likely to be most inhibited or hampered during the class session.

Machine-time-use patterns were measured using a time pattern chart. A time pattern chart is in Appendix B. This chart was kept by an enumerator at each site during five normal agricultural mechanics sessions for each class using the shop. The enumerator simply marked through a blocked number to represent minutes during which that specific machine was in use and when it was in use. Thrity minutes are shown on each chart; therefore, each class session required two charts. The total minutes of the session were divided into three equal portions and percentages of machine use by first, middle, and last portions of the session and by total session found. In computing machine-use percentages, work sessions were considered begun when the first noise making machine was put in use, and the session ended when the last noise making machine was turned off in the scheduled class period.

Methods Used in Measuring Sound Levels

A BRUEL & KJAER (B&K) Impulse Precision Sound Level Meter, Type 2204 as shown in Figure 1 was used to measure all sound level and frequency analyses for both selected noises produced by equipment and the overall or background (Bkgd.) noises. Predominant noise producing equipment identified as being used at each site by the machine-time-use charts and those noises identified as being most annoying were considered in selecting equipment noise to be analyzed.

The procedure was to record the background (Bkgd.) noise level with the microphone in Standard Position (S.P.) prior to using the sound producing equipment to be measured. Figures 2 and 3 show standard position microphone orientation. Most recordings included measurements taken in decibels (dB) on the A and C frequency weighting networks using the sound level meter described. In addition, measurements were taken in decibels at 10 octave band centers using the B&K Octave Filter Set 1613. The octave band centers used were 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 (1K Hz), 2000 (2K Hz), 4000 (4K Hz), 8000 (8K Hz), and 16000 (16K Hz). After background noises were recorded at both weighted networks and the 10 octave bands, the machine being analyzed was operated by the student in a normal manner and the 12 measurements recorded.

Procedure Used in Determining M.O. for Environmental Sound Analyses

Environmental sound levels were measured and recorded with the same instruments that were used in anlyzing noises of selected equipment. The basic difference in procedures used was microphone orientation (M.O.).

A representative microphone orientation that will measure overall sound level of the facility's environment while in normal use is necessary. In selecting microphone locations the following factors were considered:

1. Activities being performed in the shop.

2. Equipment being used and its approximate noise producing characteristics.

3. Type of instructional program being carried on.

4. Area of the shop where audio-communication is most necessary.

To give the investigator some insight into the problem of microphone orientation, he conducted some preliminary sound level measurements, both environmental and equipment, at the Oklahoma State University Agricultural Mechanics laboratories and in the vocational agriculture shop at C.E. Donart High School in Stillwater, Oklahoma. From information gathered in these investigations, the following procedure was adopted regarding microphone orientation for measuring environmental sound level: (1) by carrying the sound level meter through the shop at the first of the period, a quick check was made to determine the intensities and fre-

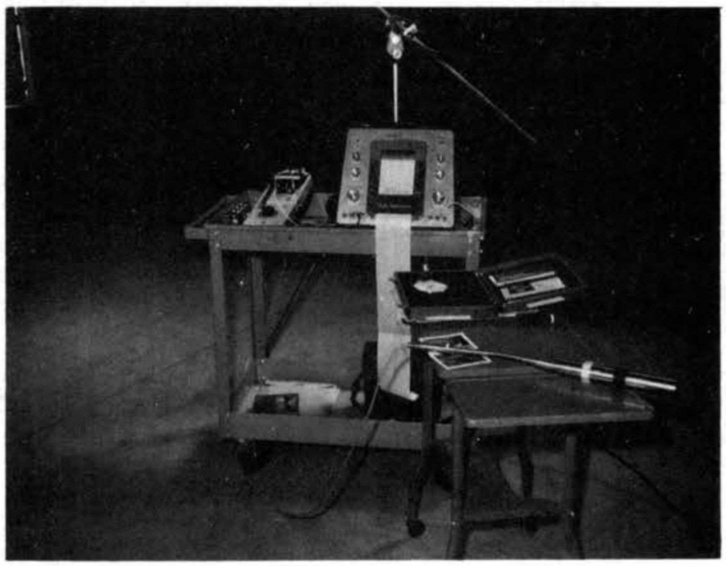


Figure 1. Instruments Used in the Study

Figure 2. Standard Position Microphone Orientation (M.O.) Microphone Hand Held

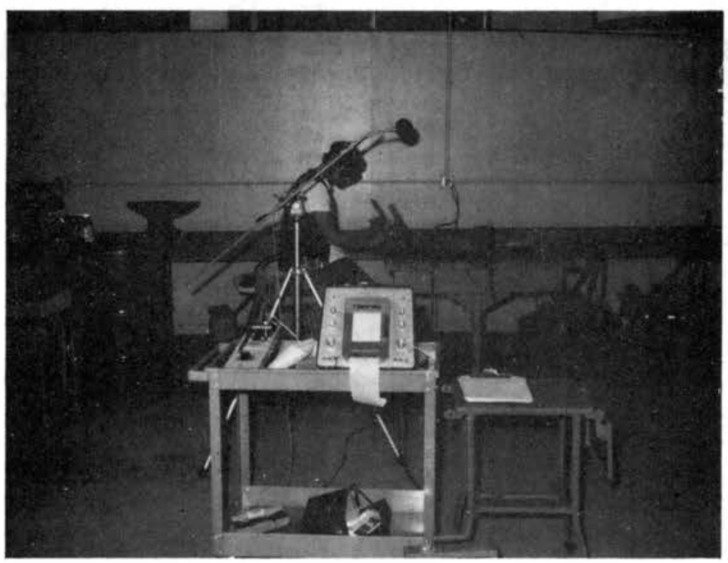


Figure 3. Standard Position Microphone Orientation (M.O.) Microphone Secured on Tripod

Note: Figure 2 - Shows abrasion cut-off saw at Site 3
Figure 3 - Shows bench grinder at Site 2

quencies of sound emanated during assumed normal shop use and (2) by talking to the instructor prior to each test, activities to be performed and locations in the shop where they were to be performed were determined.

From conferring with the instructor and observing locations of chalk boards, reference materials, and bulletin boards, the shop areas most critical to audio-communications were considered. The microphone was placed in those open areas of the shop where audio-communications were necessary, an equal distance, if possible, from the three highest noise producing activities or machines. Position of microphone (position is used here to refer to direction microphone is facing) was determined by the accoustical properties of the surface nearest the microphone and the direction or orientation of the dominant noise. The microphone was always placed 5 ft. and 4 in. above the floor on a tripod. It was believed that this level was approximately ear-high for most persons utilizing the facility. Microphone orientations used in each of the environmental measurements are illustrated on each of the facility floor plans. Measurement durations were similar in length in all tests. Longer test intervals were used for the A Scale, 500 Hz, 1K Hz, and 2K Hz measurements for all tests.

All readings were taken with the sound level meter on slow response.

> With this response Slow, the meter indication produced by a 500 milliseconds duration signal must fall between -5, -3 dB from the meter deflection produced by a steady signal of the same frequency and amplitude. Overswing due to sudden application of a steady signal must be within +1.6, + 0.1 dB of the final steady indication, and this indication should not differ from the level indicated with Fast characteristic by more than 0.1 dB. (3)

<u>Procedure for Graphically Recording Sound Levels</u>

Two methods were used to record equipment and environmental sound level (SL) data.

1. Use of machine or environmental data sheet. (See Appendix B)
2. Use of Brush strip chart recorder. (See Figure 1)

Both were used simultaneously with duration of each sample (sample is recording at each of the 12 measurements per test) being approximately one minute in length.

The Brush strip chart recorder graphically recorded signals received from the DC output of the sound level meter at both weighted networks and the 10 octave bands. The recorder chart was run at 5 mm/sec. with .05 volts per chart line for all tests using channel one on the recorder.

The two channel recorder includes an oscillograph and amplifiers as an integral unit. Channel one was used to record the signals received from the sound level meter, while channel two, due to a weighing potentiometer not being available for the study, was used as an indicator to show on the graph when range changes were made on the sound level meter.

The output amplifier and input amplifier attenuators are range switches on the sound level meter and operate in conjunction with each other. When there is a deflection on the meter, the value indicated on the meter scale is added to the range which is adjusted by the attenuator's knob. The output voltage signal from the sound level meter which drives the recorder is contingent upon the indicating meter. It does not take into account the range. Maximum output voltage for full scale deflection on the meter for the B&K sound level meter is three V RMS with a maximum, peak value of 10 volts.

To prevent input or output overload on the sound level meter and because the writing width of the recorder responds to signal variations of 10 dB, range adjustments had to be made when fluctuations of 10 dB or greater occurred.

A 1.5 volt battery was used with an on-off switch as the power source for the signal on channel two of the recorder. With the battery circuit closed the pen was deflected above the origin or base line to approximately the fifteenth horizontal line when channel two of the recorder was attenuated to .1 volts per chart line. With the switch off the pen trace went back to the base line of the graph. It was necessary to write on the graph with a felt pen the range measurement that was being recorded. Channel two simply indicated where a range change was made on the graph when the operator opened or closed the battery circuit at the same time he changed the ranges on the sound level meter.

Method Used in Determining Mean dB from Strip Chart Recorder

Inked tape graphs recorded with the brush recorder were averaged by using a planimeter, the K&E Polar Planimeter; the inked lines of the graph were traced and the area beneath the line found. The ratio of this area to the total area of section of tape being averaged was used to solve the ratio of X to 40. The number of horizontal lines counting from the base line on the graph represented X, the mean. A calibrated graph could be compared to the mean reading and a dB recording found for the interval. The mean, computed from the tape, was compared to the dB sound level recorded on the respective data sheets during the test. Figure 4 shows sample graph.

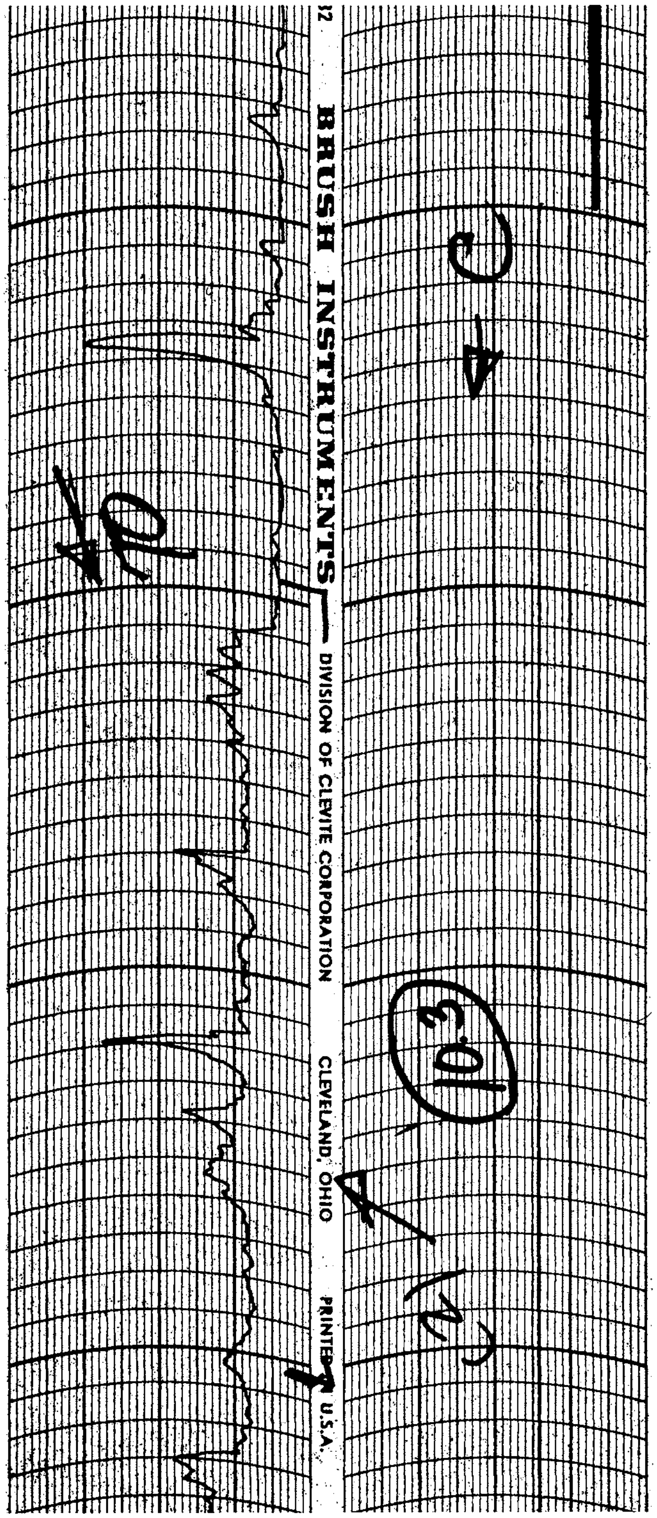


Figure 4. Brush Recorder Graph

Activities being performed during each interval which had been written on the data sheet and the characteristics of the graphs recorded were reviewed in determining which reading was the most valid for that interval. In most cases the brush tape recording data were given the highest consideration in determining the mean reading. The differences in the two readings were not significant. Significant is used here to refer to less than two dB differentiation in the 60 dB range or above.

Calibrating the Sound Level Meter

The sound level meter was calibrated before measurements were conducted at each site. There are three methods of doing this:

1. Using the built-in reference voltage
2. Using the Sound Level Calibrator, Type 4230
3. Using the Pistonphone, Type 4220

The pistonphone was used as the means of calibrating in this research. (See Figure 1) This method simply involved placing the microphone in the pistonphone which is a portable battery driven instrument that produces 124 dB re 2 X 10^5 N/m^2. With the sound level meter attenuated in the 120-130 dB range the meter reading is adjusted by the Gain Adjustment Potentiometer to a 4 dB scale reading.

Calibrating the Graphic Recorder

The pen bias was adjusted to position pen on 0, origin, of the graph. The graph was also calibrated by placing a known signal (using the pistonphone) of a 124 dB reading previous to sound measurements at each site.

The audio oscillator (Hewlett-Packard 200AB) was used in ascertaining the value in dB at one dB increments of the horizontal lines on the strip chart. The audio oscillator signal drove a speaker which produced a constant sound level at 800 Hz. Tests were conducted in a quiet room with no outside interference. Other calibrations were conducted at frequencies of 500 Hz and 1K Hz. Results were within .3 dB per chart line.

The sound level meter microphone was placed one inch from the face of the speaker and sound levels monitored were used to adjust the oscillator for one dB increments in a 10 dB range to calibrate the graph being recorded.

Means given in horizontal graph lines measured by the planimeter were converted to decibels using the calibrated graph just explained. This information provided the sound level and speech interference level for the environment and equipment analysis.

Summary

It was the intent to keep instrumentation and procedures for the study to a minimum and yet collect valid data that could be used to accomplish the objectives. This desire was based on the concern that others who might conduct a study similar to this one would not have access to more sophisticated equipment. Also because of the nature of the study, that of visiting sites that were of some distance apart, equipment that can be transported was a necessity.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Noise analyses of selected agricultural mechanics facilities are presented in this chapter. Data for the respective facilities were collected by:

1. 191 questionnaires administered to students utilizing the facilities.

2. Machine-time-use pattern charts kept by enumerators at each site.

3. Sound level meter tests and observations recorded at each site.

In this chapter, data will be analyzed and presented as follows:

1. Analysis of noise for annoyance as perceived by the respondents and from observations recorded on the machine-time-use charts.

2. Analysis of sound levels for conditions that may cause loss of hearing.

3. Analysis of noise for degree of inhibition to speech communication as measured with the sound level meter. Presentations are arranged by sites in this section.

4. Students' perception of audio-communication interference in the respective agricultural mechanics facilities.

Analysis of Noise for Annoyance

Because the evaluation of annoyance is rather subjective, a questionnaire was designed to ascertain which noises were annoying to students during a typical agricultural mechanics session.

Table II presents a summary of the objectionable noises identified by students for each site. The table is constructed so that responses from students utilizing like facility construction types can be more easily compared. The speech interference levels of four pieces of equipment are presented for each facility. Percentage of time the equipment was in use is also given for 16 pieces of equipment that were identified as annoying.

Of that equipment showing use percentages, exhaust fans were used the greatest percentage of time (from 32.1 percent to 92.6 percent). The abrasion cut-off saw, chipping slag, and the bench and disc grinders, were all found to have high use percentages. These pieces of equipment are all high noise producers.

Based on rank order the most annoying sound producing equipment were: (1) Site 1: disc grinder, (2) Site 4: hammering and chipping, and (3) Site 2: hammering and chipping. It should be noted that the highest percentage of respondents at Site 3 indicated there were no annoying sounds to them while at Site 2, 35 percent of the students responding to the questionnaire indicated they were not annoyed by any sounds in the agricultural mechanics shop. Of those students at Site 3 who indicated that they were annoyed by a sound in the shop, the disc grinder ranked the highest. On inspecting the speech interference levels found for the disc grinder, 90 and 98, and comparing these to speech interference levels of the other annoying equipment, it was found that with the exception of the abrasion cut-off saw, the disc grinder was the most annoying, which suggests that loudness is an important characteristic of a sound in causing it to be annoying.

Table III presents a breakdown of machine use in percentage during the first, middle and last portions of the session as well as by total session. It was the belief of the investigator that knowing what portion of the session a machine was most likely to be used might give some insight into what parts of a session would most likely be free from specific noises. If meaningful noise patterns can be identified, those periods with the least intensity of noises would be the most conducive to audio-communication.

It was also felt that time-use data would be helpful in equating instructional programs. Inspection of the time-use table shows all four facilities were similar in regard to percentage of the session equipment was used.

The activity, arc welding, showed the highest use percentage at Sites 1, 3, and 4. It was conducted only about a third of the time at Site 2. Oxy-acetylene cutting was conducted 95.9 percent of the time with a bench grinder being used 58.1 percent of the time at Site 2. Oxy-acetylene cutting was carried on for 48.6 percent at Site 1, 63.1 percent of the time at Site 3, and 47.6 percent at Site 4.

In reviewing the literature, eight characteristics of noise were identified as possible causes of annoyance. These characteristics were listed on the questionnaire and the students were requested to check those which they felt caused the noise they had identified to be annoying. A summary of student responses to this questionnaire item is presented in Table IV. The characteristic, loudness, was ranked first at

TABLE II

ANALYSES OF ANNOYING SOUNDS IDENTIFIED BY STUDENTS

	FACILITY PREDOMINANTLY CONCRETE BLOCK										FACILITY PREDOMINANTLY STEEL									
	SITE 1					SITE 4					SITE 2					SITE 3				
ANNOYING SOUNDS	RESPONSE NO. 69	%	RANK	SIL db	USE %	RESPONSE NO. 38	%	RANK	SIL db	USE %	RESPONSE NO. 40	%	RANK	SIL db	USE %	RESPONSE NO. 43	%	RANK	SIL db	USE %
(1) None	1	1.44	6	—	—	6	15.78	3	—	—	14	35.0	2	—	—	15	34.88	1	—	—
(2) Power Wood Saw	1	1.44	6	82*	21.4	5	13.15	4	74	18.5	—	—	—	—	—	—	—	—	—	—
(3) Disc Grinder	25	36.23	1	—	20.8	7	18.42	2	—	—	3	7.5	3	90	15.1	11	25.58	2	98	48.2
(4) Bench Grinder	1	1.44	—	—	—	—	—	—	—	—	1	2.5	6	—	58.1	—	—	—	—	—
(5) Pedestal Grinder	9	13.4	4	80	33.0	—	—	—	—	—	—	—	—	—	17.2	1	2.32	6	85	—
(6) Metal Band Saw	—	—	—	—	—	—	—	—	67	—	—	—	—	76	—	4	9.30	4	—	—
(7) Abrasion Cut-Off Saw	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2.32	6	100**	58.8
(8) Air Compressor	7	10.4	5	58	25.2	—	—	—	—	—	—	—	—	64	17.9	—	—	—	74	—
(9) Exhaust Fan or Fans	1	1.44	6	55	72.3	—	—	—	57	68.8	—	—	—	62	32.1	—	—	—	—	92.6
(10) Torch Backfire	—	—	—	—	—	—	—	—	—	—	2	5.0	5	—	—	3	8.82	5	—	—
(11) Hammering and/or Chipping Slag	11	15.94	2	—	33.5	11	28.94	1	—	48.3	17	42.5	1	—	35.9	6	13.95	3	—	52.9
(12) Dragging Table	—	—	—	—	—	4	10.52	6	88	—	—	—	—	—	—	1	2.32	6	—	—
(13) Other	2	2.88	—	—	—	—	—	—	—	—	3	7.5	3	—	—	1	2.32	6	—	—

*"A" Scale
**Average SIL when more than one reading recorded with similar conditions

TABLE III

EQUIPMENT TIME-USE ANALYSES

EQUIPMENT	PERCENTAGE TIME USED BY SITE															
	SITE 1				SITE 2				SITE 3				SITE 4			
	PORTION			TOTAL	PORTION			TOTAL	PORTION			TOTAL	PORTION			TOTAL
	1st	2nd	3rd	SESSION	1st	2nd	3rd	SESSION	1st	2nd	3rd	SESSION	1st	2nd	3rd	SESSION
(1) Band Saw	37.1	50.0	42.9	43.6	44.8	17.2	----	20.7	----	----	----	----	51.3	50.5	42.5	47.3
(2) Power Wood Saw	53.3	16.7	9.1	21.4	----	----	----	----	----	----	----	----	9.9	19.4	24.5	18.5
(3) Disc Grinder	13.1	33.9	13.1	20.8	00.0	9.6	45.1	15.1	41.3	46.0	57.3	48.2	----	----	----	----
(4) Bench Grinder	31.4	44.0	21.4	33.0*	55.8	52.9	20.0	58.1	----	----	----	----				
(5) Pedestal Grinder	31.4	44.0	21.4	33.0*	25.9	18.5	7.4	17.2	----	----	----	----	----	----	----	----
(6) Drill Press	----	----	----	----	55.6	22.2	----	25.9	----	----	----	----	15.0	23.8	18.8	19.2
(7) Abrasion Cut-Off Saw	----	----	----	----	----	----	----	----	50.7	70.4	55.3	58.8	----	----	----	----
(8) Air Compressor	22.8	20.0	32.5	25.2	00.0	7.1	46.2	17.94	----	----	----	----	----	----	----	----
(9) Electric Brush	33.9	27.1	45.5	34.8	----	----	----	----	45.7	32.6	34.8	37.7	----	----	----	----
(10) Disc Sander	90.0	40.0	----	34.0	----	----	----	----	----	----	----	----	----	----	----	----
(11) Hammering and/or Chipping Slag	19.0	35.8	44.4	33.5	55.8	41.8	15.4	38.4	56.6	45.3	56.3	63.9	47.9	51.5	46.0	48.3
(12) Arc Welding	55.6	86.7	69.4	72.3	42.5	65.4	----	32.1	92.5	92.5	93.0	92.6	65.6	73.7	66.8	68.8
(13) Oxy. Welding	31.0	13.0	3.8	15.7	88.2	100.0	100.0	95.9	35.7	31.4	31.4	32.9	----	18.2	37.5	33.3
(14) Oxy. Cutting	57.5	51.0	38.0	48.6	29.5	35.0	33.3	32.9	69.0	51.4	68.8	63.1	53.1	51.0	40.0	47.6

*Pedestal and Bench Grinder data are not separated all sites. Abruptness and frequency were both ranked second in the overall ranking, followed in order by persistant, unnecessary, others, not related, and direction emanating from, which ranked 8th with movement of sound source.

There was close agreement by sites on the rankings on all the characteristics. Eight students at Site 3 had indicated other characteristics that annoyed them. The term "other" on the table included those who indicated there were no annoying sounds and those who had written what they thought was another characteristic. In most instances it could have been placed in one of the other categories.

Table V shows a summary of the mental and physical activities that students were involved in when most susceptible to the annoying sound. These activities, lecturing, discussing, conversing, thinking, and working, were arbitrarily chosen by the investigator as activities that a student would be engaged in during normal shop sessions.

Students who were engaged in thinking were more susceptible to annoyance in all of the sites except Site 2. To determine the overall ranking of these activities, Kendall's W was computed. The Kendall Coefficient of Concordance, W, was applied to the data to determine the overall agreement among the respondent's ranking of the activities concerning the susceptibility of the activities to annoying sounds. The following formula obtained from Downie and Heath was used to compute Kendall's W. (6)

$$W = \frac{12 \sum D^2}{m^2(N)\ (N^2 - 1)}$$

Where D^2 = difference of the sum of ranks from the mean squared, M = number of respondents, and N = number of entities (activities) ranked. All W's were significant

TABLE IV

RANK ORDER OF ANNOYING SOUND CHARACTERISTICS BASED ON STUDENT RESPONSES

SOUND CHARACTERISTICS	SITE 1 NO. 123	SITE 1 %	SITE 1 RANK*	SITE 2 NO. 50	SITE 2 %	SITE 2 RANK*	SITE 3 NO. 40	SITE 3 %	SITE 3 RANK*	SITE 4 NO. 62	SITE 4 %	SITE 4 RANK*	SUM OF RANKS	OVERALL RANK
(a) Loudness	44	35.77	1	16	32.0	1	13	32.5	1	22	35.48	1	4	1
(b) Frequency	13	10.56	4	7	14.0	3	7	17.5	3	14	22.58	2	12	2
(c) Irregular, Unexpected or Abruptness	18	14.63	3	13	26.0	2	4	10.0	4	8	12.9	3	12	2
(d) Continuous or Persistant	20	16.26	2	2	4.0	7	2	5.0	6	7	11.29	4	19	4
(d) Not related to task	8	6.5	6	3	6.0	5	2	5.0	6	3	4.83	6	23	7
(f) Direction Eminating From	6	4.87	7	0	0.0	8	0	0.0	9	1	1.61	8	32	8
(g) Movement of Source	2	1.62	9	0	0.0	8	1	2.5	8	2	3.22	7	32	8
(h) Unnecessary or Avoidable	9	7.31	5	3	6.0	5	3	7.5	5	4	6.45	6	20	5
(i) Others	3	2.43	8	6	12.0	4	8	20.0	2	1	1.61	8	22	6

*Rank order on basis of number and percentage of student responses at the one percent level; therefore, it was possible to establish the overall rank on the basis of the order of the least sum of ranks. Rank order was established on the basis of the highest percentage.

Another aspect of noise which was examined regarding annoyance was to determine who was operating the equipment when it was annoying. The categories and responses in percentage by site are as follows: Site 1: "yourself," 8.47; "someone else," 76.27; "neither," 8.47. (Neither would apply to a piece of equipment that was operated automatically such as a heater fan, air compressor, etc.). Site 2: "yourself," 3.44; "someone else," 58.62; and "neither," 6.89. Site 3: "yourself," 00; "someone else," 55.56; "neither," 00. Site 4: "yourself," 9.67; "someone else," 80.68; "neither," 3.22. Those respondents who marked two of the categories and those who marked none were not included.

The "someone else" category received the highest percentage of responses at all sites.

The average number of hours each student spent in the shop per day was considered. The mean hours by site were: Site 1: 1.26 hours, Site 2: 1.26 hours, Site 3: 1.45 hours, and Site 4: 1.09 hours. This information would indicate that students at Site 3 spend one and three-fourths hours per day in the shop. Mean, hours indicate students are spending parts of a "study hall" hour or off hours in the shop in addition to the one hour in the formal class period.

Analysis of Sound Levels for Conditions That May Cause Loss of Hearing

Knowledge of exposure duration is important when determining whether a hazard exists which might cause hearing loss. The Walsh-Healey Public

TABLE V

SUSCEPTIBILITY OF SELECTED ACTIVITIES TO
MOST ANNOYING SOUNDS

ACTIVITY	SITE ONE		SITE TWO		SITE THREE		SITE FOUR			
	Sum of Ranks	True Rank	Sum of Ranks	True Rank	Sum of Ranks	True Rank	Sum of Ranks	True Rank	Total Sum of Ranks	Overall Rank
(a) Lecture	179	5	103	5	53	5	97	5	432	5
(b) Discussion	152	4	75	4	39	4	83	4	349	4
(c) Conversing	121	3	67	2	36	3	70	3	294	3
(d) Thinking	98	1	69	3	25	1	56	1	248	1
(e) Working	110	2	61	1	27	2	69	2	275	2
	W = .226*		W = .176*		W = .347*		W = .168*		W = .152*	

*Significant at the .01 level

Contract Act defines what noise levels may cause hearing loss if exposed for given durations: The Act:

> . . . compels manufacturer's to protect their employees' hearing if they sell to the federal government goods valued in excess of $10,000 or services valued in excess of $2,500. The noise limits allowed by the act are stated in part below. The regulation states (in part): (a) Protection against the effects of noise exposure shall be provided when measured on the "A" scale of a standard sound level meter at slow response.

Duration per day, hours	Sound level dB (A)
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼	115

> Exposure to impulsive or impact noise shall not exceed 140 dB peak sound pressure level. (b) When employees are subjected to sound exceeding those listed above, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels of the information given, personal protective equipment shall be provided and used to reduce sound levels within the levels of the table. (c) This section of the regulations has been revised since May 17, 1969 and now reads: If the variations in noise level involve maxima at intervals of one second or less, it is to be considered continuous. (8)

Table VI presents the maximum duration of exposure to highest recorded noise levels allowed as specified by the Walsh-Healey Act by site. Maximum sound level duration allowed for the highest environmental and equipment noises are shown for the respective facilities. Sites 1, 2, and 4 did not register any sound intensities high enough to be concerned about. Students at Site 3 could be exposed to 94 dB(A) environmental noise level up to four hours before a damage to hearing would occur.

The maximum duration that students at Site 3 may be exposed to the

98 dB(A) equipment (abrasion cut-off saw) sound level is two hours. It is allowable according to the criteria established by the Walsh-Healey Act for students at Site 4 to be exposed to the 96 dB(A) for three hours without harming their hearing. It is not probable that a student would be continuously exposed to any sound level produced in an agricultural mechanics laboratory, especially one that was PCO, for periods longer than 45 minutes.

TABLE VI

ALLOWABLE DURATION OF EXPOSURE
TO HIGHEST RECORDED NOISE LEVELS BY SITES

	Highest Noise Levels at db(A)		ALLOWABLE EXPOSURE HOURS*	
SITE	ENVIRONMENT	EQUIPMENT	ENVIRONMENT	EQUIPMENT
1	82	90	---	8
2	73	90	---	8
3	94	98	4	2
4	68	96	---	3

*Maximum duration as specified under W-H Act.

Analysis of Noise for Degree of Inhibition to Speech Communication

The following portion of this chapter is organized in sections by Sites with overall comparisons comprising the last section.

Presentation procedure by site:

1. Information is presented with floor plans and pictures for

each site.

Floor plans with equipment and microphone orientations of the respective agricultural mechanics facilities are depicted in Figures 5, 6, 7, and 8. In addition to equipment placement, specifications of major noise producing machines and equipment along with other important influencing noise characteristics of each facility are presented.

2. Information is presented in equipment noise analyses tables for each site. (Tables VIII, X, XII, and XIV)

Equipment analyses presented include: (1) Speech interference levels (not computed for all equipment); (2) Background noises prior to measurement (all Bkgd. are given in dB on the A weighted network); (3) Equipment sound levels in dB (most are A scale readings or otherwise noted); (4) Microphone orientation (when sound levels were measured and recorded); and (5) Conditions existing when sound level measurements were made. Annoyance ranks (explained in definitions) are also shown on equipment noise analysis tables for each site.

3. Information is presented in environmental noise analysis tables for each site. (Tables IX, XI, XIII, and XV)

Environmental noise analyses for each site contain the following data: (a) Speech interference level, (b) vocational agriculture class, (c) class size in number of students, (d) instructional orientation of class (LSO) Laboratory-skills-oriented, or (PCO) Project-construction-oriented (defined in Chapter 1) and (e) number of students working simultaneously. It was the belief of the investigator that, the number of students working simultaneously was more indicative of the degree of activity taking place than the class number. Other data used in the environmental noise analyses were dB reading on A and C weighted networks and frequency analysis, dB reading at 10 octave center band frequencies.

Comments include description of activities taking place in the laboratory at the time of the sound measurements and other important conditions which might influence recordings.

It was the intent of the researcher to make all the tables complete in order that generalizations could be made in comparing data from one facility to another.

For determining the maximum permissible values of speech interference levels for men with average voice strengths, the following table is provided. "Speech-interference levels should be less than the values given below in order to have reliable conversation at the distances and voice levels shown." (13)

TABLE VII

PERMISSIBLE VALUES IN DETERMINING SPEECH INTERFERENCE

Distance (Feet)	VOICE LEVEL			
	Normal	Raised	Very Loud	Shouting
1	70	76	82	88
3	60	66	72	78
6	54	60	66	72
12	48	54	60	66

Site 1: Predominantly Concrete

Table VIII presents equipment noise analyses for Site I. Seven different pieces of equipment were analyzed. Measurements were not taken at octave bands of 500 Hz, 1K Hz, and 2K Hz for the wire brush and the table saw; therefore, the speech interference level could not be computed for this equipment. However, the speech interference level was figured for a radial arm saw at Site 4, which produced a S.I.L. of 77; it was believed this would be a reading similar to what might be expected for the table saw.

The Pedestal grinder's 80 S.I.L. shown on Table VIII when compared to value in Table VII shows a very loud voice is necessary and that two people must be closer to each other than two feet in order to converse satisfactorily.

By comparing these values to the equipment time-use chart some estimation can be made as to what percentage of the time one could adequately communicate in that area (within 4-6 ft. of the equipment) of the laboratory. For example, the pedestal grinder was used 33 percent of the shop time at Site 1. Thus, for one-third of the session, speech communication would be inhibited in that area.

The wood planer located in the wood shop adjacent to the agricultural mechanics laboratory produced some interference. Its time-use was not recorded by the enumerator, but the day the investigator was at Site 1 it was being used approximately 80 percent of the time in the two class periods that coincided with agricultural mechanics class sessions. Its sound intensity with the microphone located in the agricultural mechanics shop was 72 dB(A).

The air compressor located above the hallway between shops (See

Figure 5) although not showing a very high annoyance rank did interfere to some degree. It supplied air for both shops, therefore, created disturbances above what would be expected.

The disc grinder had an annoyance rank of one. Sound intensity was not measured, but an estimated S.L. can be obtained for it by looking at the disc grinder sound levels at other sites. Normally the investigator tried to analyze the sound levels of all those machines which were annoying.

The electric wire brush produced a similar S.L.

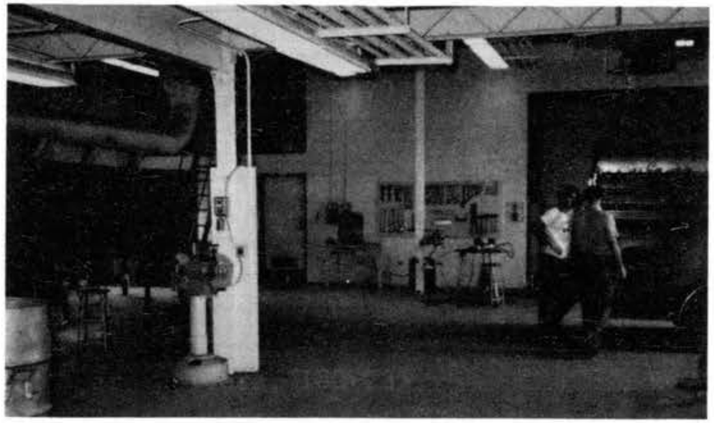
Table IX presents environmental noise analyses for Site 1. Environmental analyses of three different vocational agriculture classes and different microphone locations are given. The high S.I.L., 74, in vocational agriculture III and IV reflects grinding with both the portable disc and pedestal grinders. Comparing this S.I.L. to the tolerability level, a person would need to shout to communicate with anyone six or more feet from him.

Octave band readings are shown. In some cases there is quite a large difference in dB reading from one Hz band to another. The difference may be attributed to a change in sound sources between testing intervals.

The low S.I.L., 66, shown is for a LSO instructional program.

L E G E N D

A. Agricultural Mechanics Laboratory
B. Tool Room
C. Class Room
D. Office
E. Paint Room
F. Restroom
G. Hallway with storage area above



Area in laboratory - 2716 sq. ft.
Windows 3'10" x 3'10" - Plywood extends to ceiling above and below windows
Wall - Painted concrete (cinder block)
Ceiling - Exposed steel deck
Denotes break in ceiling height - M.O. B - 12'; M.O. A, D, and E - 16'
Microphone orientation (M.O.) A-B-C-D-E

1. Pedestal grinder/wire brush combination.
2. Ceiling heaters/fans
3. Drill press - Delta, Cat. No. 25-251
4. Pedestal grinder - Baldor 1.5 H.P. 3450 RPM, 1" stone.
5. Small engine work tables
6. Tilting arbor table saw - Atlas Model 3170, 1 H.P., 3550 RPM.
7. Metal cutting band saw - Johnson, Model B
8. Wood-working table
9. Oxy-acetylene welding booths
10. Arc welding booths - 8 arc welders, 180-235 amp. cap.
11. Welding booth exhaust fan
12. Wall mounted equipment panel
13. Wall mounted black board
14. Compressor, 23 cfm. 2 stage

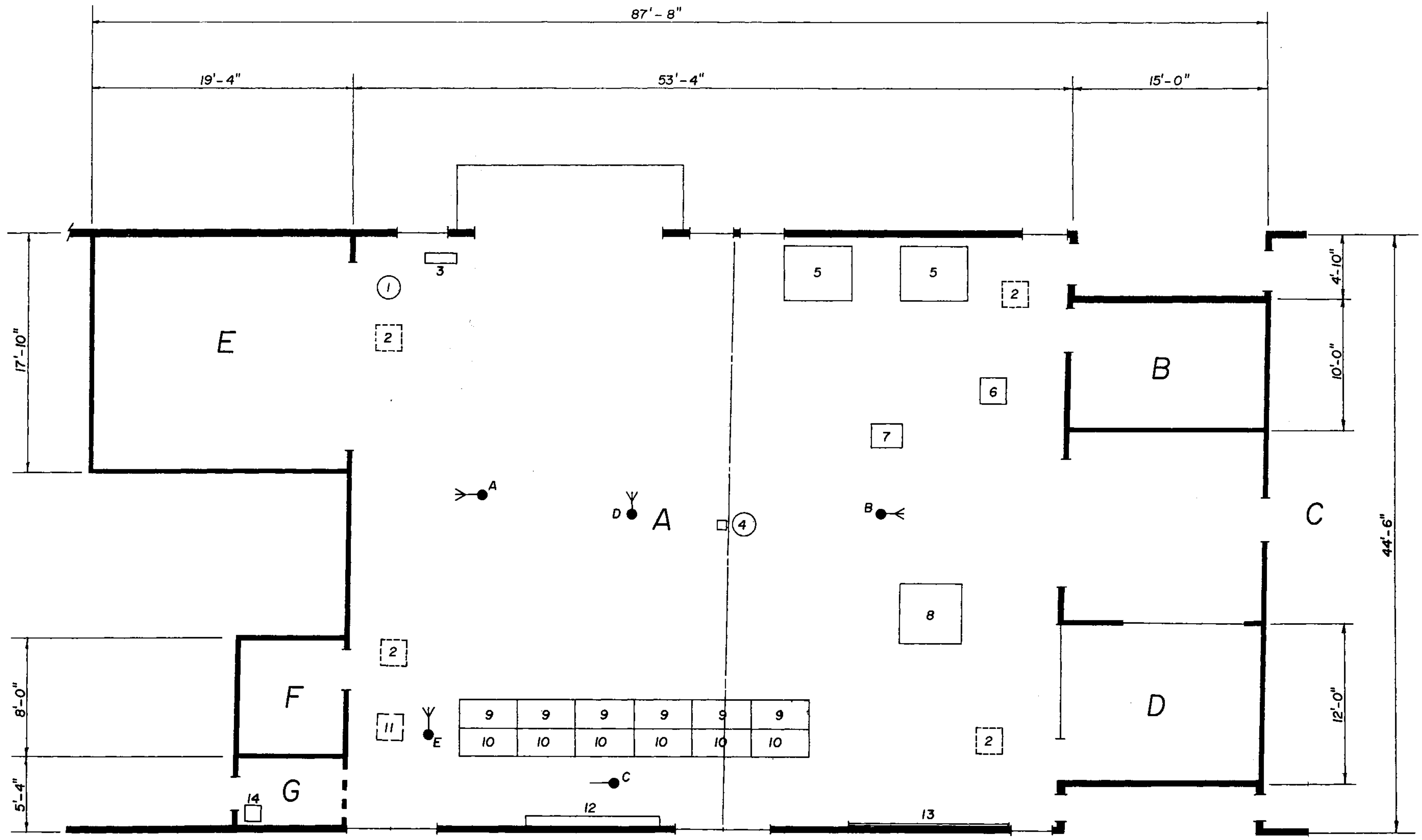


Figure 5. Site One Floorplan

TABLE VIII

EQUIPMENT NOISE ANALYSIS - SITE ONE

1. ELECTRIC POWERED WIRE BRUSH
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class in session, brushing on broad surface of steel plate, large door open	S.P.	88	74dB	

2. AIR COMPRESSOR
Annoyance Rank: 5th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class in session, air compressor located above hallway next to restroom area; woodshop adjacent to agricultural mechanics shop; air compressor used jointly by both shops	E.*	70	54dB	58
(2) Air hose used to clean arc welding booth; class cleaning up after session	C	76 c 75	70dB	

*M.O. is S.P. but 26' horizontal distance for compressor; compressor located 8' above microphone

c: Correction for difference between Bkgd. and Equip S.L. (B&K)

3. PEDESTAL GRINDER
Annoyance Rank: 4th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) Agricultural mechanics class in session, grinding on edge of ¼" steel plate	S.P.	94	82dB	80

TABLE VIII (Continued)

4. EXHAUST FANS
Annoyance Rank: 6th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class in session; both exhaust systems, small ceiling fan; and booth exhaust system in use	E.*	60	52dB	55

*Is with microphone 5'4" from floor and 10' horizontal distance toward center of shop from leading edge of vertical duct work for large fan.

5. ARC WELDER
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) Eight arc welders being used simultaneously; welding and chipping slag being conducted in booths; large door open	C	70	60dB	73

6. WOOD PLANER
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class in session in agricultural mechanics shop; wood planer is located on other side of wall in wood shop adjacent to agricultural mechanics facility	E	72	60dB

7. TABLE SAW
Annoyance Rank: 6th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class in session; sawing pine 1" by 6" with combination blade	S.P.	98	82dB
(2) Running not sawing	S.P.	68 c 67	60dB

TABLE IX

ENVIRONMENTAL NOISE ANALYSIS - SITE ONE

Class: Vocational Agriculture I (LSO)

Microphone Orientation: B　　Speech Interference Level: 66

Number of Students in Class: 16　　Number Working Simultaneously: 12

	Network		Center Octave Band									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	75	72	54	56	60	64	66	64	68	64	50	50

Comments: Large door open; both exhausts on; students performing arc welding skills with some hammering and chipping slag; all welding exercises performed in arc welding booths.

Class: Vocational Agriculture III & IV (PCO)

Microphone Orientation: A　　Speech Interference Level: 74

Number of Students in Class: 16　　Number Working Simultaneously: 13

	Network		Center Octave Band									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	68	80	62	64	70	64	84	74	64	62	52	40

Comments: Large door open; exhaust fans not in use; activities include arc welding, oxy-acetylene cutting, and grinding with both the portable disc and pedestal grinders in use.

TABLE IX (Continued)

Class: Agricultural Mechanics (PCO)

Microphone Orientation: D Speech Interference Level: 73

Number of Students in Class: 17 Number Working Simultaneously: 10

	Network		Center Octave Band									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	82	80	67	68	70	67	70	76	74	85	82	78

Comments: Large door open; exhaust fans not in use; activities include arc welding, hammering and chipping, oxy-acetylene cutting, and using portable disc and pedestal grinders.

The speech interference levels shown are probably more indicative of the true sound levels than are the A scale readings because they are computed from three test intervals encompassing a longer period of time.

Site 2: Predominantly Steel

Table X presents data regarding equipment noises at Site 2. The facility at Site 2 is constructed basically of steel, but three of the interior walls are sealed with plywood. There is exposed insulation on underneath side of roof. (See Figure 6) The right angle grinder again shows the highest sound intensity. It is noted that a check was conducted to test whether standard position microphone orientation was in the near field. By doubling the distance from the standard, 4 ft. to 8 ft., the S.P. was shown in the near field by the reduction of 6 dB in the far reading.

Although no student had indicated the welding booth exhaust fan as the most annoying sound to him in the shop, it did interfere with audio-communication. As can be seen in the table, with no class activity and with M.O. at B_1 a C scale reading of 86 dB was created by the exhaust systems alone. C scale is more responsive to lower frequencies than A scale. This reading is higher than some facility sound levels during normal class sessions.

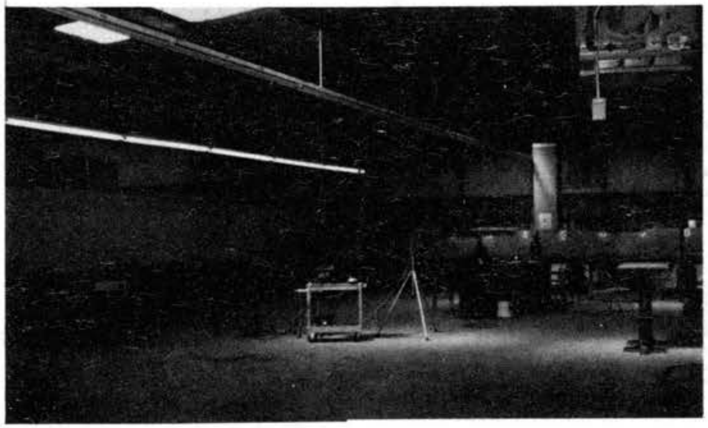
Annoyance rank, as explained in the definitions in the first chapter, is the rank based on the number of students who identified noises that were most annoying to them and did not consider those noises that were second or third in annoyance.

Those sound levels recorded with the microphone placed between the welding booths and the end wall, M.O. C, are most critical in regard to communications because this area is where instructions are given by the teacher to students working in the welding booths. With five arc welders in operation and the exhaust fan on, a SL(A) reading of 89 dB was recorded. C microphone orientation in this case would be the same as S.P. for the near welder.

A sound level of 68 dB is shown for the air compressor while spraying. The connotation of spraying refers to the students using the air hose for cleaning by blowing slag, etc. from the welding booths at the end of the period.

L E G E N D

A. Agricultural Mechanics Laboratory
B. Office
C. Classroom
D. Tool & Storage Room
E. Restroom



Area in laboratory - 3640 sq. ft.
Wall - Inside, sealed with 3/4" H&D Plywood, Painted
Ceiling - Underneath side of gable roof 1½" mineral wool with 4 mil. polyethylene (plastic film) vapor barrier.
Exhaust fans - (a) mounted in center of roof, Acme Model LA18E6
(b) mounted in duct centered directly over welding booths, Acme Model LA21G4
Windows - 3' x 2'6" aluminum horizontal slide
Large Door 12' x 12'

1. Arc welding booths, 180-250 amp. cap.
2. Oxy-acetylene welding booths
3. Air compressor
4. Pedestal grinder
5. Drill press - Delta Rockwell
6. Metal band saw - Johnson, Model B
7. Hossfield metal bender
8. Skylites
9. Oxy-acetylene welding table
10. Ceiling mounted heater/fan
11. Work benches
12. Bench grinder/ wire brush, Rockwell 23-635, 1/3 H.P.

Ventilation intake , 6' x 3' (End wall next to welding booths) - adjustable louvers

Microphone orientation - (M.O.)
A-B_1-B_2-B_3-C

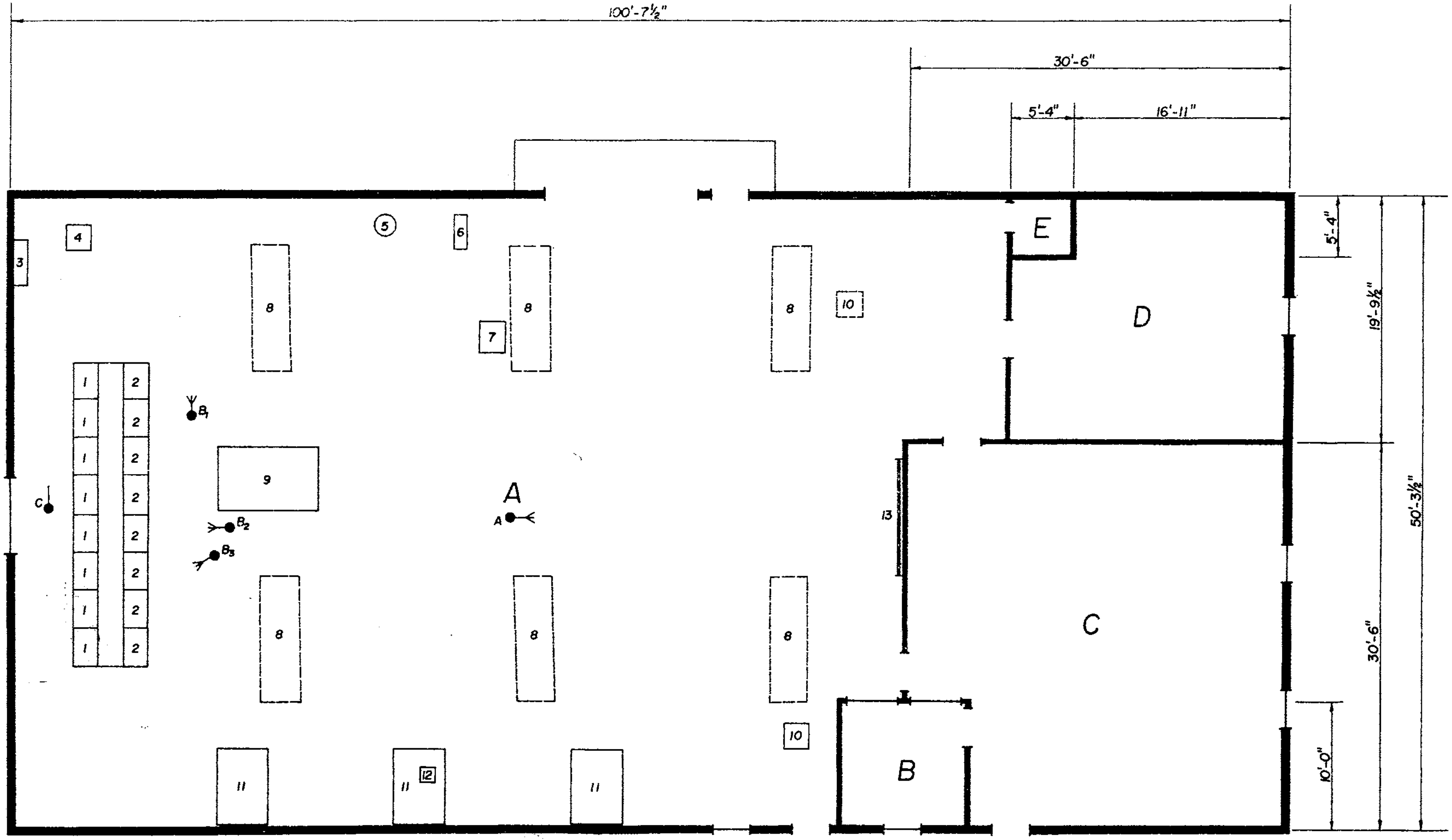


Figure 6. Site Two Floorplan

TABLE X

EQUIPMENT NOISE ANALYSIS - SITE TWO

1. ARC WELDER
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) Five arc welders in operation in adjoining booths; welding on ¼" mild steel plate using 80-110 amp. with E6011 1/8" electrode; arc welding exhaust system on; large door open	B_1	72	60dB	
(2) Same as above	C	89	60dB	

2. PORTABLE DISC (Right Angle) GRINDER
Annoyance Rank: 3rd

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class activity; using worn disc on solid plug in 2" pipe mounted in vice on wood table; large door open	S.P.	90	50dB
(2) Same as above		84	60dB

3. METAL BAND SAW
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class activity; sawing ¼" 2" by 2" angle iron; large door open	B_1	76	60dB

TABLE X (Continued)

4. AIR COMPRESSOR
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class activity; air compressor is mounted 8' off floor; compressor running not spraying	B_1	64	50dB
(2) Same as above except spraying	B_1	68	50dB

5. EXHAUST FAN (Ventilation Fan)
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class activity; small ventilation fan in middle of shop roof	B_1	61	42dB	55
(2) Facility vacated; arc welding system fan in ceiling installed with duct work; vibrations are amplified by metal roof and duct	C	72	42dB	69
(3) Both ventilation systems in operation simultaneously	B_1	69 86(C) c 68	61dB 70dB (C)	

Site 2 environmental analyses are presented in Table XI. Sound interference levels shown for both classes, vocational agriculture II which was LSO and vocational agriculture IV which was PCO, were similar.

Sound levels for the two classes ranged from 70 dB on the A scale to 48 dB at 16K Hz for the vocational agriculture II class and 73 dB on the A scale to 44 dB at 16K Hz for the vocational agriculture IV class.

Activities occurring in the two classes were quite different. The vocational agriculture II class which was LSO was involved in oxy-acetylene welding skills with very few other activities taking place. The vocational agriculture IV class was involved in project construction activities, including utilizing the metal bender, drill press, and metal band saw.

It is important to note that at Site 2 for the LSO class of 16 students only six on the average were involved in shop activities.

Although the S.I.L. recorded for the vocational agriculture IV class was relatively low, 60, there was a great fluctuation in sound levels, 10 dB or more per interval, due to the type of activities performed. There were numerous impulse noises recorded in the vocational agriculture II class due to the hammering and chipping of slag.

Site 3: Predominantly Steel

Equipment noise analyses recorded at Site 3 presented in Table XII summarize the data for six different pieces of equipment.

Of the six analyzed, the metal abrasion cut-off saw (See Figure 7) emitted the highest sound intensity, 98 dB(A) with microphone orientation at standard position and 96 dB(A) with M.O. at location A. Microphone orientation A was 20 ft. horizontal distance from the saw. A S.I.L. of

TABLE XI

ENVIRONMENTAL NOISE ANALYSIS - SITE TWO

Class: Vocational Agriculture II (LSO)

Microphone Orientation: A Speech Interference Level: 62

Number of Students in Class: 16 Number Working Simultaneously: 6

	Network		Center Octave Band									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	70	70	54	46	54	55	60	64	61	60	54	48

Comments: Exhaust fans not in use; activities include oxy-acetylene welding, grinding, chipping slag, and pounding and hammering while testing welds.

Class: Vocational Agriculture IV (PCO)

Microphone Orientation: B_2 Speech Interference Level: 60

Number of Students in Class: 8 Number Working Simultaneously: 5

	Network		Center Octave Band									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	73	67	54	55	54	53	51	66	58	60	50	44

Comments: Large door open; exhaust fan not in use; activities included using the metal bender, drill press, and metal band saw; Bkgd. noise with no one in the shop is 42dB(A); with students in the shop but no one working Bkgd. is 60dB(A).

of 98 with the microphone at a 20 ft. distance would seem to indicate an intolerable condition throughout the facility when trying to give instructions.

Through inspection of the equipment time-use schedule, Table III, it was evident that the condition would exist over one-half of the session and 70 percent of the time in the middle part of the session.

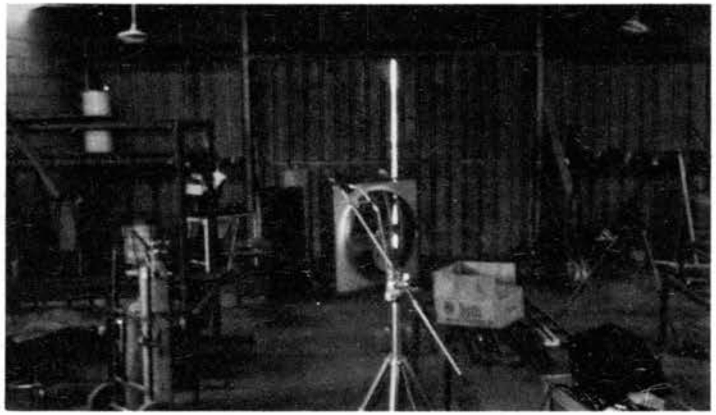
Table XIII presents two different environmental noise analyses at Site 3. Both classes analyzed for speech interference levels were PCO. Noise characteristics noted in the studyhall group were continuous with reading fluctuations at 6 dB. Noises in the vocational agriculture IV class were impulses with 10 dB or more fluctuation.

The studyhall group showed a 77 dB reading for the A scale to a 50 dB reading at the 16K Hz octave band center. The vocational agriculture IV class showed a 94 dB reading for the A scale to a 72 dB reading at the 16K Hz octave center band. The largest difference in decibels shown between intervals for the studyhall group was 18 dB which occurred between 8K Hz and 16K Hz. The greatest fluctuation or difference recorded for the vocational agriculture IV group was 24 dB which occurred between 250 Hz and 500 Hz.

The speech interference level, 78, measured in the vocational agriculture IV class reflects the influence of the metal cut-off saw on the noise conditions present. A person would have to be shouting to be understood when trying to talk to anyone three feet away.

L E G E N D

A. Agricultural Mechanics Laboratory
B. Restroom (Two walls concrete cinder block)
C. Classroom (Wall concrete cinder block)



Area in laboratory - 2132 sq. ft.
Windows - 3'8" x 4'3"
Wall - Exposed unpainted steel (one end wall and part of another unpainted cinder block)
Ceiling - Underneath gable, steel roof exposed
Large door - 8'10" x 12'
Microphone orientation (M.O.) A

1. Arc welders, 225 amp. cap.
2. Drill press - Delta
3. Pedestal grinder
4. Electrical service panel
5. Air compressor, Saylor Bell - 200 psi, 1.5 H.P.
6. Ceiling mounted heater/fan
7. Abrasion cut-off saw
8. Work tables
9. Skylites
10. Portable oxy-acetylene rigs
11. Tool panels
12. Powered metal hacksaw - Marvel No. 1 (location not shown)

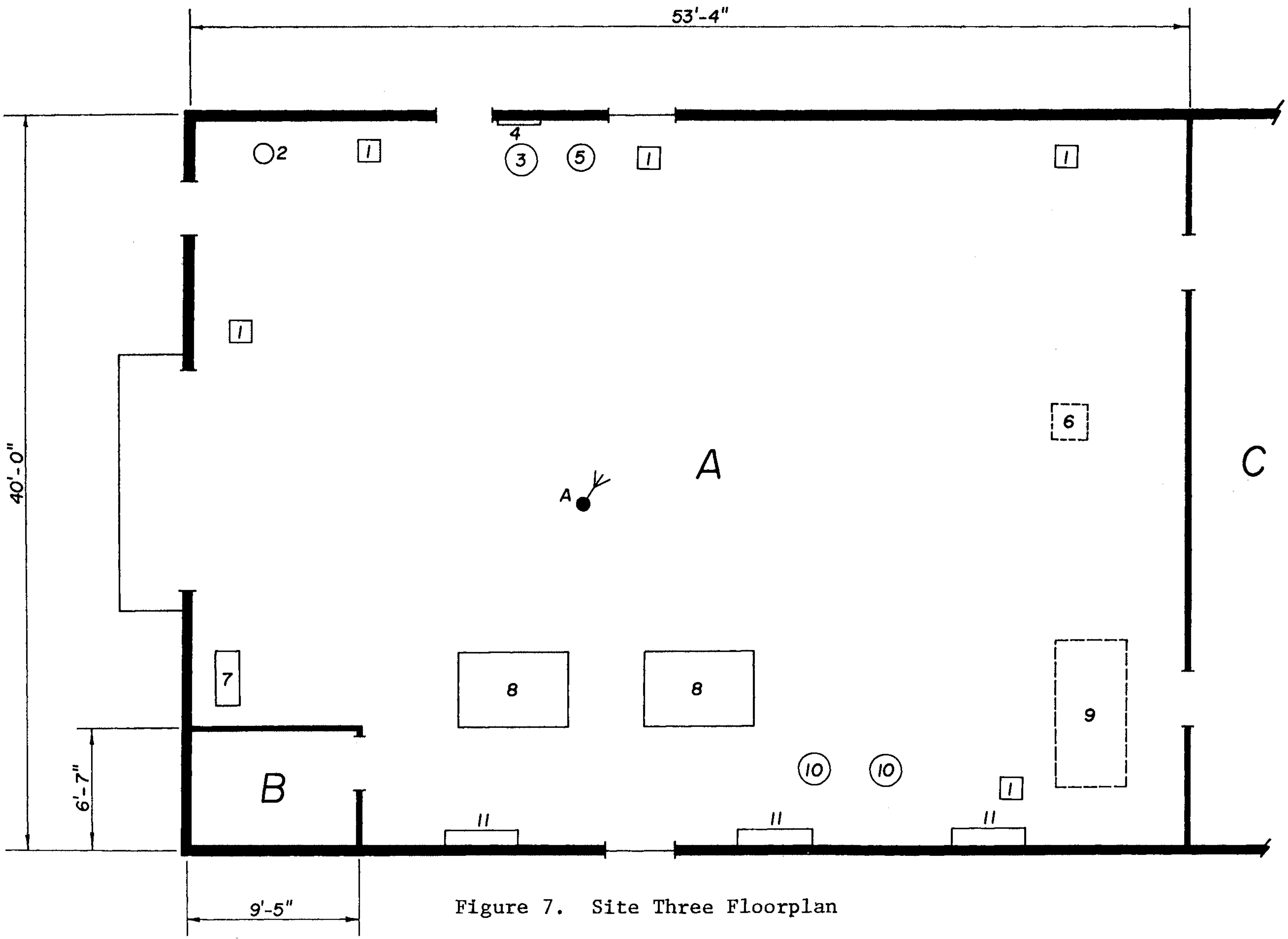


Figure 7. Site Three Floorplan

TABLE XII

EQUIPMENT NOISE ANALYSIS - SITE THREE

1. ARC WELDER
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class in session; welding at 90 amps. with a transformer 225 amp. capacity welder using 1/8" E6011 Rod; welding on a table with no shields; welding 1/4" angle iron	S.P.	72	60dB	60

2. METAL ABRASION DISC CUT-OFF SAW
Annoyance Rank: 6th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No other activity; large door open	S.P.	98	58dB	101
(2) Class in session; large door open (S.L. does not raise appreciably with large door shut)	A	96	76dB	98

3. PEDESTAL GRINDER
Annoyance Rank: 6th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class in session; grinding on steel pipe	S.P.	85	60dB
(2) Running not grinding	S.P.	69	60dB
(3) Class in session; grinding on ¼" x 2" x 2" steel angle; large door open	A	89	76dB

TABLE XII (Continued)

4. PORTABLE (Right Angle) GRINDER
Annoyance Rank: 2nd

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class in session; grinding on metal gate made of 1" pipe; only slight decay in sound when microphone was backed away from 4' to 10'	S.P.	98	60dB

5. AIR COMPRESSOR
Annoyance Rank: None*

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class in session; large door shut	A	74	62dB
(2) Same as above, but spraying	A	76	62dB

*Instructor indicated that air compressor was used very little

6. OXY-ACETYLENE CUTTING
Annoyance Rank: 5th*

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) No class in session; using 25# psig oxygen and 7# psig acetylene; cutting ¼" angle iron using #2 Smith tip	S.P.	72	60dB

*Expressed annoyance to backfire that occurs not necessarily to oxy-acetylene cutting.

TABLE XIII

ENVIRONMENTAL NOISE ANALYSIS - SITE THREE

Class: Study Hall Group (PCO)*

Microphone Orientation: A   Speech Interference Level: 69

Number of Students in Class: 12   Number Working Simultaneously: 9

	Network		Center Octave Band									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	77	78	72	70	68	70	70	69	68	66	68	50

Comments: Large door open; activities included constructing projects, oxy-acetylene cutting, and arc welding; abrasion cut-off saw used very little.

*Students working during their off hour - Not a formal class

Class: Vocational Agriculture IV (PCO)

Microphone Orientation: A   Speech Interference Level: 78*

Number of Students in Class: 10   Number Working Simultaneously: 8

	Network		Center Octave Band									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	94	86	66	66	64	68	92	70	68	72	72	72

Comments: Large door open; activities included hammering, oxy-acetylene cutting and arc welding being performed; cut-off saw used intermittently, thus explaining big variations in readings from one interval to next.

*Reflects influence of abrasion cut-off saw

Site 4: Predominantly Concrete

Table XIV presents the equipment noise analyses at Site 4. Six pieces of equipment were analyzed for noise at Site 4. Of the six analyzed, the radial arm saw recorded the highest reading with a 96 dB(A) when microphone orientation was at S.P. and was followed closely with a 94 dB(A) measurement taken of sounds emitted by a steel table being dragged across the concrete floor. The microphone was located 12 feet horizontal distance from where the table was being dragged and was positioned at 0 degree incidence. The annoyance rank of the radial arm saw was 4th and the table 5th.

Three other sound level measurements were made of the radial arm saw with different microphone orientations and/or different conditions existing during the measurement. In the instances where the saw was actually being used, a pine board 2" by 6" was being ripped with a combination blade. The large door was open.

Other equipment analyzed in addition to the table and radial arm saw were the ceiling heater fan whose location is shown in Figure 8, the welding exhaust fan, a metal band saw, and the activity, arc welding, and the arc welder itself.

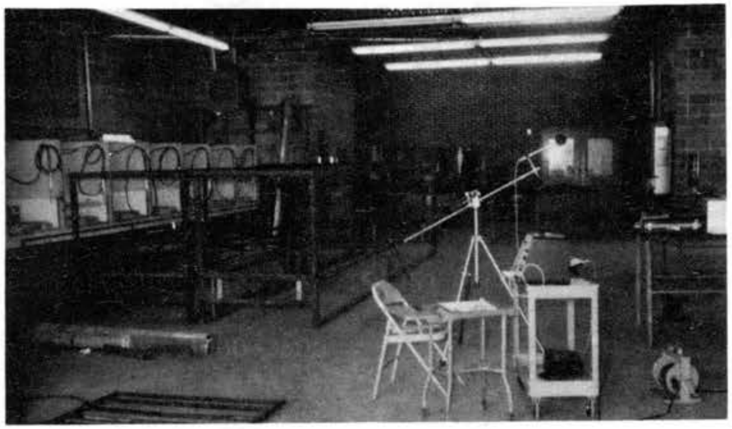
The arc welder emitted a 74 dB(A) sound level with the microphone orientation at standard position. The activity of arc welding with eight welders being operated simultaneously showed a 67 dB(A) reading when the M.O. was at B as shown in Figure 8.

The metal band saw produced the same dB(A), 67, as the welding activity. Microphone orientation was at B for the band saw noise analysis measurement.

The welder exhaust system for Site 4 was located in the end wall

L E G E N D

A. Agricultural Mechanics Laboratory
B. Restroom
C. Tool Room
D. Class Room



Area in laboratory - 3075 sq. ft.
Windows 4' x 5'
Wall - Inside, unpainted concrete /cinder block
Ceiling - Steel Deck - Height 16'
Large Door - 12' x 16'6"
Microphone orientation A-B-C-D-E

1. Arc Welders/Booths (180-250 amp. cap.)

2. Oxy-acetylene welding booths

3. Electrical service panel

4. Ceiling mounted heater/fan

5. Metal band saw - Johnson, Model B

6. Radial arm saw/ general purpose blade
Rockwell Delux 105, Cat. No. 33-310
3450 RPM

7. Drill press - Delta Rockwell, Cat. No. I5-251

8. Bench grinder, B & D, 8";RPM 3000-3600
(location not shown)

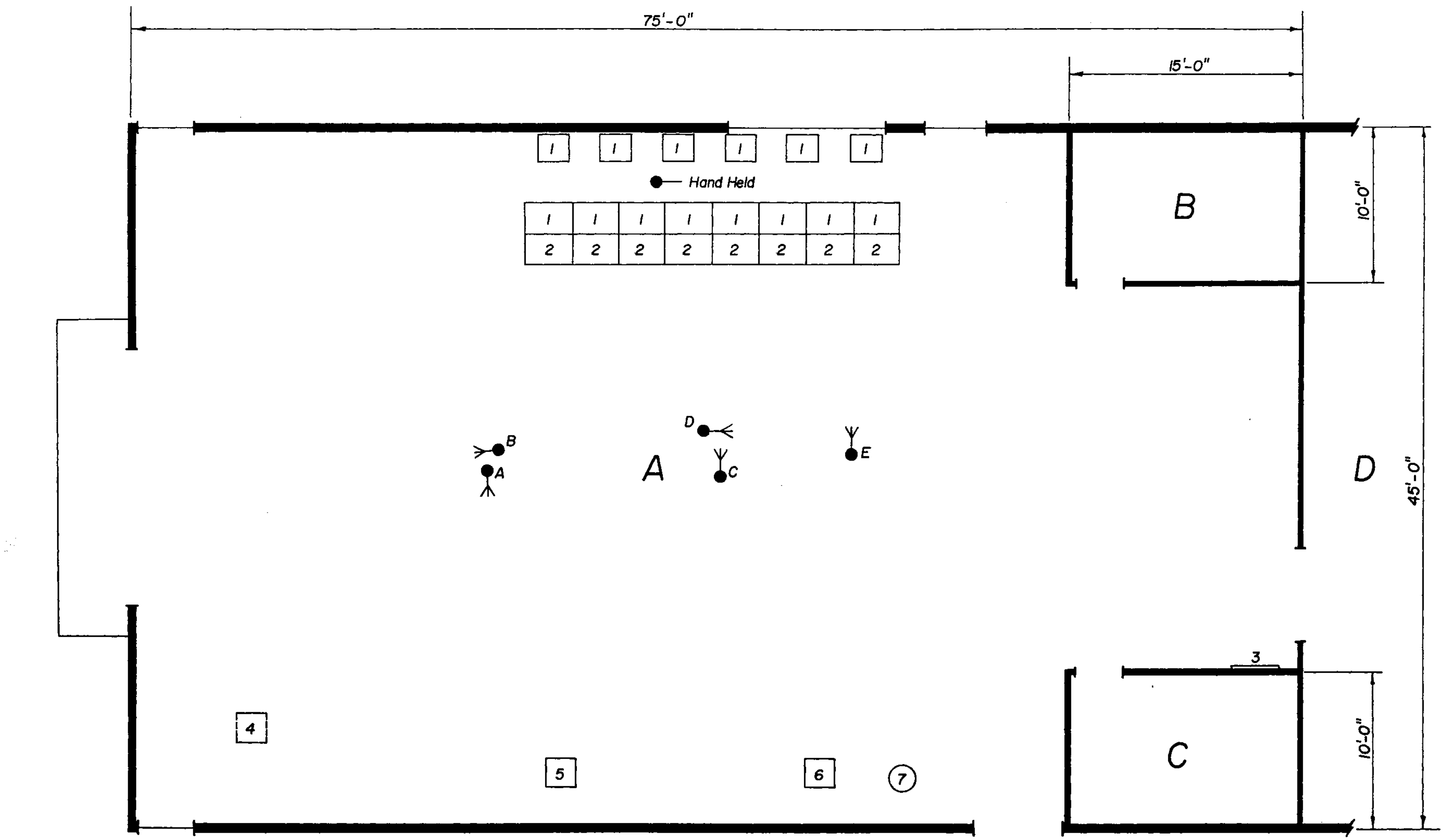


Figure 8. Site Four Floorplan

TABLE XIV

EQUIPMENT NOISE ANALYSIS - SITE FOUR

1. CEILING HEATER FAN
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class in session, no other activity, large door open	C	53	52dB	46
(2) No class in session, no other activity, large door open	S.P.	57	52dB	50

2. WELDING BOOTH EXHAUST FAN
Annoyance Rank: None*

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class in session, no other activity, large door open	A	60	52dB	53
(2) Same conditions as above	S.P.	64	52dB	57

*Exhaust fan is only run at those times arc welding is being conducted. Arc welding with microphone at location B emits 67dB(A). Noise levels therefore masking the noise emitted by the exhaust fan.

3. STEEL TABLE*
Annoyance Rank: 5th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) No class in session, no other activity, microphone on tripod 12' horizontal distance from where table is dragged, large door open	E	94	52dB	88

*Table was dragged across concrete floor.

4. METAL BAND SAW
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)
(1) Normal class activity, saw being used to saw 7/8" sucker rod, large door open	B	67	62dB

5. ARC WELDER
Annoyance Rank: None

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) Normal shop activity with class in session, large door open, welding on ¼" plate using 1/8" E6011 electrode at 90 amp. using a 225 amp. capacity transformer type welder	S.P.	74	*	
(2) Normal activities with class in session, 8 arc welders going (welders same type as explained above), no chipping.	B	67	**	60

*Bkgd. noise level was not recorded. S.P. recording was made while 5 to 7 arc welders in adjoining booths were in operation.

**No Bkgd. levels are given for far field microphone locations when sound levels emitted are basically of specific equipment.

6. RADIAL ARM SAW
Annoyance Rank: 4th

Conditions Existing During Measurement	M.O.	Equip. SL(A)	Bkgd. SL(A)	S.I.L.
(1) Normal class activity, saw being used to rip a pine 2" by 6", class in session with students constructing projects in the Bkgd, large door open	B	76	60dB	74
(2) No class in session, no other activity in Bkgd, saw being used to rip a pine 2" by 6", large door open	D	88	52dB	76
(3) No class in session, no other activity in Bkgd, saw running but not sawing, large door open	D	69	52dB	58
(4) No class in session, no other activity in Bkgd, saw being used to rip a pine 2" by 6", large door open	S.P.	96	52dB	77

and was the lowest noise producing exhaust system.

The heater fan noise analyzed was not significant. There was not enough difference between fan noise and background noise to differentiate.

The four environmental noise analyses presented in Table XV are for three different vocational agriculture classes. The agricultural mechanics class was analyzed with two different microphone orientations for comparison.

Both speech interference levels recorded with the different microphone orientations are similar, 60 and 63. About half of the students in the class were working simultaneously in both measurements. Sound levels measured for the agricultural mechanics class were sporadic with 10 dB or more fluctuation at times due to students hammering.

The speech interference level for the vocational agriculture III and IV class was 59 and for the vocational agriculture II class, 61.

The vocational agriculture II class was the only LSO oriented instructional program analysis at Site 4. Two-thirds of the class was working simultaneously.

Table XVI presents a summary of the environmental noise analyses for all four sites. Class and type of class, number of students working simultaneously, microphone orientation, and speech interference level are listed by site. Mean number of students and mean speech interference level are shown.

The facility at Site 1 was commensurate to the facility at Site 3 regarding mean speech interference levels. The two facilities were different with regard to size (square footage) and construction type.

TABLE XV

ENVIRONMENTAL NOISE ANALYSIS - SITE FOUR

Class: Agricultural Mechanics (PCO)

Microphone Orientation: A   Speech Interference Level: 60

Number of Students in Class: 12   Number Working Simultaneously: 5

	Network		Center Octave Bands									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	68	73	56	54	61	60	65	60	56	56	40	42

Comments: Large door open; activities included students hammering, carrying in sucker rod, and arc welding.

Class: Agricultural Mechanics (PCO)

Microphone Orientation: B   Speech Interference Level: 63

Number of Students in Class: 12   Number Working Simultaneously: 6

	Network		Center Octave Bands									
	A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB	62	70					62	58	70			

Comments: Large door open; activities included arc welding and oxy-acetylene cutting.

TABLE XV (Continued)

Class: Vocational Agriculture III & IV (PCO)

Microphone Orientation: B — Speech Interference Level: 59

Number of Students in Class: 12 — Number Working Simultaneously: 7

Network		Center Octave Bands									
A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB 62	68	54	52	64	60	64	55	58	57	50	32

Comments: Large door open; activities included hammering, using radial arm saw, and metal band saw for short periods of time.

Class: Vocational Agriculture II (LSO)

Microphone Orientation: D — Speech Interference Level: 61

Number of Students in Class: 15 — Number Working Simultaneously: 10

Network		Center Octave Bands									
A	C	31.5	63	125	250	500	1K	2K	4K	8K	16K
Mean dB 68	70	55	55	60	58	60	61	61	52	53	36

Comments: Exhaust fan on, large door open; activities included working in welding booths, hammering and chipping slag; 8 arc welders being operated simultaneously.

TABLE XVI

SELECTED COMPARISONS FOR THE FOUR SITES

SITE	COMPARATIVE FACTOR				
	Class	Class Type	No. Students Working Sim.	M.O.	S.I.L.
1 (Concrete)	Ag. I	LSO	12	B	66
	Ag. III & IV	PCO	13	A	74
	Ag. Mech.	PCO	10	D	73
			Mean 11.7		Mean 73.5 *
2 (Steel)	Ag. II	LSO	6	A	62
	Ag. IV	PCO	5	B_2	60
			Mean 5.5		Mean 61.0
3 (Steel)	S.H.	PCO	9	A	69
	Ag. IV	PCO	8	A	78
			Mean 8.5		Mean 73.5
4 (Concrete)	Ag. Mech.	PCO	5	A	60
	Ag. Mech.	PCO	6	B	63
	Ag. III & IV	PCO	7	B	59
			Mean 6.0		Mean 60.7

*Average (73.5) of the PCO classes at site 1, which were most representative of sound levels produced in that facility. Mean of the three classes is 71.0.

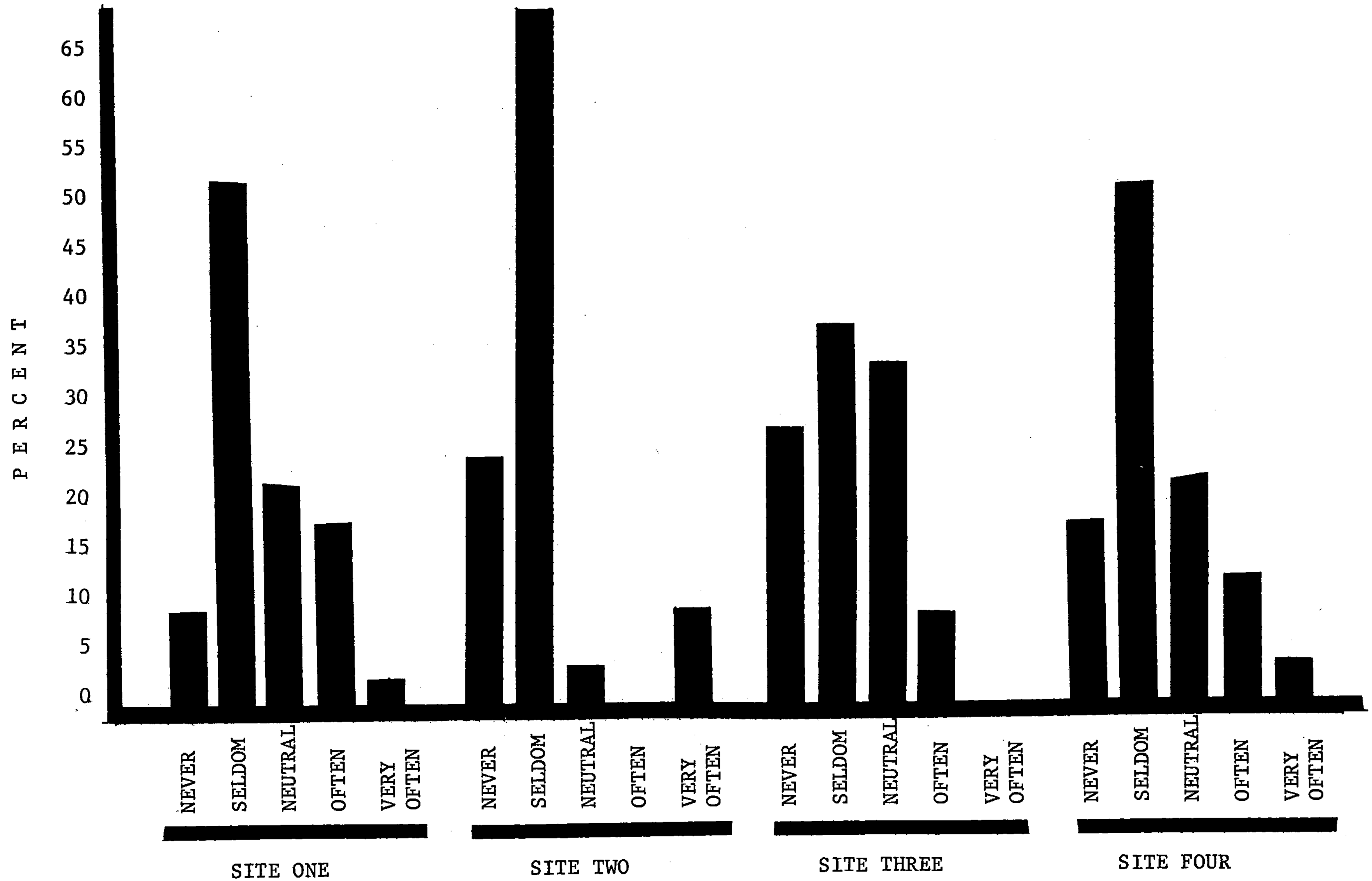


Figure 9. Students Perception of Frequency of Interference to Audio Communication

Site 2 and Site 3 recorded similar speech interference levels and their facilities were of different construction types. As alluded to previously, Site 2's interior walls are plywood with exposed insulation on underneath side of roof.

The mean number of students working simultaneously for Site 1 and Site 3 were 11.7 and 8.5 respectively or almost 3.5 students difference; but if the intensity, number of students working per square foot of floor space is considered, they would be nearly equal.

One piece of equipment, the abrasion cut-off saw, was a contributing factor to the higher speech interference level recorded at Site 3; but the 69 shown for the studyhall group which used the saw only slightly (four or five minutes in the entire session) is higher than any speech interference level recorded for either Site 2, another steel facility, or Site 4, a concrete block facility.

Students Perception of Audio-Communication Interference

Frequencies of inhibition to audio-communication in each facility during normal class sessions as perceived by students are illustrated by the bar graph, Figure 9.

The term "never" as used here indicates that at no time in a normal agricultural mechanics class session did the respondent feel that he was unable to hear his instructor adequately. "Often" indicates his hearing was interfered with by noises often.

Average speech interference levels are shown for each facility. Site 3 with one of the highest speech interference levels showed the highest "never" and "neutral" percentages, 26 and 32 respectively. Site 1 with a 73.5 speech interference level facility showed the second highest "seldom," 52, but also the highest percentage of respondents indicating that they could not adequately hear the instructor "often" because of noise interference present in the laboratory.

A Pearson product-moment correlation coefficient was computed to determine if any significant relationship existed between the speech interference levels for each facility and the students perception of the respective facility's aural environment.

No significant relationship was found at the five percent level for any of the frequencies: (a) "never," (b) "seldom," (c) "neutral," (d) "often," (e) "very often," and the mean speech interference levels.

The following formula was used to compute the Pearson product moment.

$$r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{\left[N \sum X^2 - (\sum X)^2\right]\left[N \sum Y^2 - (\sum Y)^2\right]}}$$

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Summary of the Study

The central purpose of this study was to analyze the different noises found in four agricultural mechanics facilities selected as being representative of those commonly in use in Oklahoma. The facilities were equated and categorized according to (1) fabrication types, (2) size of building, (3) number, size and type of equipment, (4) number of students utilizing the facility, and (5) type of instructional programs housed.

Noises in each of the facilities were analyzed for: (1) speech interference levels, (2) sounds objectionable to students, and (3) sound level durations causing hearing loss.

The four structures housing agricultural mechanics programs analyzed in the study represented two basic types: (1) those constructed predominantly of steel, and (2) those constructed predominantly of concrete. Instructional program types conducted at each facility were identified as: (1) laboratory skill oriented or (2) project construction oriented.

Completion of the study involved collection and analysis of data regarding the following specific objectives which were formulated to guide the research effort:

1. To identify the sound levels and speech interference levels, created by types of educational programs in each category of facilities

selected as representative of those used in Oklahoma for vocational agricultural mechanics programs.

2. To identify the most annoying sounds perceived by students in the selected facilities during normal use.

3. To assess the annoying characteristics of sounds (intensity, frequency, abruptness, consistency, appropriateness, localization, necessity, and movement of source) as perceived by students and to measure certain of these characteristics with a sound level meter.

4. To determine in which of a selected group of mental and physical activities students are susceptible to the most annoying sound.

5. To analyze noise created by selected equipment in facilities for sound level, frequency, speech interference level, and degree of annoyance.

6. To determine the degree of impairment to the desired aural environment for each selected facility as perceived by the respective students and as measured with a sound level meter.

7. To determine if sound levels exist in the selected agricultural mechanics facilities for prescribed lengths of time that are harmful to the individual's health as described in the Walsh-Healey Act.

This concluding chapter is a concise review of the study findings related to the purposes and objectives. The investigator's conclusions derived from the findings along with recommendations which the investigator believed were warranted by the results are presented.

Data for the study were collected by means of a (1) questionnaire administered by the investigator to the students who utilized the respective facilities studied, (2) machine-time-use pattern chart kept for a minimum of five agricultural mechanics sessions per class by an enumerator at each site, and (3) recordings of measurements made with a precision sound level meter. Two types of records were compiled for the sound level meter readings. One method involved the utilization of the Brush recorder that graphically recorded the sound level measurements made with the B&K sound level meter. Environmental and machine-use data sheets were kept by the investigator in addition to and to coincide with the strip chart recordings. The data sheets provided a means for the investigator to record those activities and variables that were observed and relevant to each measurement.

The questionnaire was used to evaluate the students' perceptions of (1) most annoying sound in the laboratory, (2) selected characteristics that caused sound to be annoying, (3) student engaged activities that were most susceptible to objectionable sound, (4) number of hours students worked in the agricultural mechanics laboratory per day, (5) who was operating the noise causing equipment when annoyed, and (6) how often overall noise levels caused by shop activities prevented students from hearing well enough to understand verbal instructions.

The machine-time-use schedule chart was designed to augment and validate annoyance aspects of sounds. It also provided some insight into the length of time different sounds would be occurring.

The sound level measurements made with the sound level meter were used in determining the (1) sound intensities and (2) sound frequency characteristics of equipment and the total environment.

This information was used in turn to compute speech interference levels and those sound levels at specified durations which cause loss of hearing. Tables were offered that summarized the data collected.

Facility floor plans with equipment specifications and placement complimented with photographs were illustrated to give more insight into the conditions that existed at each facility during the test.

This study was concerned with analyzing noises in four selected agricultural mechanics facilities for (1) speech interference levels, and (2) sounds that were most objectionable to students. Seven specific research objectives were formulated to guide the conduct of the study.

Findings of the Study

Annoying Sounds to Students

Based on rank order, the most annoying sound producing equipment would be as follows: (1) Site 1, disc grinder; (2) Site 4, hammering and chipping; (3) Site 2, hammering and chipping; and (4) Site 3, showed more responses indicating that there was not a sound that annoyed them. Of those Site 3 students who indicated that they were annoyed by a sound in the shop, the disc grinder ranked the highest. The investigator attempted to identify the most annoying sounds to students through the use of the questionnaire early enough in the testing period to analyze for their intensity and frequency characteristics. This desire was not realized in every case, but at Site 4 it became evident that a nonsuspecting piece of equipment, a table, was causing sounds that were annoying to some students. Four students out of 38, or 10.5 percent, indicated that the sound emitted from dragging a steel table across the floor in their facility was most annoying to them.

The low annoyance rank of the abrasion cut-off saw at Site 3, the only facility possessing this machine, may be attributed to the brief period of time, approximately four weeks, it had been in use.

Equipment Time Use

The activity, arc welding, exhibited the highest percentage of time-use when compared to other equipment for three of the four sites. Grinders, oxy-acetylene cutting, and chipping and hammering all ranked high in time-use at all sites. Oxy-acetylene welding ranked first based on highest percent of time in use at Site 3. This was due to the fact that those students at Site 3 engaged in the LSO class were involved in that particular skill during the week enumerations on machine-time-use charts were made.

Characteristics of Annoying Sounds

Loudness, frequency, abruptness, persistence, non-related, orientation, source movement, and necessity were characteristics of sounds identified for students. The characteristic "loudness" was ranked first by respondents at all four sites as the one most responsible for causing sounds to be objectionable.

Rank order was established on the basis of the highest percentage of responses. Frequency and abruptness were ranked second overall, followed by persistence, necessity, others, relatedness, with orientation and movement of sound source tied for the overall rank of eight.

Susceptibility of Selected Activities to Annoying Sounds

Activities students are most likely to become annoyed in by overall rank are: first, thinking; second, working; third, conversing; fourth, discussing; and fifth, lecturing. It was surprising to note that the activity "working" was second in overall rank and was more susceptible to annoying sound than were the activities conversing, discussing, and lecturing.

The Kendall Coefficient of concordance was applied to the overall rank among respondents and was found significant at the .01 level.

Person Causing Noise

"Someone else" was operating the noise producing equipment when it was most objectionable.

Mean Hours Spent in Shop

The average number of hours spent working in the agricultural mechanics laboratory were: Site 1, 1.26 hours; Site 2, 1.26 hours; Site 3, 1.45 hours; and Site 4, 1.09 hours.

Hazardous Sound Levels

Maximum sound levels, both environmental and equipmental, were found not to be hazardous for the duration students were exposed at all sites. The maximum environmental sound level, 94 dB(A), and equipment sound level, 98 dB(A) were recorded at Site 3. Both measurements reflected the influence of an abrasion cut-off saw. Maximum environmental sound levels recorded at the other sites were: Site 1, 82 dB(A); Site 2, 73 dB(A); Site 4, 68 dB(A).

Sound Levels Found at the Different Sites

Site 1, Predominantly Concrete. Seven different pieces of equipment were analzyed. Sound levels in dB(A) found for the equipment analyzed were: (1) wire brush, 88; (2) air compressor, 70; (3) pedestal grinder 94; (4) exhaust fan, 60; (5) arc welder, 70; (6) wood planer (in wood shop adjacent to agricultural mechanics facility), 72; and (7) table saw, 98.

Three environmental sound level analyses were conducted at Site 1. The speech interference levels were: (1) vocational agriculture I, LSO, 66; (2) vocational agriculture III and IV, PCO, 74; (3) agricultural mechanics, PCO, 73. Mean S.I.L. was 73.5. The mean number of students working at the site simultaneously was 11.7.

Site 2, Predominantly Steel. Five different equipment noises were analyzed at Site 2. The equipment analyzed and their respective sound levels were (1) arc welder, 89 dB(A); (2) portable disc grinder, 90 dB(A); (3) metal band saw, 76 dB(A); (4) air compressor, 64 dB(A);and (5)exhaust fan, 72 dB(A).

Two environmental sound analyses were conducted at Site 2. The speech interference levels found were: (1) vocational agriculture II, LSO, 62; (2) vocational agriculture III, PCO, 60. The mean S.I.L. at Site 2 was 61.0. The number of students working simultaneously per class was 5.5.

Site 3, Predominantly Steel. Six different equipment noises were analyzed at Site 3. Their sound levels were as follows: (1) arc welder, 72 dB(A); (2) metal abrasion cut-off saw, 98 dB(A); (3) pedestal grinder, 89 dB(A); (4) portable right angle grinder, 98 dB(A); (5) air compressor, 74 dB(A), with microphone in the far field; and (6) oxy-acetylene cutting, 72 dB(A). The metal cut-off saw sound level was the highest found in the four facilities studied.

Two environmental sound analyses were conducted at Site 3; they were: (1) a group working in their off hour and (2) vocational agriculture IV. Their speech interference levels were 69 dB(A) and 78 dB(A) respectively. Both were PCO. The mean S.I.L. was 73.5, the same as Site 1. The mean number of students working simultaneously was 8.5.

Site 4, Predominantly Concrete. Six equipment noise analyses were conducted at Site 4. The radial arm saw produced 96 dB(A) when ripping a 2" by 6" pine board. This was the highest recording at Site 4. Due to the sound of a steel table being identified by ten percent of the students at the site, it was measured and found to emit 94 dB(A). Other equipment sound levels were: (1) ceiling heater fan, 55 dB(A); (2) exhaust fan, 64 dB(A); (3) arc welder, 74 dB(A). The activity of arc welding with eight arc welders in operation simultaneously with microphone in the far field was analyzed and found to be 67 dB(A).

Three environmental sound analyses were conducted at Site 4. Two tests were conducted in the agricultural mechanics class with different microphone orientations. The difference in speech interference level of the two measurements was 3 dB(A). The two agricultural mechanics speech interference levels were 60 and 63. The third class analyzed was a vocational agriculture III and IV class which recorded a 59 S.I.L. The mean S.I.L. was 60.7. The mean number of students working simultaneously was 6.0. All classes were PCO.

Students Perception of Audio Communication Interference

The highest percentage of students felt that audio-communication was "seldom" impaired at their respective facility during normal operations. The second highest percentage showed students' "neutral" (no feeling either way) regarding the aural environment at Sites 1, 3, and 4. The second highest percentage of respondents at Site 2 felt that they were "never" impaired in their hearing by noises in the agricultural mechanics laboratory.

Computation of the Pearson product-moment correlation indicated no relationship between degrees of speech interference and students perception of the aural environment in the respective facilities.

Conclusions

Based upon analysis of the study findings relative to the stated purposes and objectives of the study, the investigator arrived at the conclusions stated as follows:

1. The most annoying sounds to students in the agricultural mechanics laboratory are those emitted from (a) pedestal and portable disc grinders and (b) hammering and chipping slag.

2. The loudness of a noise is the most predominant sound characteristic which causes it to be annoying.

3. Noise is most objectionable when a student is "thinking" as compared with other mental and physical activities he may be engaged in while in the agricultural mechanics laboratory.

4. The student does not believe that audio-communications are interfered with by noise in the typical agricultural mechanics laboratory.

5. According to speech interference level data, shouting to very loud voice levels are required for persons to effectively converse when six to 12 feet apart with activities in progress.

6. The larger, better accoustically treated facilities exhibit lower sound level readings, although the amount of work taking place as indicated by percentages of machine-use is more influential and crucial in regard to the aural environment of a facility than type of building construction.

7. There is no appreciable difference between noise levels in predominantly concrete buildings and predominantly steel buildings.

8. The laboratory oriented and project construction oriented instructional programs exhibit little difference in noise levels.

9. There are no sound intensities produced in typical agricultural mechanics facilities that cause permanent hearing loss to the student at the durations he is exposed.

10. Exhaust fans and the activity of arc welding exhibit sound levels in the 70 decibel range. This coupled with high time-use percentages cause them to be major contributors to speech interference.

Implications and Recommendations

Based upon the data collected, study findings, and the observations made by the investigator while conducting the study, certain general recommendations were formulated as follows:

1. That teachers and students should become more cognizant of noise pollution and its influence on the educational environment.

2. That instructors identify those objectionable sounds and levels and rectify or reduce them.

3. That prior planning be practiced in the design and equipping of agricultural mechanics facilities in expediting a more conducive aural environment.

4. That sounds emitted from equipment in the agricultural mechanics laboratory be analzyed with regard to proper equipment placement.

It was the intent in the design of this study with regard to procedure and instrumentation to conduct an investigation that would allow those who are confronted with noises to utilize the techniques that were developed.

The recommendations were formulated for this study with the intent of suggesting research that could be conducted relative to noise in school environments.

The following specific suggestions and recommendations are presented for consideration in replication of the study.

1. That a larger number of facilities be analyzed than were investigated in this study and that facilities be randomly selected.

2. That multiple microphone placements be used in recording sound levels simultaneously. Multiple microphone locations would facilitate the recording of sound levels at different locations in the laboratory simultaneously. Also, longer time intervals per test would be possible when using this procedure.

3. That measurements be conducted for a two or three week duration at each facility. This could be accomplished through the use of a magnetic tape recorder and the sound level analyses conducted at a later date.

It is realized if recommendations two and three were adopted somewhat more instrumentation would be necessary than was used in this study.

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APPENDIX A

SCHOOL ____

NAME OF STUDENT ____

VO-AG I II III IV Or Agricultural Mechanics - (Circle the one you are enrolled in this hour.)

CLASS PERIOD ____________________

DATE ____________________

We are attempting to conduct a research study in identifying noises in vocational agricultural mechanics facilities that are annoying or bothersome to students. You are being asked to cooperate in this endeavor.

INSTRUCTIONS: All items pertain to your experiences in the agricultural mechanics shop this semester (Spring, 1971).

1. What is the average or approximate number of hours you spend in the agricultural mechanics shop each day? (This includes scheduled or formal class hours plus extra hours spent in shop work as during study hall.) ______________ hours.

2. Is there a specific (one) noise or sound in the agricultural mechanics shop which annoys or bothers you? If so, name what causes this noise. If there is more than one sound that annoys you, identify the one that bothers you most. (The next three questions (2), (3), and (4) concern the specific sound level you have named.)

   ____

3. Who is operating the noise causing equipment you identified above when it bothers you most? (Circle One)

   (a) YOURSELF
   (b) SOMEONE ELSE
   (c) NEITHER - (Example - if automatically controlled ventilation fan was the cause of the sound which annoys you, neither yourself nor any other person was manipulating it.)

4. What causes you to be annoyed by the sound you have previously identified? Place a check mark by those factors which cause this sound to be annoying.

_____(a) Because of its loudness.
_____(b) Because it is shrill or has a high frequency.
_____(c) Because it is irregular or changes, or is unexpected.
_____(d) Because it is continuous or persistant.
_____(e) Because it is not related to what you are doing. (Example - a gasoline engine running at the same time you are trying to weld.)
_____(f) Because of the direction or location from which the sound or noise is coming.
_____(g) Because it moves about from one location to another.
_____(h) Because you feel the noise could be avoided or because of the time during which the noise is caused. (Example - someone using the grinder at the same time the instructor is lecturing.)
_____(i) If there are other reasons not stated, identify and explain them on line provided.

____

5. During which of the following five suggested activities does the noise you have identified annoy you most? (Rank in order the following five suggested activities by placing a (1) by the activity at which you are annoyed or disturbed most, (2) before the second most critical activity, etc.)Rank all five even though your 4th and 5th ranked activities may not be appropriate to the noise you have identified.

_____(a) LECTURE - During the lecture periods in the shop when no shop activities are taking place.
_____(b) DISCUSSION - When discussions are taking place while some shop equipment is in operation (3 or more people involved).
_____(c) CONVERSING - When you are trying to converse (talk) with another student or teacher while some shop equipment is being operated (2 people involved)
_____(d) THINKING - When you are performing some mental activity such as designing or planning a project you are building, measuring or computing areas or sizes, etc. It is assumed other shop activities are being carried out by other students at the same time you are engaged in this mental activity.
_____(e) WORKING - When you are working or performing some manipulative task such as welding, operating a piece of equipment, etc.
_____(f) NONE OF THE ABOVE - If you are annoyed while engaged in an activity other than those listed above, identify and explain activity on lines provided.

____

____

6. Does the total overall noise level produced by normal agricultural shop activities prevent you from hearing well enough to understand the instructions spoken by your teacher? (Circle one)

   (a) NEVER
   (b) SELDOM
   (c) NEUTRAL - No feeling either way
   (d) OFTEN
   (e) VERY OFTEN

APPENDIX B

TIME PATTERN CHART

SCHOOL_______________ DATE_______________

ENUMERATOR_______________ CLASS_______________

SOCIAL SECURITY NO._______________ PERIOD_______________

PAGE NO._______________ TIME OF DAY_______________

SHORT DESCRIPTION OF ACTIVITIES BEING CARRIED OUT DURING ENUMERATION:

HOUR_______________

MINUTES PAST THE HOUR

MACHINE AND GROUPS OF MACHINES BEING OPERATED	AVER. NO.*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Arc welding		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2. Oxy-acet. weld.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3. Oxy-acet. cut.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
4.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
5.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
6.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
7.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
8.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
9.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
10.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
11.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
12.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
ACTIVITY																															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
4.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
5.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
6.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
7.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
8.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
9.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
STUDENT TALKING		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
TEACHER TALKING		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

*Average No. of Machines Being Operated Simulataneously

DESCRIPTION OF ABOVE

ENVIRONMENTAL S.L. DATA

SCHOOL____________________________________ DATE____________________

METER SPEED______________________ CLASS______________________________

AIR TEMP.____________________ db°F PERIOD_____________________________

CHART SPEED______________________ CLASS TIME BEGINS_____ ENDS_____

CHART VOLT.______________________ NO. STUDENTS IN CLASS______________

MIC. LOCATION____________________ HEIGHT_____________________________

TIME INTERVAL EACH MEASUREMENT____

SCALE		FLUCTUATION	MACHINES IN OPERATION
A	______db	±	______________________
B	______db	±	______________________
C	______db	±	______________________
31.5	______db	±	______________________
63	______db	±	______________________
125	______db	±	______________________
250	______db	±	______________________
500	______db	±	______________________
1K	______db	±	______________________
2K	______db	±	______________________
4K	______db	±	______________________
8K	______db	±	______________________
16K	______db	±	______________________

MICROPHONE LOCATIONS AND ORIENTATION

MACHINE S.L. DATA

SCHOOL____________________ DATE____________

METER SPEED________________ CLASS____________

AIR TEMP.______________db°F PERIOD____________

CHART SPEED________________ CLASS TIME BEGIN____ ENDS____

CHART VOLT________________ NO. STUDENTS IN CLASS________

TIME INTERVAL AT EACH MEASUREMENT____________________

MACHINE________________

MODEL________________

SER. NO.________________

RPM________________

OTHER DESCRIPTIONS AND KINDS OF OPERATION:

____

____

____

MICROPHONE ORIENTATION:

TESTS OF STANDING-WAVE PATTERNS AND DECAY OF SOUND LEVEL WITH DISTANCE

____

____

	NETWORK			OCTAVE					BANDS				
MIC. LOC._____	A	B	C	3.15	63	125	250	500	1K	2K	4K	8K	16K
MACH. & BKGD.													
BKGD.													
MIC. LOC._____													
MACH. & BKGD.													
BKGD.													

APPENDIX C

Mr. Hallard Randell
Agricultural Mechanics Specialist
State Department of Vocational-Technical Education
1515 West Sixth
Stillwater, Oklahoma 74074

Dear Hallard:

Hallard, I would appreciate you and the District Supervisors helping me to select 10 or 12 representative agricultural mechanics facilities that are nearly equal in respect to the following criteria:

(1) Square feet
(2) Number and size windows
(3) Insulation
(4) No sealed ceiling
(5) Number size and type of machines
(6) Number of students in shop
(7) Age of facility

Please place the names of schools having these facilities under the respective category. Category headings are defined in attached proposal.

Type of Instruction Laboratory Oriented		Type of Instruction Project Construction Oriented	
Metal Building	Concrete Block	Metal Building	Concrete Block
(1)	(1)	(1)	(1)
(2)	(2)	(2)	(2)
(3)	(3)	(3)	(3)

Sincerely,

Lon R. Shell
Graduate Student
Agricultural Education

CRITERIA CHECK LIST

School______________________________ School Phone____________________

Instructor__________________________ Home Phone_____________________

---

(1) Predominantly (a) Metal or ____
(b) Concrete bldg.? ____

---

(2) Does it have exposed insulation on the inside? ____

---

(3) Does it have a sealed drop ceiling? ____

---

(4) What is the average number of students in shop classes? ____

---

(5) What classes are in the shop and what periods are they in the shop?

Ag. I ________
Ag. II ________
Ag. III ________
Ag. IV ________
Ag. Mech. ________

---

(6) What is the approximate square feet of floor area in shop? ________

---

(7) What would be the last week I could come and shop would be in normal use? ________

---

(8) Approximately what percent of work time is used for the building of projects? ________

---

(9) What dates would shop not be in use due to contest, shows, etc.? ________

____
____
____
____

APPENDIX D

IDENTIFICATION OF SITES

SITE 1: Blackwell, Oklahoma

SITE 2: Drumright, Oklahoma

SITE 3: Roland, Oklahoma

SITE 4: Wagoner, Oklahoma

APPENDIX E

DESCRIPTION OF INSTRUMENTS USED IN STUDY

B & K Sound Level Meter - The instrument conforms to IEC 179 for Precision Sound Level Meters, the proposed IEC recommendations for Impulse Sound Level Meters and to DIN 45 633 parts 1 and 2.

With the 1" microphone 4145 it has a dynamic range of 15 dB(A) to 140 dB and a frequency range of 2 Hz to 18 kHz.

The amplifier's linear response range is from 2 Hz to 70 kHz and it contains in addition to the A, B and C frequency weighting networks the new D weighting network. When the B & K Octave Filter set 1613 is added it becomes an easily operated and portable frequency analyzer. Two recorder outputs are provided - AC for the recording of ordinary sound and vibration and DC which is principally intended for the recording of impulse sound.

Pistonphone - This is a portable, battery driven instrument. It produces 124 dB re 2 x 10^5 N/m^2 ± 0 dB at 250 Hz ± 1% sinusoidal waveform. They are individually calibrated and a barometer, reading direct corrections for changes in barometric pressure, is supplied. It fits 1" to 1/8" microphone.

Octave Filter Set 1613 - This filter set is designed to allow the 2204 to analyze noise and vibration. It fits the meter with the aid of four screws thus making one compact and portable unit. There are 11 octave filters with centre frequencies arranged from 31.5 Hz to 31.5 kHz in accordance with ISO standards. Hence the overall frequency range covered is 22 Hz to 45 kHz which therefore includes the entire audio-frequency range.

Each filter satisfied the requirements of IEC Recommenation 225, and ASA S1.11 class II.

Brush Recorder - Mark II - The Brush Recorder Mark II provides immediately visible, permanent chart recordings on two channels over a wide amplitude and frequency range (d.c. to 100 cps). The Recorder includes oscillograph and amplifiers as an integral unit which is operated from any a.c. outlet through one power cord.

The recorder is designed for a minimum of operator adjustments, with three simple controls per channel, and self-cleaning, self-priming, pens. Pushbuttons permit instant selection of chart speeds (1,5, 25, and 125 mm/sec). Other features are fast front-loading change of chart paper, unitized components, and a slide-out chassis for quick inspection.

Extreme stability and high sensitivity are featured in the Recorder; a 10 millivolt input signal produces a pen deflection of one chart line (mm).

Audio-Oscillator 200AB - Hewlett-Packard - The Model 200 AB Audio Oscillator is designed for general purpose audio testing and measurements. The resistance-capacity oscillator used in this instrument will retain its high degree of accuracy for long periods of time with no adjustment. The push-pull output amplifier used in the Model 200 AB has a large amount of overall negative feedback for maximum stability and low distortion.

The rated output of the 200 AB is across a 600 ohm load whether it is balanced or unbalanced. The instrument's internal impedance varies with frequency. The output impedance is approximately 50 ohms from 20 Hz to 10 kHz; from 10 kHz to 40 kHz, it increases and varies with instruments. Approximately 250 ohms is maximum through the 40 kHz range.

The output voltage is adjustable from 0 to 24.5 volts (1 watt) across a 600 ohm resistive load over the full range of 20 to 40,000 Hz. It is sufficient for modulating signal generation or other applications that require considerable power.

VITA

Lon R. Shell

Candidate for the Degree of

Doctor of Education

Thesis: ANALYSES OF NOISE IN SELECTED AGRICULTURAL MECHANICS FACILITIES

Major Field: Agricultural Education

Biographical:

Personal Data: Born in Neosho, Missouri, December 26, 1939, son of Willis and Elosia Shell.

Education: Graduated from Wyandotte High School, Wyandotte, Oklahoma in May, 1958; received the Bachelor of Science degree from Oklahoma State University in 1962, with a major in Agricultural Education; received the Master of Science degree from Oklahoma State University in 1967, with a major in Agricultural Education; requirements for the Doctor of Education degree will be completed in the summer of 1971 at Oklahoma State University; attended East Texas State University, while on the faculty there from 1968-70; attended Colorado State University during the summer of 1969; included in the latter program of studies were courses in Teaching Methods, Agricultural Mechanization, and Educational Philosophy.

Major area at doctoral level is Agricultural Education with a minor in Agricultural Mechanization.

Professional Experience: Vocational agriculture instructor, Stilwell Public Schools, 1962-65, and Skiatook Public Schools, 1965-67. Instructor in the Department of Agriculture, teaching agricultural mechanization courses, East Texas State University, 1967-70.

Professional Organizations: Member of Phi Delta Kappa Educational Fraternity, American Society of Agricultural Engineers, American Vocational Association, and National Vocational Agriculture Teachers Association.