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ASSESSMENT OF NOISE INDUCED HEARING  
IMPAIRMENT IN A CEMENT FACTORY

BY



DR. JOHN B. K. YABANI

A DISSERTATION SUBMITTED TO THE  
SCHOOL OF PUBLIC HEALTH,  
UNIVERSITY OF GHANA, LEGON  
IN PARTIAL FULFILMENT OF THE REQUIREMENT  
FOR THE AWARD OF DEGREE OF  
MASTER IN PUBLIC HEALTH

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## DECLARATION

I hereby declare that this submission is my own work and that to the best of my knowledge, It contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any degree or diploma of a university or other institute of higher learning except where due acknowledgement is made in the text.



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## ABSTRACT

**TITLE:** ASSESSMENT OF NOISE-INDUCED HEARING IMPAIRMENT IN A CEMENT FACTORY AT TEMA. GHANA.

**OBJECTIVE:**

**GENERAL:** - To assess the prevalence of occupational noise-induced hearing impairment in a cement factory.

- SPECIFIC:** (1) To measure the noise levels at different sections in the factory
- (2) To compare the prevalence of hearing impairment among workers of different age-groups.
- (3) To compare the prevalence of hearing impairment among workers with different lengths of exposure.
- (4) To determine whether the speech frequency range of those workers with hearing impairment is affected.

**DESIGN:** Cross sectional study

**SETTING:** Cement factory with a captured population of 308 workers.

**PARTICIPANTS:** One hundred workers were selected at random from three hundred and eight workers. The selected workers were interviewed to discover other risk

factors contributing to hearing loss.

A recent auroscopic examination report was examined to rule out any ongoing ear infection. The workers then underwent audiometric assessment with a wide range qualitone Model WRB 6097 Diagnostic Audiometer calibrated according to American National Standard Institute (ANSI) 1969 standard.

**MAIN OUTCOME MEASURES:** Noise levels at different locations in the factory were measured and prevalence of Noise-induced hearing loss assessed.

**RESULTS:** The worst areas of toxic noise was the production section where noise levels ranged between 80 dBA and 108 dBA(decibels -A-weighted). Even though noise levels in the engineering section was below the threshold limit value, most of the workers from this section carry out maintenance work for long hours in the production section.

Forty-two (42%) out of the 100 workers selected showed definite noise-induced hearing impairment, whilst 15 (15%) workers were strongly suspected of having noise-induced hearing impairment, 38 workers (38%) had good hearing acuity whilst 5 (5%) had excellent hearing acuity.

Out of 42 workers who were forty years of age and below, 10 workers (23.8%) showed noise-induced hearing impairment, whilst out of 58 workers who were above forty years of age, 32 workers (55.2%) showed hearing impairment. Hearing normally declines with age.

The effect of aging and noise exposure are additive, consequently the prevalence of noise induced hearing loss increases with age.

Eleven workers (35.5%) of the 31 workers who had had noise exposure for up to five years showed noise induced hearing impairment (NIHI), for exposure between 6 and 10 years, 3 workers (23%) of 13 workers showed NIHI, for the exposure period 11-15 years, 6 workers (28.6%) out of 21 workers exhibited NIHI, and for those with exposure period 16 years and above, 22 (62.9%) out of 35 workers exhibited N.I.H.I.

For the first 10 years of exposure to noise, 14 workers (31.8%) out of 44 workers exhibited N.I.H.I, whilst 28 workers (50%) out of 56 workers who had more than 10 years exposure exhibited NIHI, therefore the prevalence of noise induced hearing impairment increases with increasing length of noise exposure.

Out of the 42 workers who had noise-induced hearing impairment, 37 of them (88.1%) had no problem engaging in normal conversation. Only 5 of the workers (11.9%) showed signs of mild defect in the speech frequency range.

#### **LIMITATIONS:**

Unavailability of pre employment baseline audiometric data.

#### **RECOMMENDATIONS:**

##### **To Government**

- (1) Government should update existing legislations and provide statutory regulations and code of practices for



control of noise in industries.

- (2) The Government agency in charge of health should establish an occupational health service which could be integrated into the primary health care delivery service.
- (3) The Workmen's Compensation Scheme operated by the Labour Department is unsatisfactory, it should be updated to cover all occupational diseases.

**To Management**

- (1) A hearing conservation programme should be set up in the industry.
- (2) Management should make sure that pre-employment medical examination are conducted for their workers followed by routine periodic examinations.
- (3) Management should organise regular meetings to discuss occupational health and safety problems with trade unions and supervisors.
- (4) Management should team up with managements of other factories to set up a well equipped occupational health service which will cater for their occupational health needs with a full or part time industrial physician.

**To Trade Unions**

- (1) They should hold regular educational seminars on occupational health and safety for workers.
- (2) Whilst they make sure that management provides the necessary protective equipment, they should monitor to

ensure that protective devices are worn always by workers and also ensure that newly employed workers undergo pre-employment audiometric assessment.

## CHAPTER 1

### 1. INTRODUCTION

#### 1.1 BACKGROUND INFORMATION

Noise is the most ubiquitous of all industrial pollutants in Ghana. Workplace noise is the most common single cause of the impaired hearing acuity in the developing countries like Ghana. Although excessive noise has long been recognised as harmful to the ears, too little attention has been paid to reduce noise at the source, or to prevent the transmission of noise from the source to the workplace. The reason for this is not so much the lack of technical knowledge for controlling the hazard and its attendant noise-induced hearing impairment (NIHI), but rather it is underrated because there are no obviously demonstrable effects and also because the noise exposed workers look apparently healthy. There is only a gradual but progressive loss of hearing acuity and also loss of communication with family members and friends due to noise exposure. Many people take good hearing for granted without taking any precaution until it has been lost.

Hearing is one of our most sensitive and fundamental warning mechanisms. It is receptive to impressions from all possible sources and open to impulse whether we are asleep or awake. Modern technology with radio, television and telecommunications has given the ear even greater importance in our daily lives. Unfortunately modern living conditions and civilization have made hearing the sense most often and easily damaged. Today, our environment contains many different noises that the ears are neither designed

to withstand nor shut out. Consequently loud and incessant noise can damage the hearing apparatus to such an extent that the individual becomes completely or partially isolated from his surroundings. Whereas blindness evokes instant sympathy, deafness goes unrecognised. It is a hidden handicap.

Dr. Robert Koch, the discoverer of the tuberculosis bacillus, and one of the most important scientists of all times, is reputed to have said a few months before his death in 1910 "The day will dawn, when people begin to fight noise with the same intensity and bitterness as cholera and the plague". The point is, can we afford to wait for this prediction to come true? What is needed now is to make everyone aware of the hazards and the remedies, and so generate a general movement to combat noise. According to experts noise is likely to become one of our most serious public health and environmental problems in the near future.

## 1.2 STATEMENT OF THE PROBLEM

Today's workplace is undergoing accelerated changes in technology. An increasing level of mechanization, increased machine speeds and density of machinery, are some of the reasons why many workers are exposed to excessive noise levels. Noise has long been known to cause hearing loss. Exposure to noise, particularly cumulative noise can result in a gradual loss of hearing, handicapping individuals in the long run by disturbing their social activities and degrading their quality of life. Poor hearing results in difficulties in many work tasks, and in extreme

cases lowers the whole working capacity of the worker. Such consequences also result in economic losses to the entire society.

The rapid increase in industrial and environmental noise and the occurrence of noise-induced hearing impairment, both in industrialized and the developing countries, dictate the urgent need of concentrating on intervention programmes.

Awareness of industrial noise problems has continued to grow during the past two decades as a result of increasing noise exposure and the increased understanding of the effects of noise, and also because of new rules and regulations limiting noise exposure.

Valuable information has been gained through research although the magnitude of this research remain relatively small compared to the amount of research on other environmental problems. Estimates in occupational health hazard in Ghana show that 40% of people employed in industry develop hearing impairment in the first 5 years.<sup>1</sup>

Noise exposure occur extensively in our industries in Ghana, namely the Textiles, Cement, Iron and Steel, Aluminum industries, Mines and Quarries and Forestry operations. Consequently there is the need to determine the extent of the problem.

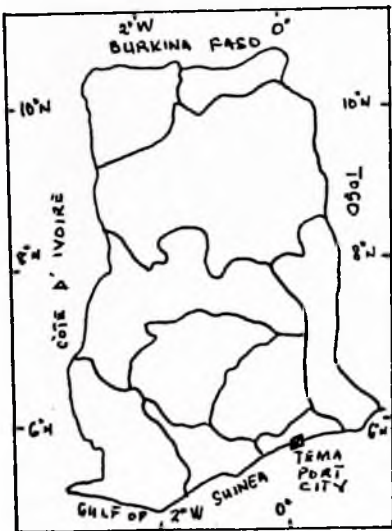
### 1.3 DESCRIPTION OF STUDY AREA

The study area the cement factory is located at the Port City of Tema, as shown on the map of Ghana below, where 40% of all industrial activities take place. It is situated at the Tema Port,

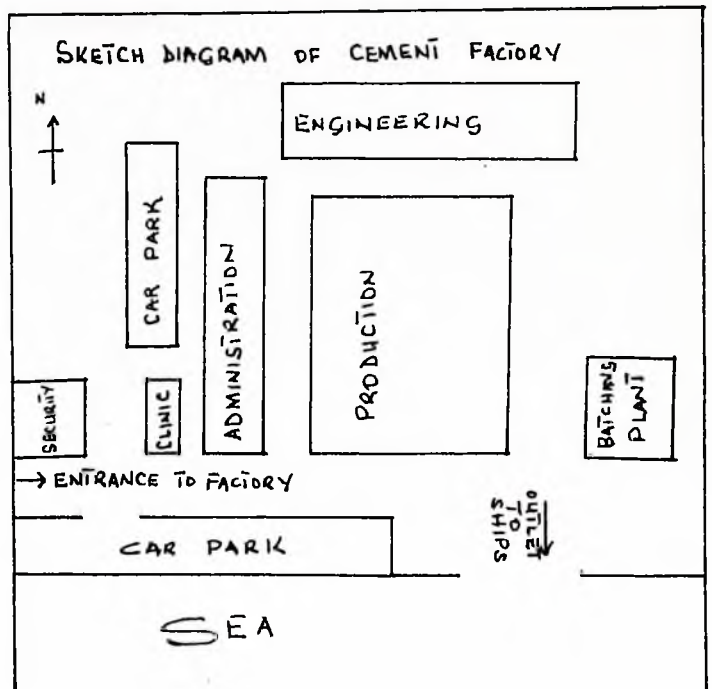
which makes it easily accessible to both personnel and raw materials. The raw material , that is the clinker is brought by ship which docks some few metres from the factory and the clinker is discharged by vehicles to the factory. The finished product is also carted out to its destination by vehicle.

The factory is divided into three departments, production, engineering and administration. A sketch map of the factory is shown below. The factory has a clinic in the premises, the staff are general nurses and a medical assistant who have not undergone any training occupational health, so they treat minor ailments and refer cases beyond their capabilities.

The factory is generally noisy.



MAP OF GHANA SHOWING THE LOCATION OF THE CEMENT FACTORY AT TEMA



#### 1.4 OBJECTIVES

1.4.1 General: To assess the prevalence of occupational noise-induced hearing impairment in a cement factory.

- 1.4.2 Specific:
- (1) To measure the noise levels at different locations in the factory.
  - (2) To compare the prevalence of hearing impairment among workers of different age groups.
  - (3) To compare the prevalence of hearing impairment among workers with different lengths of exposure.
  - (4) To determine whether the speech frequency range of workers with hearing impairment is affected.

## CHAPTER 2

### LITERATURE REVIEW

#### 2. GENERAL FEATURES OF NOISE

##### 2.1 NOISE AND ITS CHARACTERISTICS AND MEASUREMENTS

Noise is any unwanted sound.<sup>2</sup> As a concept noise is an irregular subjective sound perception, and sensitivity to noise varies widely from one person to another depending on the momentary psychic and physical condition of the individual.

Noise is a term used to identify or define an acoustic event that is judged by a receiver as undesirable and unwanted.

Almost all mechanical processes occurring in industry produces noise as a side effect of the processes.

The characteristics of noise are (a) intensity (b) frequency combination (c) duration and (d) loudness.

The intensity of sound is the average amount of sound energy passing through a unit area in a unit time. The intensity of sound is expressed in watts per square metre ( $W/m^2$ )

$$\text{Intensity} = \frac{\text{Sound Power}}{\text{Surface area of sphere}} \quad W/4\pi r^2$$

For practical purposes the intensity of sound is normally presented as a sound level using a logarithmic unit called the decibel (dB). A sound level change of one decibel can just be detected by the human ear. If a sound level is increased by 10 decibels any where within the range of hearing the ear perceives it as a doubling in loudness. A dropping of 10 decibels is perceived

as halving in loudness.

Frequency is the numbers of pressure variations of sound per second, it is measured in Hertz. The normal range of hearing for a healthy individuals extends from approximately 20 Hz to 20 KHz.

Noise in which energy is concentrated chiefly on the 1,000 - 4,000 Hz range is the most traumatising to the ear from the hydrodynamic point of view.<sup>3</sup> In principle the very high intensity noises are more distinctly associated with the higher frequencies than are the less intense noises.

A sound which has only one frequency is known as a pure tone.

Most industrial noises consist of a wide mixture or combination of steady state continuous, intermittent and impulsive noise<sup>4</sup> with different frequencies known as broadband noise.

## **2.2 NOISE MEASURING INSTRUMENTS**

### **2.2.1 Sound Level Meter**

A sound level meter is the most commonly used device for measuring sound pressure. In order to quantify exposure to sound it is essential to make sound pressure measurement to determine potential risk to employees or assess the effectiveness of engineering or control compliance to legal requirements.

The choice of measuring equipment depends on reasons for making the noise evaluation and the type of noise involved, whether it is impact, steady state or intermittent.

The sound level meter consist of a microphone, an amplifier and an indicating meter. The meter responds to noise in the audible frequency range from about 20 Hz 20000 Hz. A fairly simple sound survey may have a single weighting net work, others contain filters that may be switched into the circuit to cut out or alternate certain frequency ranges.

The A-weighted net work in the sound level meter produces a frequency response similar to that of the human ear at relatively low sound pressure levels and is used mostly for sound level measurements involving damage-risk criteria.

The C-weighted net work produces a relatively flat response over the entire frequency range (a response similar to that of the human ear at relatively high sound pressure levels).

#### 2.1.2 The Octave Band Analyser

Another basic instrument used in evaluating noise is the octave band analyser. This instruments consists of a series of electronic filters tuned to allow specific frequency bands to pass through. The octave-band analyser is used in conjunction with the sound level meter. Each filter allows one octave to pass and is identified by its centre frequency.

#### 3.1.3 Dosimeter

A dosimeter is utilized to determine individual worker exposure. This instrument is a small sound pressure device that is activated whenever noise exceeds a predetermined level and is

capable of recording the time element. The instrument produces a recorded time distribution of sound pressure that have exceeded a certain intensity level.

Dosimeters are relatively small in size and are worn by individual workers to tabulate total doses of sound over time.

Calibration of sound measuring equipment is an essential part of a noise measurement programme. Instruments can be affected by pressure, temperature, microphone sensitivity, cable attenuation and so on.

### 2.3 THE NOISE SURVEY

When making measurements of noise, the position of the microphone in relationship to the noise source is an important consideration. Where the noise is perpendicular to the axis of the microphone a high-intensity reading may occur, however, if the noise source is located parallel to the axis a lower reading results. The most accurate reading can be obtained by using an intermediate angle of incidence of about 30 degrees.

The evaluation of the individual worker exposure to noise requires that the microphone be located within the hearing zone of the worker. This zone is defined by the Occupational Safety and Health Administration (OSHA) as a 60 cm diameter sphere surrounding the head. Several measurements in this zone should be made to determine whether the sound pressure is uniform.

Since sound pressure generated from a noise source is dependent on the environment in which it is located, it is

necessary to describe this environment. This description should include the dimensions of the environment; type of materials covering the walls, floor and ceilings; type and number of noise sources; location of workers; and locations where noise measurements were made.

#### 2.4 OCCUPATIONAL NOISE INDUCED HEARING LOSS

The term noise induced hearing impairment refers to loss of hearing resulting from long term exposure to more intense sound. The pathologic changes usually occur slowly, the severity depending on the intensity frequency and duration of noise exposure. Over several years the accumulated trauma causes a progressive loss of hearing. No pain is noted although sensory cells are being damaged.

The absence of subjective discomfort makes noise induced hearing loss particularly insidious, since loss of hearing appears only after considerable permanent damage has occurred. The hearing loss may range from mild to profound and also result in tinnitus (ringing in ears).

Occupational noise induced hearing loss therefore covers the disease entity which afflicts the worker who is exposed to noise above the threshold limit value.

There are 3 forms of hearing loss that are induced by noise.<sup>5</sup>

- (1) The temporary threshold shift
- (2) Permanent hearing loss that is produced in man by

repeated exposure to loud sounds over months or years and is also called occupational hearing loss.

- (3) Permanent hearing loss produced by very brief exposure to very loud sound. The term acoustic trauma has been reserved for this one.

## 2.5 THRESHOLD LIMIT VALUE (TLV)

The threshold limit value is the time weighted average concentration for a normal 8-hour workday, 40 hour work week to which nearly all workers may be repeatedly exposed, day after day, for a whole working life without adverse effect. Threshold Limit Values are generally time weighted average (TWA) exposure levels calculated over an eight hour period.

For noise the threshold limit value is 85 dBA Time Weighted Average. Because of wide range in susceptibility among workers, exposures to levels less than the recommended TLV may cause hearing impairment in some individuals. It is on this basis that it is cautioned that TLVs are not guaranteed safe exposure levels but rather to be used as guides by professionals who must use judgement in applying them to specific situations.

## 2.6 TEMPORARY THRESHOLD SHIFT (TTS)

Temporary threshold shift or auditory fatigue results from exposure to excessive noise. One who exhibits TTS is suspect of being over exposed to hazardous noise. TTS is more pronounced within the range of hearing above 1000 Hz and it is usually bilateral, although one ear may be more involved than the other.

Recovery from Temporary Threshold Shift is generally logarithmic in time.

The greater the amount of TTS observed following the cessation of the noise that has caused the shift the greater the period of auditory rest that must intervene before the pre-exposure thresholds of hearing returns. If an additional exposure occurs before the hearing threshold returned, the longer will be the period of time required away from noise before hearing eventually returns.

Subjective responses of persons who acquire TTS usually notice that voices seem 'muffled' and slight to moderate amounts of tinnitus (ringing in ears) may be evident especially in quiet surroundings.

Frequently people who experience TTS fail to realise that any exposure to noise that causes temporary shifts is a clear indication of over exposure. The potential value of TTS is available adjunct to the operational conduct of a hearing conservation programme. Pre and post noise exposure audiograms can serve to identify qualitative degrees of over exposure.

Generally, a TTS of 10 dB or more within the hearing range from 500 Hz through 2000 Hz and/or 15 20 dB or more at 3000 Hz and above are considered excessive.

## 2.7 PERMANENT THRESHOLD SHIFT (PTS)

As in TTS, permanent threshold shift are attributed to excessive noise. Today enough knowledge concerning hazardous noise

exists so that permanent shifts can be prevented. Unfortunately permanent shifts still occur in thousands of people before they subjectively notice any change in the functional status of their hearing. Part of this problem is due to the fact that humans possess such tremendous capacity for hearing, that quite a substantial loss in acuity must occur before the threshold of audition are poor enough for the individual to actually notice the loss.

During the early stages of noise induced hearing loss there are several clues observed. These include:

- (a) The loss or shift occur within the hearing range above 2000 Hz.
- (b) The shift is bilateral with one ear more involved than the other.
- (c) The shift is most pronounced at 4000 Hz and then 3000 Hz and 6000 Hz.<sup>6</sup>
- (d) The individual does not notice the shift because it has not moved into the primary speech hearing frequency range (ie. 500 Hz through 2000 Hz).
- (e) The person may notice a high pitch ringing or aural tinnitus following cessation of the noise.

Routine monitoring audiometry that uses baseline threshold audiograms for each person can identify the presence of early permanent shifts, so that corrective action can be taken to prevent

further over exposures. Permanent shifts due to noise are irreversible and cannot be corrected by either medical or surgical procedures. The lower the magnitude of over exposure, the longer the period of time that must pass before substantial shift occur.

The higher the magnitudes of over exposure, the shorter the period of time required to measure significant amount of permanent threshold shift.

## 2.8 OCCURRENCE OF ONIHL

Occupational noise induced damage to hearing is one of the commonest occupational disorders in both the developed and the developing world, it ranks second only to physical injury in industry.

In 1971, the United Kingdom factory inspectorate estimated that 590,000 of the 6.4 billion workers employed in manufacturing industries were exposed to noise levels of 90 dBA or more for at least 6 hours per day. This estimate does not cover other noisy industries such as agriculture, forestry, mining, quarrying, transport and other service industries.<sup>7</sup>

In one of the major manufacturing industries in United Kingdom which has been doing audiometric screening for several years, there is evidence for noise damage in 40% of the noise exposed workforce, and 8% having hearing threshold level (averaged over 500 Hz, 1000 Hz and 2000 Hz) of 25 dB or more, in at least one ear.<sup>7</sup>

The hazard from noise is ubiquitous in Ghana's industries. In the textiles, furniture and other industries. In the textile,

furniture and other industries, it has been estimated that 40-45% of young persons employed in industry develop noise induced hearing loss by the end of the first five years of employment.<sup>1</sup>

The extent of ONIHL could also be estimated from national data on the annual incidence of cases awarded compensations or benefits. But this data is non existent in Ghana.

In a recent survey of small factories (Foo et al 1985) found that approximately 38% (Singapore), 42% (Hong Kong), 83% (Korea) and 92% (Phillipines) of workers were exposed to noise above 85 dBA in the work place. Among the workers surveyed 12% Korea, 15% Hong Kong, 40% Singapore and 74% Phillipines had a hearing loss in excess of 30 dB. This clearly shows that NIHL is a major problem in the countries of the developing world.<sup>8</sup>

Most studies of association between noise exposure and hearing loss in humans are retrospective measurements of hearing sensitivities of numerous individuals correlated with noise exposures.

The variability within these studies is usually large and it is difficult to predict the precise magnitude of hearing loss that will result from a specific sound exposure. Prospective studies of selected hearing levels over a long time while other sound exposures are carefully monitored are costly and time consuming, and due to high rate of attrition, require a large number of subjects. When significant hearing loss is found for ethical reasons exposures must be reduced and this will interfere with the relationships under study.

## 2.9 SOUNDS THAT ARE DAMAGING TO HEARING

To define what sounds can damage hearing, sound levels whether across all frequency bands or taken band by band is not enough. The duration of exposure for a day and accumulated over many years is critical. Sound levels associated with particular sources are often cited, but predicting the likelihood of NIHL from such sources also requires knowledge of typical durations and the number of exposures. There is a reasonable agreement that sound levels below 75 dBA will not engender a permanent hearing loss, even at 4000 Hz. At higher levels the amount of hearing loss is directly related to sound level for comparable durations.

The damaging effect of noise on hearing are considered to depend on the energy content of the noise, so that equal energy causes equal hearing loss. According to the equal energy principle, a 3 dB increase in A-weighted equivalent level corresponds to a doubling of energy and exposure duration.<sup>4</sup>

The principle has been adopted to the international standard published for risk assessment purposes.<sup>10</sup>

Although sound exposures that are potentially hazardous to hearing are usually defined in terms of sound level frequency band widths and duration, there are several simple approximations that indicate that a sound exposure may be suspected as hazardous. Hazardous noise may be suspected if the listener experiences

- (a) difficulty in communication while in the sound
- (b) ringing in the ear tinnitus after exposure to the sound.

(c) the experience that sounds seem muffled after leaving the sound exposure area.

In consideration of sounds that can damage hearing, it is the acoustic energy of the sound reaching the ear, not its source, that is, it does not matter if the hazardous sound is generated by a machine in the workplace.

Operations that could Produce Harmful Noise

- Rock drilling
- Artillery Gunfire
- Engine run ups
- Trip hammers
- Punch presses
- Wire weaving
- Blasting
- Engine testing
- Textile weaving
- Woodworking
- Petroleum cracking
- Stamping
- Paper making

Approximate decibel range for some harmful noise conditions

90 - 100 dB

- Air compressor
- Screw machine
- Punch press

Air drill  
Milling machine  
Spinner  
Loom

100 - 115 dB

Heavy machine shop  
Paper shredder  
Buffing machine  
Header  
Planer  
Speed hammer  
Circular saw  
Boiler factory  
Hammering on steel

116 - 130 dBA

Drop forge Hammer  
Clumping hammer  
Chipping hammer  
Hydraulic press  
Air plane engine  
Diesel engine

130 dBA and above

Jet engine  
Rocket engine  
Large siren

## 2.10 ASSESSMENT OF OCCUPATIONAL NOISE INDUCED HEARING LOSS (AUDIOMETRY)

Hearing loss is measured by determining the auditory threshold sensitivity at various and different frequencies (pure tone audiometry). Pure tone audiometry is also used in industrial hearing conservation programmes to determine whether adequate protection against hazardous sound levels is ensured.

The first audiometric sign of noise induced hearing loss resulting from broad band noise is usually a loss of sensitivity in the higher frequencies from 3,000 through 6,000 Hertz (Hz) resulting in a characteristic audiometric "notch".<sup>9</sup>

With additional hearing loss from noise or aging, the threshold at 8,000 Hz may worsen and eliminate this characteristic audiometric pattern. The hearing loss is usually bilateral but some degree of asymmetry is not unusual, especially with lateralized noise sources.

After moderate noise exposure, temporary threshold shift may occur, and during a period of relative quiet, threshold will return to normal levels. If the exposure continues on a regular basis permanent threshold shifts will result, increasing in magnitude and extending to the lower and higher frequencies. If the exposure continues NIHL increases more rapidly in the early years. After many years of exposure, NIHL levels off in the high frequencies, but continue to worsen in the low frequencies.

An important consequence of the sensitivity loss associated with NIHL is difficulty in understanding speech. Whereas a large

proportion of the energy in speech is contained within the low frequency range, much of the information required to differentiate one speech from the other is contained within the higher frequencies with significant hearing loss in the high frequencies, important speech information is often interfering sounds such as ground noise, competing voices or room reverberation may reduce listener's receptive communication ability. The presence of tinnitus may be an additional debilitating condition.

#### 2.11 PATHOLOGICAL CORRELATION OF OCCUPATIONAL NOISE INDUCED HEARING LOSS.

The pathology of occupational noise induced hearing loss was first elucidated in 1890 by Habermann who reported that the spiral organ, especially the sensory hair cells was affected.

It was also shown that the site for election for occupational noise-induced hearing damage was the spiral organ about 11 mm distant from the beginning of the basal turn. This locus responds particularly to frequencies of around 4,000 Hz. Electron microscopic studies of noise damage to the human ear have shown complete degeneration of the nerves in the spiral osseus lamina as well as the corresponding degeneration of the spiral organ of the Cochlea in the region 10.5 14.5mm from its basal end.

This discrete pathology of ONIHL explains the audiometric pattern of affected individuals ie. initially a notch on the audiogram at or around 4,000 Hz. More detailed investigation have shown that the initial dip in hearing can be at 3000 Hz, 4000 Hz or

6000 Hz<sup>11</sup> and if 5000 Hz is tested the dip may be worse at this frequency.<sup>12</sup>

As the noise damage expands over the basal region of the spiral organ, so does the audiometric notch deepen, the upper limb of the notch fall away and the lower limb fall progressively towards the lower frequencies but characteristically leaving the lower frequencies intact.

In contrast age related hearing loss is associated with degeneration of the vestibulocochlear nerve and probably all the sensory elements in the cochlea. However, the impact of aging on the spiral organ is distinct from that of noise damage since it starts to involve the structures of the basal turn and then progress towards the apex. This pathological process is also reflected in the audiometric pattern.

Classically the aging audiogram is that of essentially normal hearing for the lowest frequencies within the audiogram falling off as the higher frequencies are reached.

Saunders and colleagues have suggested three mechanisms for noise-induced cellular damage to the cochlea.

The first mechanism relates to the mechanical properties of the internal ear and the fact that over stimulation could directly damage cochlea receptor cells or neural elements.

In general the outer hair cells are more susceptible to noise damage than the inner hair cells and the third row of the outer hair cells is more susceptible than the other two rows of outer hair cells.

The second mechanism relates to the destruction of metabolic or homeostatic processes in the cell. Mitochondrial swelling, may result from alterations in the ionic concentrations in the mitochondria and the intercellular space. Acoustic injury may also disrupt the enzyme systems within the hair cells which are critical for energy production, protein synthesis and ion transport. Tears of the various membranes within the cochlear could well permit endolymph and perilymph to mix, such that a toxic environment for the cells could be established.

The third mechanism for Occupational Noise-Induced Hearing Loss is one that attributes the damage to changes in the cochlear vascular system.

The site of election of the 4000 Hz notch has been a subject of considerable speculation. The basal part of the cochlear partition lies in the path of the vibratory motion between the fenestra vestibuli and fenestra cochleae, however the most effective acoustic stress is at the frequency, which, in terms of the bulge of the travelling wave, has the fastest rise time and 4000 Hz probably represents a compromise between the decrease in sensitivity of the cochlea towards higher frequencies and the still increasing rise time.

As regards vascular factor, it could well be postulated that the end arterial type of cochlear blood supply is the weakest in respect of that of the cochlear partition which is about 10 mm distant from the basal end.

### 3.12 NOISE DOSE

Owing to the varying duration of noise exposure, measurements on workers who move between different noise environments during the working day can be obtained using noise dose meters.

These are portable noise instruments carried in a persons pocket. The microphone is separated from the dose meter body and placed preferably close to the worker's more noise exposed ear.

Noise dose meters display the percentage of the daily allowable noise dose.

Two different ways of calculating the noise dose are used namely, the I.S.O. method (in U.K) and the O.S.H.A method (in U.S.A). The difference between these two methods is due to allowance incorporated for the recovery of hearing during quiet periods.

Currently both methods essentially use a basis of 90 dB(A) for an eight hour day.

The International Standards Organisations (ISO) 1999 defines one method which uses only the energy criteria and makes no allowance for the recovery of hearing. Thus an increase of three decibel in the sound pressure level halves the permissible exposure period for example an increase in sound level from 90 dBA to 93 dBA must be accompanied by halving of the permissible exposure duration from 8 hours to 4 hours.

In the United States the Occupational Safety and Health Administration (OSHA) defines another relationship which permits a 5 dB increase in sound level for each halving of the allowable

exposure period.

Thus an increase in sound level from 90 dBA to 95 dBA is accompanied by a halving of the allowable exposure duration from 8 to 4 hours.<sup>13</sup>

So using the dosage criteria it represents the noise level over an 8-hour exposure that gives a dosage of 100%.

In a noise environment of 90 dBA a dosimeter designed according to the ISO and OSHA standards will register a dose of 100% in 8-hours as shown below.

EXPOSURE TIME FOR (HR) FOR 100% DOSE	DOSAGE % FOR 8 HR. EXPOSURE	AVERAGE NOISE LEVELS dBA	
		OSHA (USA)	ISO (UK)
16	50	85	87
8	100	90	90
4	200	95	93
2	400	100	96
1	800	105	99
½	1600	110	102
¼	3200	115*	105
1/8	6400	115*	108

\* OSHA does not recommend exposure above 115 dBA.

The advantage of using the noise dose is that the maximum permitted dose in one shift of 8-hours is 100%. If for example a worker receives 60% dose in the first 2 hours, he may only receive 40% during the remaining 6 hours, he must be moved therefore to a location with a lower equivalent sound level (Leq). This may be calculated as follows:

$$\begin{aligned}
40\% \text{ in } 6 \text{ hours} &= \frac{40\%}{6} \text{ per hour} \\
&= \left(\frac{40\%}{6} \times 8\right)\% \text{ in } 8 \text{ hours} \\
&= 53 \frac{1}{3} \approx 50\%
\end{aligned}$$

Thus the new Leq. (to give a noise dose of 50% in 8 hours)

$$\begin{aligned}
&= 87 \text{ dBA in UK} \\
&\quad (85 \text{ dBA in USA})
\end{aligned}$$

### 2.13 RELATIONSHIP BETWEEN HEARING LOSS AND DURATION OF NOISE EXPOSURE

It is difficult to predict for any individual the level and duration of exposure required to cause damage. Although noise induced hearing loss is felt to be extremely unlikely at sound levels below 80 dBA. Noise damage become increasingly likely at the sound level rise above this.

The relationship between the various parameters of occupational noise exposure and resulting hearing loss was studied by Burns and Robinson in an investigation of predominantly steady state noise in industry in the 1960s. They reduced the number of parameters to two. The most meaningful method for expressing the noise appeared to be in terms of the "A-weighted" noise level.

The two parameters were combined into a composite noise exposure index termed the noise immission level which reflected in the energy principle where successive 3 dBA increases in noise levels above a "safe" level for an 8-hour working day require a corresponding halving of the exposure time. The National Physical

Laboratory produced a set of tables to show the expected noise induced hearing losses at various frequencies for a given noise immission level for the various centiles of susceptibility. The use of these tables have been recognised by the courts in the United Kingdom. Since then Robinson has analysed the data of 13,000 ears which had appeared in the literature over 30 years now.

A new model for NIHL relationship was produced which is not dependent on the energy principle, although is still yet to be used to express short term (within 24 hours) noise exposure by means of an equivalent continuous sound level. The noise induced hearing loss (N) in the model is expressed by an increasing exponential growth function of the form

$$N = N_{MAX} \{1 - e^{(-T/T_0)}\}$$

$T_0$  is a kind of time constant for the growth of N

$N_{MAX}$  is an asymptomatic limit value of the noise induced component of threshold shift.  $N_{max}$  will depend primarily on noise level and on susceptibility (percentile).

#### 2.11.1 Noise Immission Level

A United Kingdom government sponsored investigation using 1000 subjects has suggested that the amount of threshold shift are related to the total noise exposure (dependent on the noise level and its duration). The actual shift in threshold corrected for natural loss of acuity with age, was found to correlate well with

the NOISE IMMISSION LEVEL(NIL) defined as

$$NIL = L_A + 10 \log t$$

Where  $L_A$  = Level of noise in dBA.

t = number of years duration.

Although industrial noise have many different spectra. The United Kingdom investigation found this to have no significant effect on the threshold shifts of those tested. The precise amount of shift varied considerably from subject to subject.

#### 2.14 FACTORS DETERMINING SUSCEPTIBILITY OF OCCUPATIONAL NOISE-INDUCED HEARING LOSS

2.14.1 **Gender:** There is little difference in hearing thresholds between young males and female children. Between ages 10-20 males begin to show reduced high frequency auditory sensitivity relative to females. Women continue to demonstrate better hearing than men into advanced age. These gender differences are probably due to greater exposure of males to noise rather than to their inherent susceptibility to the effects of noise but both psychological and biochemical factors have been incriminated as factors governing different susceptibilities.<sup>9</sup>

2.14.2 **Age:** Hearing loss due to age is termed presbycusis. In the opinion of Glorig (1958). The term presbycusis should be restricted to hearing loss due to physiological changes associated with aging.<sup>2</sup>

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Schuknecht 1955 described presbycusis as being due to degenerative changes originating in the basal part of the cochlea, extending towards the apex and affecting simultaneously and equally the various structures in the cochlea and the afferent and efferent nerve fibres. He later classified presbycusis into four types (a) Sensory (b) Neural (c) Metabolic and (d) Mechanical. Sensory presbycusis is characterized by atrophy of the organ of corti in the basal end of the cochlea and auditory nerve and typified by abrupt high tone hearing loss. The neural type appears as poor speech discrimination but not until advance stage, being the result of loss of neural population in the auditory pathways. Metabolic presbycusis is a slow progressing sensorineural hearing loss manifested functionally as a flat audiogram. The only microscopic sign is atrophy of the stria vascularis. Possibly the stria vascularis is essential to the maintenance of the bioelectric and biochemical properties of the endolymph. The disturbance then consist in the defects in the physical and chemical processes by which energy is produced and made available for use by the sense organs.

Mechanical presbycusis might be referable to the stiffening of the basilar membrane or some other disorder in motion mechanics of the cochlear duct. The functional manifestation of mechanical presbycusis is a descending audiometric curve.

Presbycusis tend to start in the 8000 Hz frequency whereas noise induced hearing loss starts in the 4000 6000 Hz frequency range.

In presbycusis hearing loss is improved by use of hearing aid but NIHL does not improve with hearing aid, medical or surgical treatment.

Typical levels of presbycusis at various ages have recently been incorporated as Annex A in the International Standard Organization Standard 1999.2 (1989). It may be used to estimate the portion of overall hearing loss that is attributable to exposure to excessive noise.

#### 2.14.3 Ototoxic Drugs

The three major categories of presently used ototoxic drugs are the amino glycoside antibiotics (PTS producing agent), the "loop" diuretics and the salicylates both TTS producing agents.

Studies of temporal aspect of interaction indicates that interaction was strongest when drug and noise exposures were carried out concurrently.<sup>14</sup>

Available data suggested that Kanamycin established a condition of vulnerability throughout the cochlea, because mild normal exposure to low frequency noise produced small but definite lesions in the apex, although Kanamycin damage manifests itself first in the basal parts of the cochlea.<sup>15</sup>

Hawkins et al<sup>16</sup> have reached opposite conclusions in that an interaction only occurred if the locus of primary damage of drug and noise coincided and if the noise levels exceeded 100 dB. A recent study on the interaction of neomycin and noise confirmed the

potentiative interaction found in the single pertinent study with this drug<sup>17</sup>, this is important because the basic mode of action of aminoglycoside antibiotics, namely an impairment of phospholipid metabolism, had been worked out with this particular drug<sup>18</sup>.

#### 2.15 PREVENTION OF OCCUPATIONAL NOISE INDUCED HEARING LOSS

One occupational strategy to achieve adequate prevention of occupational noise hearing loss is to put a hearing conservation programme (HCP) in place, whenever noise exposure levels exceed levels capable of causing hearing loss ie. 85 dB continuous exposure.<sup>19</sup>

Hearing conservation programme for occupational settings must include the following interacting components:

- (1) Sound surveys to assess the degree of exposure of the worker to hazardous noise.
- (2) Engineering and administrative noise controls to reduce exposures.
- (3) Education to inform at risk individuals as to why and how to prevent hearing loss.
- (4) The use of hearing protective devices (earplugs earmuffs and canal caps) to reduce the sound reaching the ear.
- (5) An industrial audiometric testing programme to provide baseline audiometric data at the beginning of employment and at periodic intervals, to identify hearing loss, to aid diagnosis, and to monitor the status of a persons

hearing loss.

- (6) Acquisition and training of personnel.
- (7) Assessment of programme effectiveness and the need for paying compensation should the hearing conservation programme fail.

## 2.16 INTERNATIONAL REGULATIONS AND STANDARDS

2.16.1. The first regulatory action by the United States Government with respect to occupational noise was Walsh-Healy Public Contracts Act in 1969.<sup>9</sup>

2.16.2 In 1971, the Occupational Safety and Health Administration (OSHA) promulgated an occupational noise standard (CFR 29, 1910.95 for manufacturers involved in interstate commerce.

This standard set a maximum exposure of 90 dBA time weighted average (TWA) for an 8-hour period with a 5 dB trading ratio (ie. for each 5 dB increase or decrease in level, the permissive exposure time is halved or doubled respectively).

In 1983 OSHA issued an amendment to this standard requiring that a hearing conservation programme be instituted if workers were exposed to TWA noise levels of 85 dBA.<sup>9</sup>

2.16.3 The recently adopted International Standard ISO 1999 provides information on the efficacy of this occupational noise regulation. Evaluation of the risk of sustaining a hearing handicap for individuals exposed chronically below 90 dBA suggest

that the occupational noise standard as it presently exists does provide protection against NIHL. The problem has been the failure to fully implement and enforce these regulations. The OSHA has been criticized for not fully enforcing these regulations in workplaces covered by the OSHA conservation amendment.<sup>9</sup>

## 2.17 NATIONAL LEGISLATIONS

Before independence there were legislations to protect the health safety and welfare of the worker such as the Gold Coast Ordinance of 1956 Clause 25, in respect of workplaces in labour health areas, however the ordinance is outmoded and has proved impractical. The major legislation in the field is the Ghana Factories Ordinance (1952) enlarged in 1970 as the Factories, Offices and Shops Act number 328.<sup>20</sup> The Mining Area Health Ordinance which provides the declaration of the mining area for specific control and the Mining Regulation Act 1970, The Occupational Diseases Instrument and Workmen's Compensation Act No. 174 (1963).

The Factories, Offices and Shops Act is in 88 sections enumerated in eleven parts with four schedules.<sup>21</sup> It does not apply to mines.

Section 26 on noise and vibration states that noise and vibrations likely to affect the health of persons employed in any factory, office or shop shall be reduced as far as possible by appropriate and practicable measures.

Section 29 provides for medical supervision in specified situations in any factory or shop.

Section 30 empowers the Minister by legislative instrument to modify or extend the provision of the act so as to secure the health or welfare of persons employed. There is no provision however in the act for the employment of medical or paramedical personnel, even in large establishments. The Factories Act gives the minister no jurisdiction over mines though the labour inspectorate is so empowered.

The responsibility for the monitoring and enforcement of labour laws pertaining to occupational health and safety is fragmented or distributed among a number of ministries. This leads to ineffective enforcements of the laws and consequently to inadequate implementation of the legal requirements in industry.

## CHAPTER 3

### METHODOLOGY

#### 3.1 TYPE OF STUDY

The type of study employed is cross sectional.

Cross sectional study is a type of observational study in which both risk factors (in the case of this study toxic noise levels) and disease (occupational noise-induced hearing impairment) are ascertained at the same time.<sup>22</sup> Observation of a group is made during a cross sectional slice in time. It is specially suited for enquiring into subtle perhaps even subclinical health effects for which records are unlikely to exist.

Since cross sectional studies are essentially prevalent studies, the actual relationship between the health effect and time cannot be readily explored, the prevalence of the health effect is compared among subgroups with varying exposure, age, personal habits or medical histories.

Cross sectional study is very easy to conduct, very rapid and less expensive to accomplish as compared to case control and cohort studies. Its principal weakness lies in the possible relationship between the workers having the health problem and the likelihood of these workers appearing in the study group. Since workers who become ill may stay away from work, quit or retire early at one point in time, the current workers will probably be healthy. The exclusion of some affected workers will obviously minimize an association or decrease the chances of its being detected.

Conversely if presence of the adverse health effects of the exposure make an individual more likely to volunteer for the study, an over-estimate of the association may occur.

It should be admitted that the unavailability of baseline audiometric data is a serious limitation of this study, but despite this limitation prevalence figures are useful for determining the extent of the problem and valuable for rational planning of hearing conservation programme for the rest of those entering into employment in the industry. These results will serve as baseline data for subsequent surveys to determine cause relationship of toxic noise levels and hearing impairment.

### 3.2 TARGET POPULATION

This is a captured population of 308 workers, made up of production, engineering and Administration Staff.

Production	-	123
Engineering	-	121
Administration		<u>64</u>
	=	308

### 3.3 SAMPLING METHOD AND SAMPLE SIZE

The crucial step in preparing to conduct a study was the determination of the number of subjects, adequate enough to answer the questions posed by the study. The sample size was calculated using the formula for single proportion.<sup>23</sup> The prevalence of the exposure in the target population is 40% and a confidence interval of 90% and the margin of error of 5.

Substituting these in the formula

$$\begin{aligned}n &= \frac{p(1-p)}{e^2} \\ &= \frac{40 \times 60}{5^2} \\ &= 96\end{aligned}$$

n = sample size  
p = percentage  
e = margin of error

Therefore the minimum sample size to answer the question posed by the study is 96 but for convenience it was approximated to 100.

100 workers out of 308 worker were selected randomly using the "Lottery" method.<sup>23</sup>

Using a list of 308 workers each worker was given a number from 1 to 308 and these numbers were written on small pieces of paper. All the 308 papers were put in a hard card box. The box was then shaken vigorously to ensure randomization. Hundred papers were then picked out of the box and the numbers picked constituted the sample. The names were then categorized into various sections as follows:

Group 1	Production	-	50
Group 2	Engineering	-	42
Group 3	Administration	-	8

Group 1 are workers in the production section who are presumed to be the most-at-risk for exposure to noise.

Group 2 are workers in engineering section who are moderately exposed to noise because they carry out maintenance works in the production section for long hours.

Group 3 are workers in the administration section who are least exposed to the noise hazard.

The noise survey of machines and equipment of the factory was undertaken using Castle Associates CA-102 sound level meter.

The workers selected for the study were invited one after the other for an interview. The questionnaire was filled by the interviewer to discover factors other than occupational noise which could contribute to hearing impairment. The questionnaire concentrated on age, length of service, past occupational history, past medical history, hobbies and ear pathology. (see Annex 1).

Recent report of auroscopic examination of the workers selected were examined to rule out any ear infections or accumulation of ear wax.

The workers then underwent audiometric assessment. A wide range qualitone Model WRB 6097 diagnostic audiometer calibrated according to ANSI 1969 standard. Six frequencies were tested ie. 500, 1000, 2000, 3000, 4000, 6000 Hz. The procedure was simple to administer and painless to receive. It was done in a very quiet room in the clinic of the factory. It was made sure that the headband were correctly placed and the earphones were on the proper ear. The test was administered by setting the frequency at 1000 Hz and presenting a tone that was easily heard at 50 dB. The tones were presented for one or two seconds and if response was obtained by the individual, he indicated by raising a finger. The intensity of the sound was decreased to 40 dB and so on in similar increments until the threshold is reached. The threshold was measured by

ascending and the descending techniques in 5 dB steps and repeating a second and third time until the threshold was determined. Audiometric zero is the average hearing level for a large group of young normal healthy adults. Rarely does an individual hear precisely at zero for all frequencies.

Responses were recorded on the audiometric test form. The manual audiometer was used. (see Annex 2 for results).

Systematic error was eliminated by comparing results obtained by the specialist audiologist and the researcher using the same instrument.

#### 3.4 VARIABLES

(1) AGE:- The age of the worker was taken as at his last birthday. Workers will be grouped in 10 years age intervals to show the prevalence of noise induced hearing loss among workers.

(2) Early Loss Index (E.L.I) at 4000 Hz.

In accordance with E.L.I. at 4000 Hz any worker whose hearing threshold lies within category A and B has excellent and good hearing acuity respectively. To have category C is to be at the verge of noise induced hearing impairment (NIHI) but to fall in category D is to have a definite noise-induced hearing impairment. The categories are shown below:

Category

A	:	0	7 dB	Excellent
B	:	8	22 dB	- Good
C	:	23	29 dB	Suspect for NIHI
D	:	30 dB and above		Definite NIHI

(3) Exposure in years: This is the number of years the worker has worked in the factory, and workers will be grouped into 5 exposure year intervals to determine the prevalence of noise-induced hearing impairment among workers with different lengths of service.

(4) Hearing loss at speech frequency (500, 1000 and 2000 Hz). The combined average of the hearing acuity at frequencies 500, 1000 and 2000 Hz was calculated.

If the result fell within category a ie. 25 dB or less then the worker has no hearing loss in the speech frequency range.

If the result fell between 26 and 40 dB then the worker is said to have slight hearing loss in the speech frequency that is category B. The worker has moderate hearing loss in the speech frequency if the combined average fell between 41 and 55 dB that is category C.

Category D is moderate loss when the combined average at 500, 1000, 2000 Hz fell between 56 - 70 dB, severe - 71 90 dBA, profound loss 90+ dBA.<sup>24</sup>

(5) Noise levels were measured at different locations in the factory in decibel A-weighted (dBA) with the help of the

sound level meter.

Noise levels greater than the threshold limit value (TLV) of 85 dBA was said to be toxic and that below TLV of 85 dBA were not toxic.

### 3.5 DATA COLLECTION INSTRUMENTS AND DATA COLLECTION TECHNIQUES

- (1) Questionnaire
- (2) Audiometer
- (3) Sound level meter

Data collection techniques used are:

- (a) face to face interview of the workers one after the other. This will enable me explain the purpose of the study to them to get them interested and participate fully in the study.
- (b) Observation to see whether workers used hearing protective devices when they were at their workplaces. This was done during noise level measurements at the different locations in the factory.
- (c) Using available information of recently conducted auroscopic medical examination by the Ear, Nose and Throat specialist.

### 3.6. PRETESTING

This was carried out among selected group of workers from the Textile factory who were not included in the study.

The aim was to pretest the questionnaire and other data collection tools. The information and experiences obtained from the pretesting was used to modify the conduct of the main study including logistics. The data from the study was used to test computer entry procedures and suitability of the data base format and of data coding verification, editing and the tabulation procedures. Pretesting lasted for two days.

### 3.7 DATA PROCESSING AND ANALYSIS

This was done using EPI INFO version 6.01 computer package. It involved the calculation of the prevalence of noise-induced hearing loss among workers of different age groups, exposure groups etc. Microsoft Works version 3.0 Window computer package was used to draw the graphs.

### 3.8 LIMITATIONS

1. Unavailability of pre-employment audiometric baseline data, so the data collected in this study will serve as baseline for subsequent studies.
2. Time constraint.
3. Financial constraint

### 3.9 POTENTIAL SOURCES OF BIAS

1. A form of selection bias often found in occupational studies is the healthy worker effect. The effect is reflected by workgroups that have lower mortality rates

than the general population, despite hazardous exposures. This type of bias is explained by self-selection or medical selection of more healthy people into employment that requires physical stamina. The inability to randomize people to exposure and the resulting bias makes the interpretation of occupational studies difficult. It was difficult to overcome such a bias so a random sample was selected from among the captured population.

2. There is a possible bias from defective data collection instruments, like the sound level meter, audiometer and questionnaire. To prevent this the instruments were calibrated and pretested before use.
  
3. Effect of the interview on the informant. A situation arose when workers expressed the fear that information collected could be used against them for example early retirement. This was prevented by adequately explaining the purpose of the study to the workers and assuring them of the confidentiality. They were interviewed without interference from other workers.

CHAPTER 4

RESULTS

TABLE 1

NOISE SURVEY OF MACHINES AND EQUIPMENT AT  
DIFFERENT WORK STATIONS  
IN THE CEMENT FACTORY 1995

MILLING DEPARTMENT

FEEDMILL TABLE 1 (station 1)	----->	95 dBA
FEEDMILL TABLE 2 (station 2)	----->	100-103 dBA
MILL FLOOR 1 (station 3)	----->	105-108 dBA
MILL FLOOR 2 (station 4)	----->	99-100 dBA
COMPRESSOR HALL 1 (station 5)	----->	89-90 dBA
COMPRESSOR HALL 2 (station 6)	----->	90-92 dBA
COMPRESSOR HALL UPSTAIRS (station 7)	----->	95-100 dBA
GEAR BOX HALL MILL 3 (station 8)	----->	100-102 dBA
GEAR BOX HALL MILL 1 (station 9)	----->	100-105 dBA
GEAR BOX HALL MILL 2 (station 10)	----->	95-98 dBA

PACKING DEPARTMENT

FIRST ROTOR PACKER (station 11)	----->	83-87 dBA
SECOND ROTOR PACKER (station 12)	----->	77-80 dBA
LOADING OF CEMENT INTO VEHICLES (station 13)	----->	86 dBA

ADMINISTRATION DEPARTMENT

GENERAL OFFICE (station 14)	----->	72-78 dBA
LABORATORY (station 15)	----->	75-78 dBA
CANTEEN (station 16)	----->	67-78 dBA

ENGINEERING DEPARTMENT

WORKSHOPS (station 17)-----> 83-84 dBA

Noise survey of machines and equipment at different work stations shows that, the worst area was the production department (stations 1-13). The noise levels in this department ranged between 77 dBA and 108 dBA. The noise level at the engineering department(station 17) ranged between 83 dBA and 84 dBA. The administration department (stations 14-16) had noise levels ranging between 67 dBA and 78 dBA. This is illustrated graphically in figure 1, the threshold limit value of 85 dBA is marked.

# NOISE LEVEL AT DIFFERENT WORKSTATIONS AT THE CEMENT FACTORY

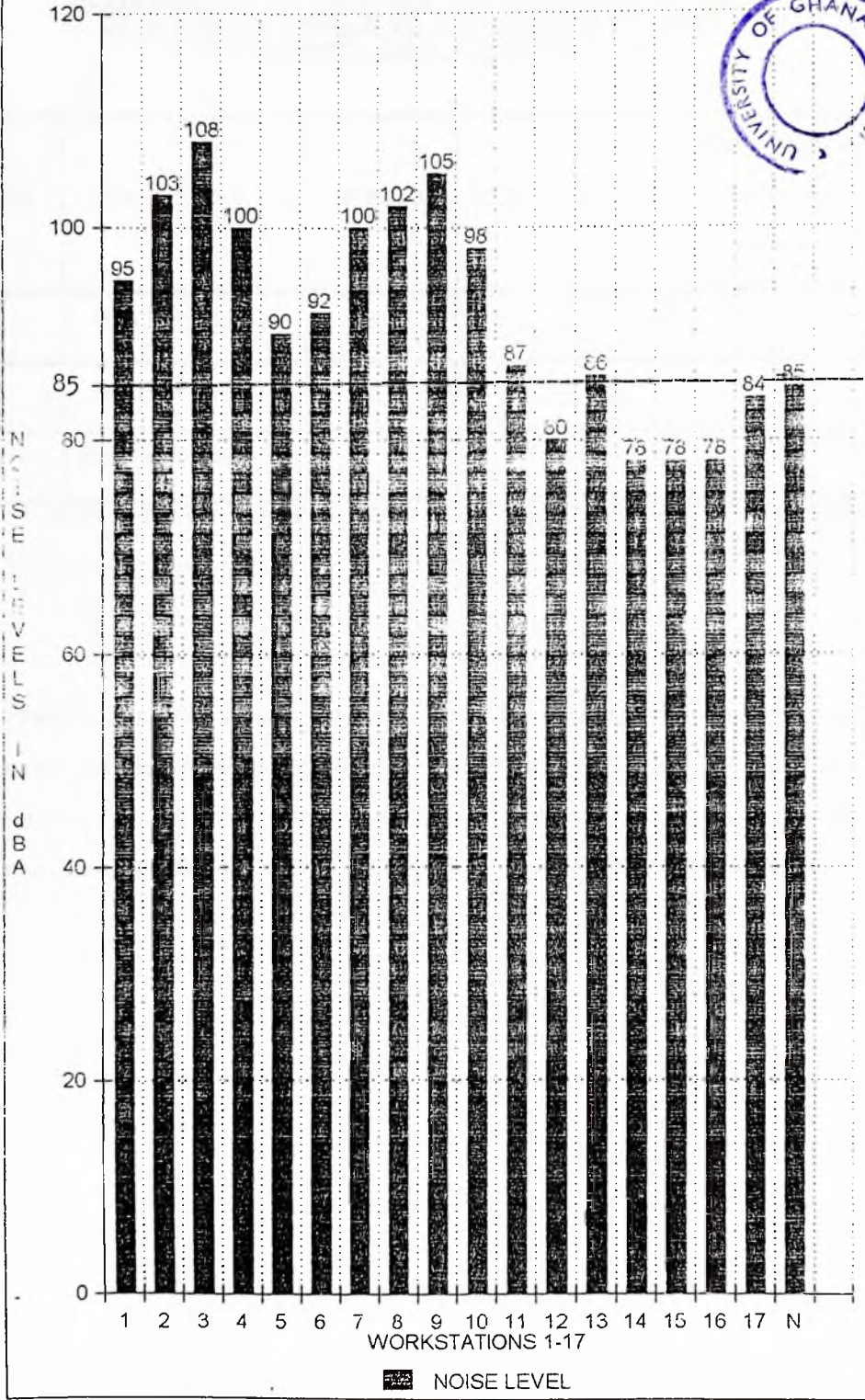


Figure 1

TABLE 2

DISTRIBUTION OF MEAN AGE AND DURATION OF SERVICE  
OF A RANDOM SAMPLE OF 100 WORKERS OF VARIOUS  
DEPARTMENTS IN A CEMENT FACTORY

GROUP	DEPARTMENT	NUMBER	MEAN AGE YRS	MEAN DURATION OF SERVICE IN YEARS
1	PRODUCTION	50	39	11
2	MAINTENANCE	42	43	12
3	ADMINISTRATION	8	47	15

\* Most of the figures have been approximated to the nearest whole number

Table 2 shows that the mean ages of workers in the production, engineering and administration departments were 39, 43 and 47 years respectively and the duration of in the production, engineering, administration departments were 11, 12 and 15 years respectively.

TABLE 3

DISTRIBUTION OF EARLY HEARING LOSS INDEX (ELI) AT  
400 HERTZ AUDIOMETRY AMONG 100 WORKERS OF  
A CEMENT FACTORY

CATEGORY OF HEARING ACUITY IN DECIBEL (dB)	NUMBER IN CATEGORY	PREVALENCE IN CATEGORY
CATEGORY A : 0 - 7 dB = EXCELLENT HEARING ACUITY	5	5%
CATEGORY B : 8 - 22 dB = GOOD HEARING ACUITY	38	38%
CATEGORY C : 23-29 dB = SUSPECT OF NOISE INDUCED HEARING LOSS (NIHL)	15	15%
CATEGORY D : 30 dB <sup>+</sup> (and) = DEFINITE NOISE HEARING LOSS above	42	42%

Table 3 shows that out of the 100 workers of the cement factory assessed, 5 (5%) of them had excellent hearing acuity, 38 (38%) workers had good hearing acuity, 15 (15%) were borderline cases who were strongly suspected of having noise-induced hearing impairment and 42 (42%) workers had definite noise-induced hearing impairment. This is illustrated graphically in figure 2.

PREVALENCE OF N.I.H.L  
AMONG 100 WORKERS OF THE CEMENT FACTORY

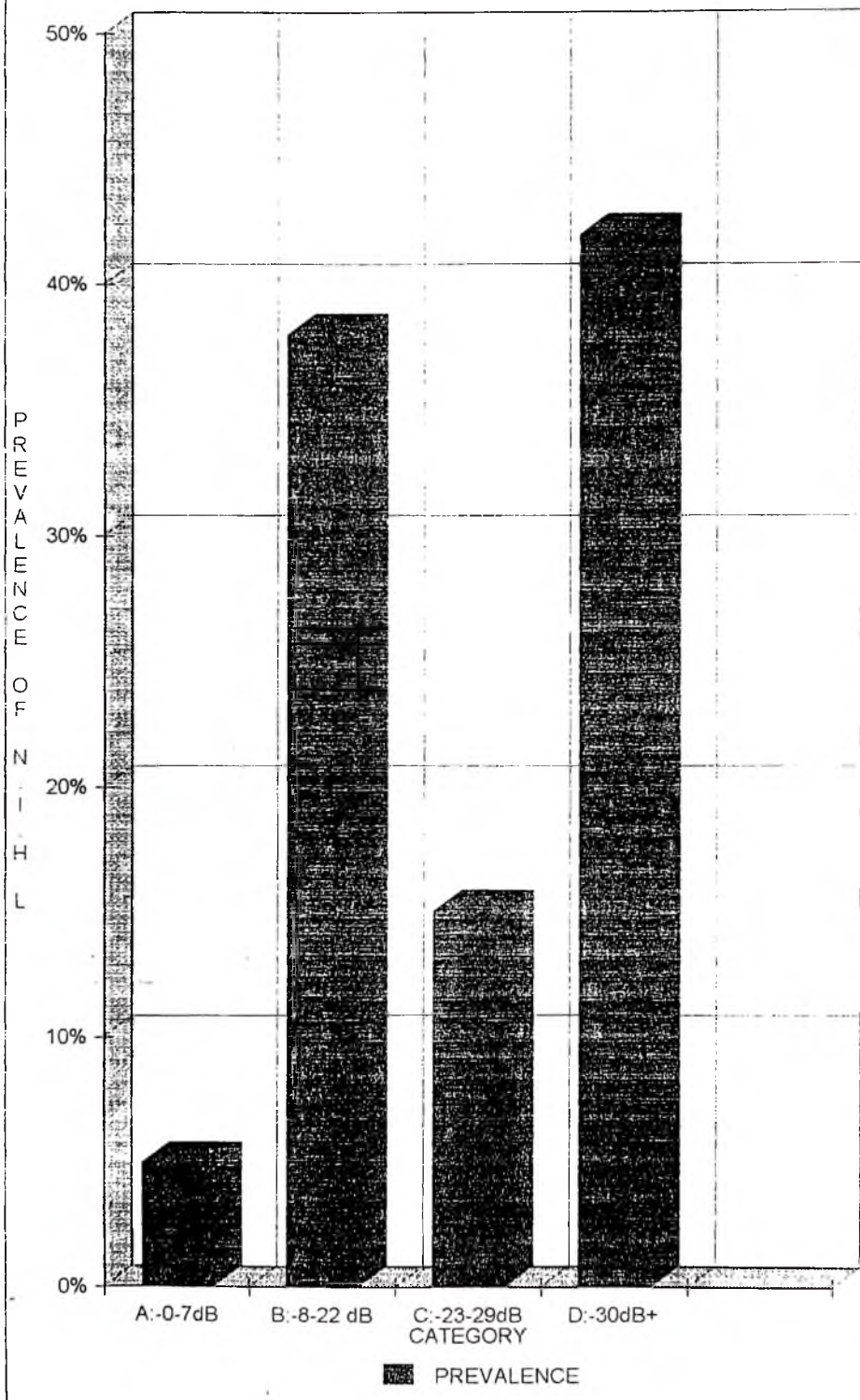


Figure 2

TABLE 4

AGE DISTRIBUTION AND OCCUPATIONAL NOISE-INDUCED HEARING LOSS AT 4000HZ 100 WORKERS IN THE CEMENT FACTORY

(A)

AGE GROUP YRS	NUMBER TESTED	NUMBER WITH NOISE-INDUCED HEARING LOSS	PREVALENCE OF NOISE INDUCED HEARING LOSS
24 33	21	7	33%
34 43	35	9	25.7%
44 53 <sup>+</sup>	44	26	59%
ALL AGES	100	42	42%

(B)

AGE GROUP YRS	NUMBER TESTED	NUMBER WITH NOISE-INDUCED HEARING LOSS	PREVALENCE OF NOISE INDUCED HEARING LOSS
LESS THAN 40 YRS	42	10	23.8%
GREATER THAN 40 YRS	58	32	55.2%

Table 4a showed that in the age group 24 - 34 years, 7 workers (33%) out of 21 workers had noise-induced hearing impairment, 9 workers (25.7%) out of 35 workers in the age-group 34 43 years had noise-induced hearing impairment, whilst 26 workers (59%) out of the 44 workers of the age-group 44 - 53+ years had noise-induced

hearing impairment. This is illustrated in figure 3.

Regrouping the workers into those who are 40 years and below, and those above 40 years, it was shown in Table 4b that 10 workers (23.8%) out of the 42 workers aged 40 years and below, had noise-induced hearing impairment. For the age-group above 40 years, 32 workers (55.2%) out of 58 workers had noise-induced hearing impairment. This demonstrate an increase of noise-induced hearing impairment with age. This is illustrated graphically in figure 4.

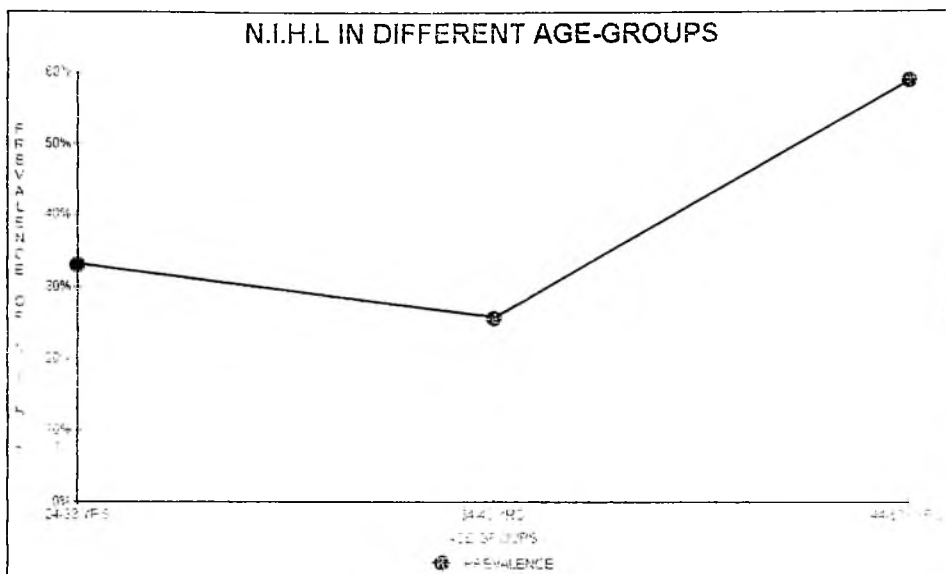


Figure 3

### N.I.H.L IN DIFFERENT AGE-GROUPS

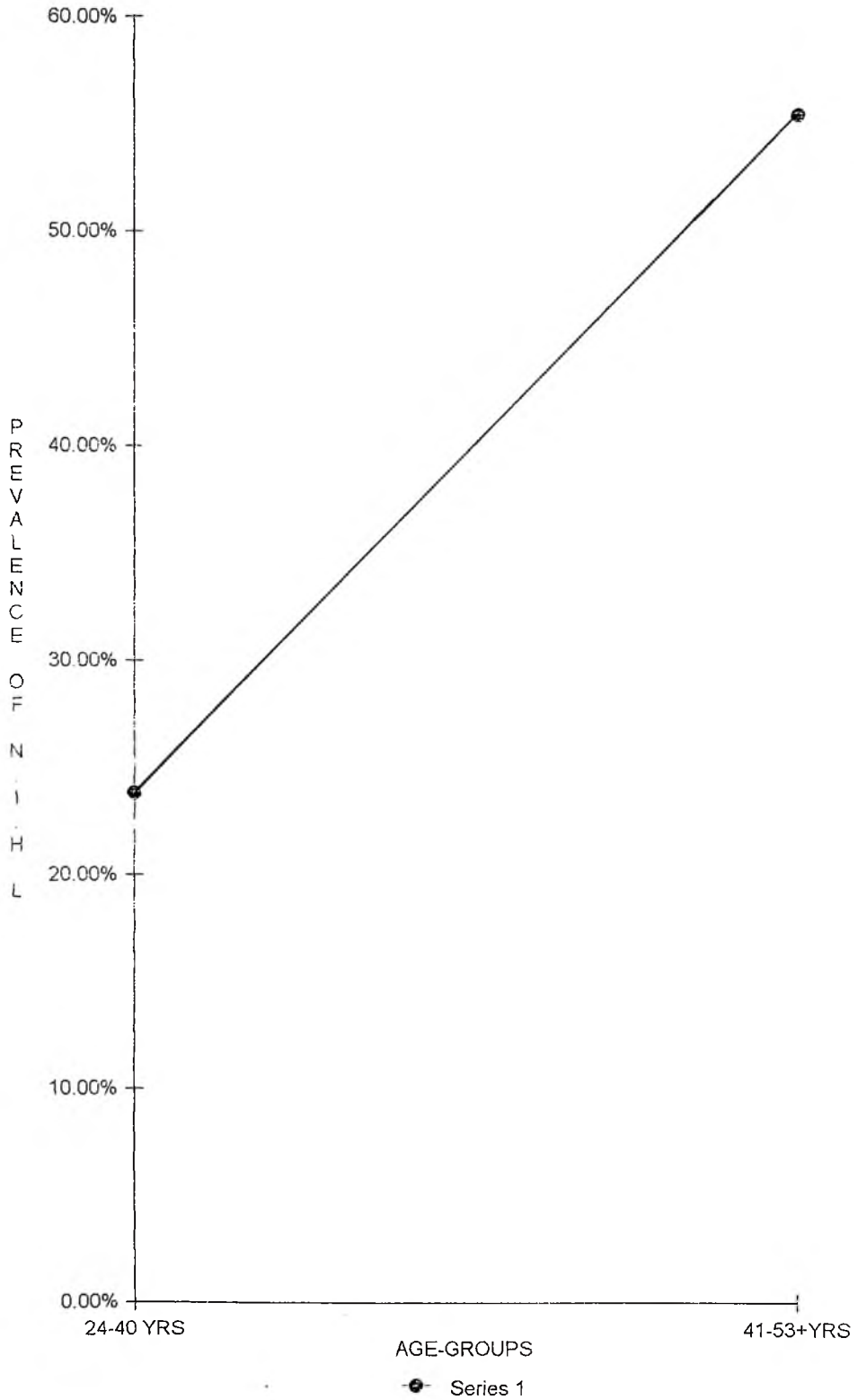


Figure 4

TABLE 5

DURATION OF SERVICE RELATIVE TO NOISE-INDUCED  
HEARING LOSS AMONG 100 WORKERS IN A CEMENT FACTORY

5A

DURATION OF SERVICE IN YEARS	NUMBER TESTED	NUMBER WITH NOISE-INDUCED HEARING LOSS	PREVALENCE OF NOISE-INDUCED HEARING LOSS
0 5	31	11	35.5%
6 10	13	3	23.1%
11 15	21	6	28.6%
16 - 20 <sup>+</sup>	35	22	62.9%
	100	42	42%

5B

DURATION OF SERVICE IN YEARS	NUMBER TESTED	NUMBER WITH NOISE-INDUCED HEARING LOSS	PREVALENCE OF NOISE-INDUCED HEARING LOSS
1 - 10	44	14	31.8%
11 <sup>+</sup>	56	28	50%
ALL	100	42	42%

Table 5a showed that 11 workers (35.5%) out of 31 workers who had served for the first 5 years exhibited noise-induced hearing impairment. Three (23.1%) of the 13 workers who had served between

6 and 10 years developed noise-induced hearing impairment. Six (28.6%) of the 21 workers who served between 11 and 15 years had noise-induced hearing impairment, and 22 workers out of the 35 workers who had served 16 years and above had noise-induced hearing impairment. This is illustrated in figure 5.

In another analysis of the same data in table 5b, 14 (31.8%) of the 44 workers who had served for the first 10 years had noise-induced hearing impairment, whilst 28 (50%) of the 56 workers who had served more than 11 years exhibited noise-induced hearing impairment as illustrated in figure 6.

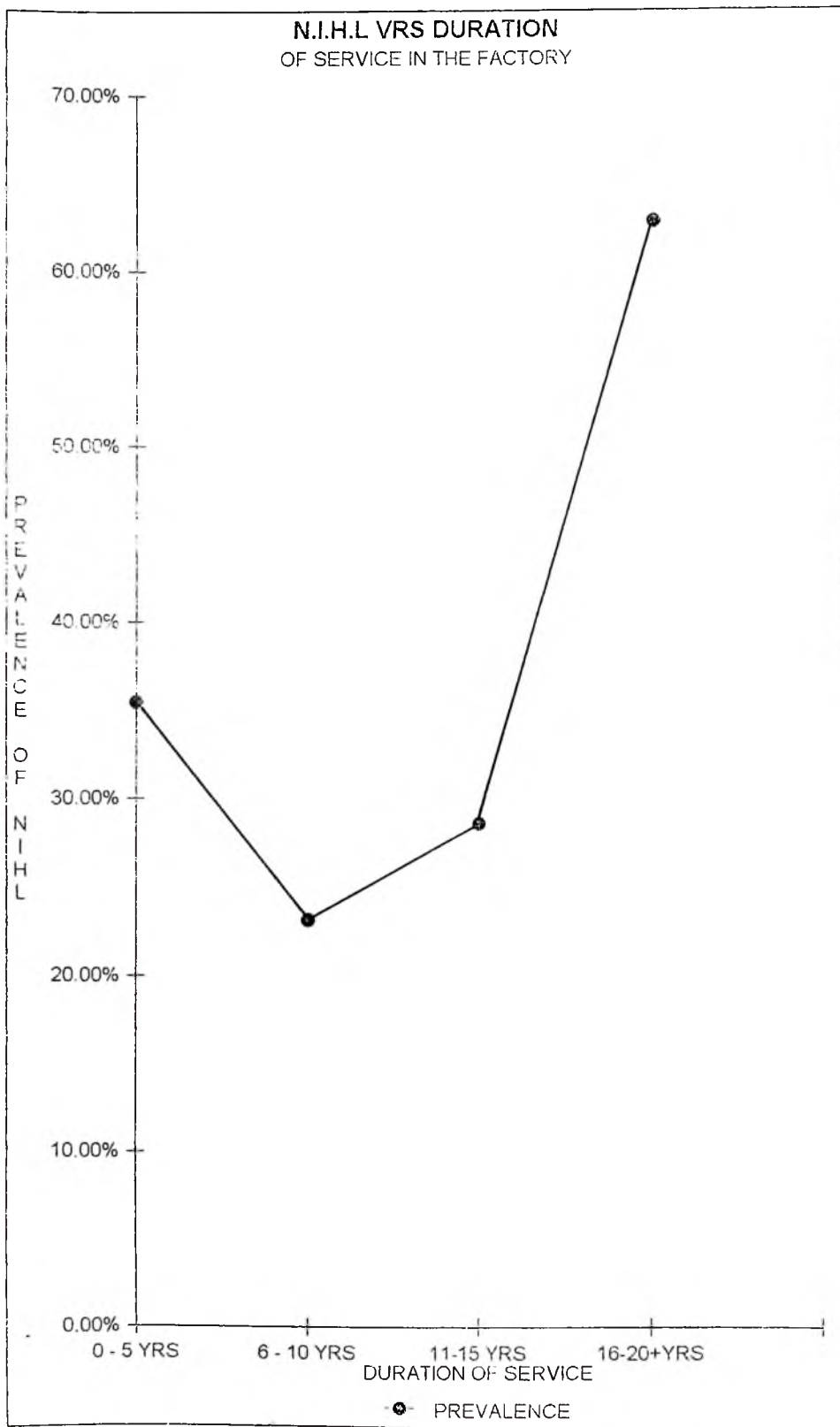


Figure 5

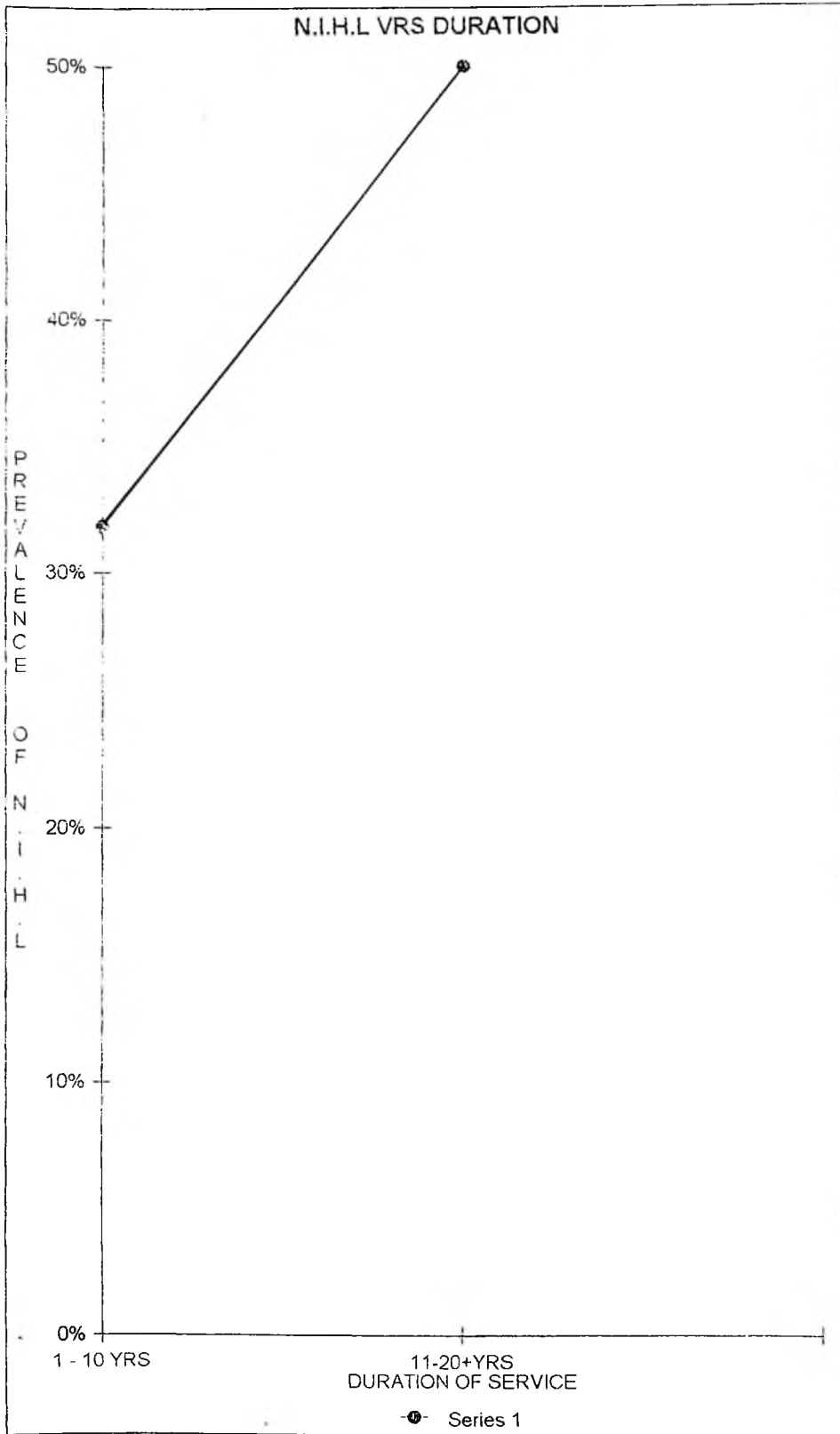


Figure 6

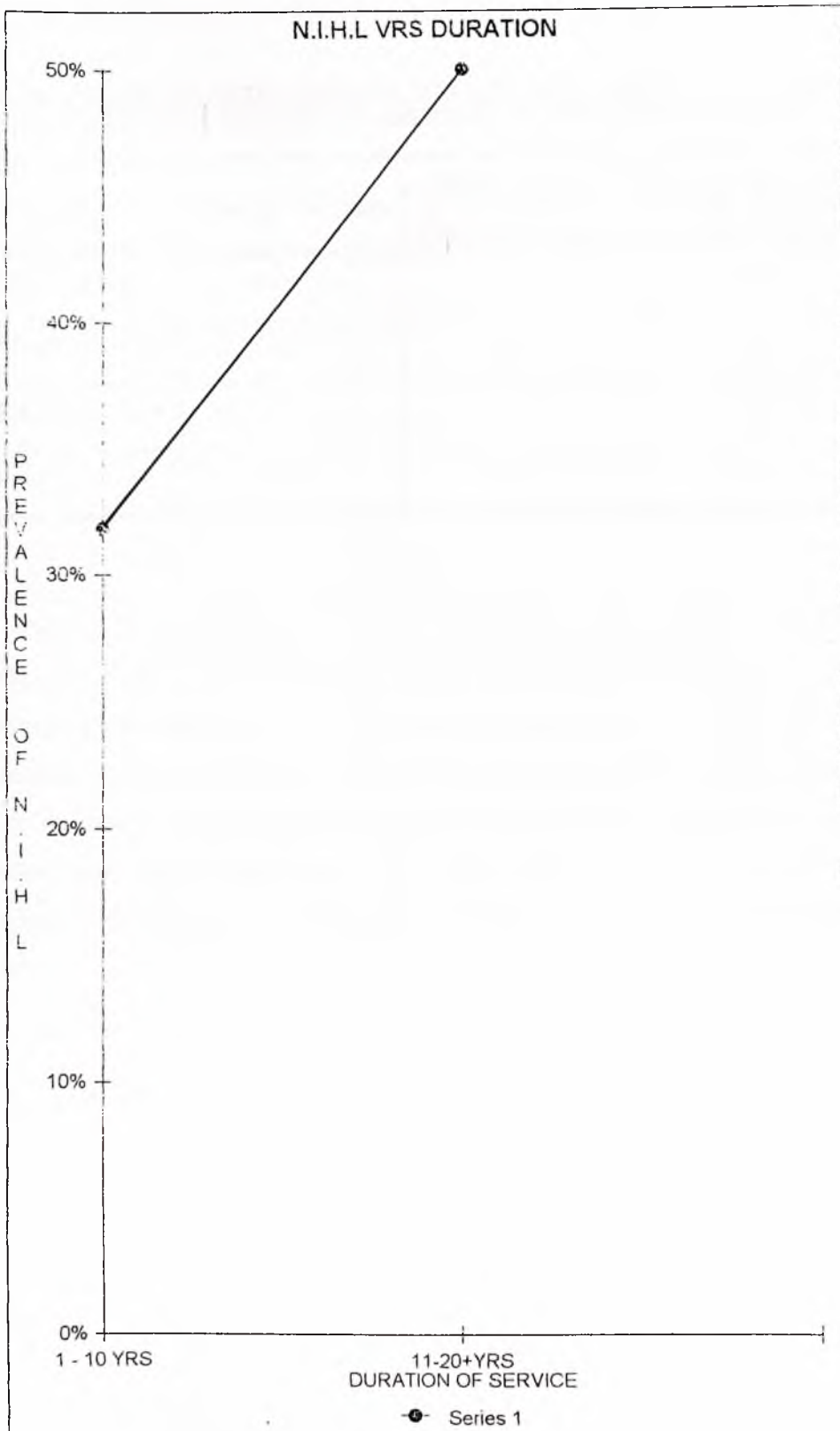


Figure 6

TABLE 6

DISTRIBUTION OF NOISE-INDUCED HEARING LOSS AMONG 100 WORKERS  
SELECTED FROM VARIOUS DEPARTMENTS OF THE CEMENT FACTORY

DEPARTMENT	NUMBER TESTED	NUMBER WITH NOISE-INDUCED HEARING LOSS	PREVALENCE OF NOISE-INDUCED HEARING LOSS
PRODUCTION	50	22	44%
MAINTENANCE	42	19	45%
ADMINISTRATION	8	1	12.5%
ALL	100	42	42%

Table 6 shows that 22 (44%) of the 50 workers from the production department had noise-induced hearing impairment. Of the 42 workers who work at the engineering department, 19 (45%) of them had noise-induced hearing impairment. Only 1 worker (12.5%) out of the 8 workers in the administration department developed noise-induced hearing impairment, he was moved from the production department where he had worked for 6 years. This is illustrated in figure 7.

# N.I.H.L IN DIFFERENT DEPTS

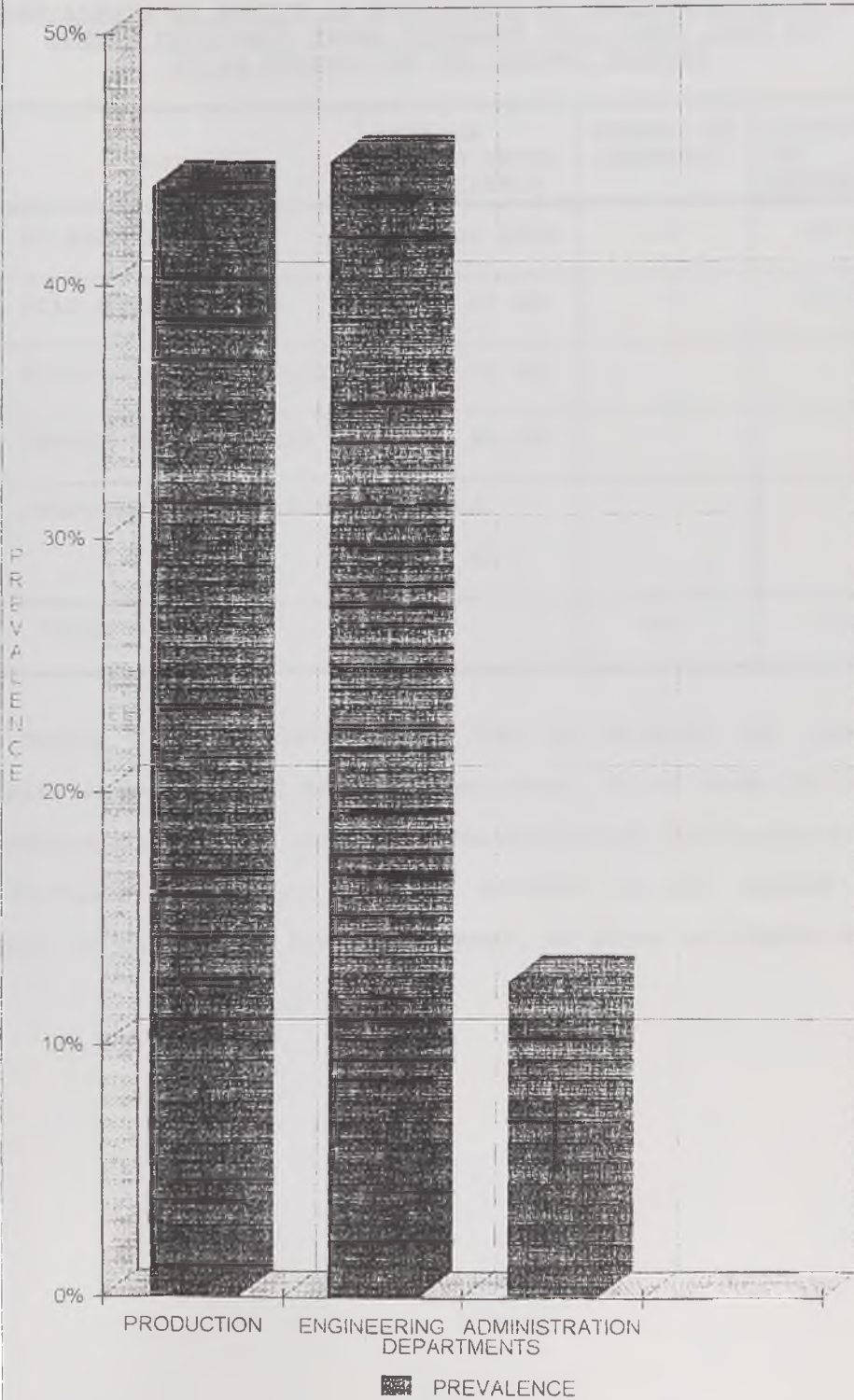


Figure 7

TABLE 7

PREVALENCE OF EFFECT OF NOISE-INDUCED HEARING LOSS ON THE  
SPEECH FREQUENCY RANGE (AVERAGE 500, 1000, 2000 Hz)  
OF 42 WORKERS IN THE CEMENT FACTORY

CATEGORY	AVERAGE SPEECH LEVEL IN DECIBELS	NUMBER IN CATEGORY	PREVALENCE IN CATEGORY
A : NO HEARING LOSS	25dB or LESS	37	88.1%
B : MILD HEARING LOSS	26 - 45 dB	5	11.9%
C : MODERATE HEARING LOSS	46 70 dB		
D : SEVERE HEARING LOSS	71 90 dB		
E : PROFOUND HEARING LOSS	91 and above dB		
TOTAL		42	100%

Table 7 shows that out of the 42 workers who exhibited definite noise-induced hearing impairment, 37 of them (88.1%) had no problem engaging in normal conversation and also execute verbal instructions perfectly. Only 5 workers (11.9%) showed slight defects in the speech frequency range, as shown in figure 8

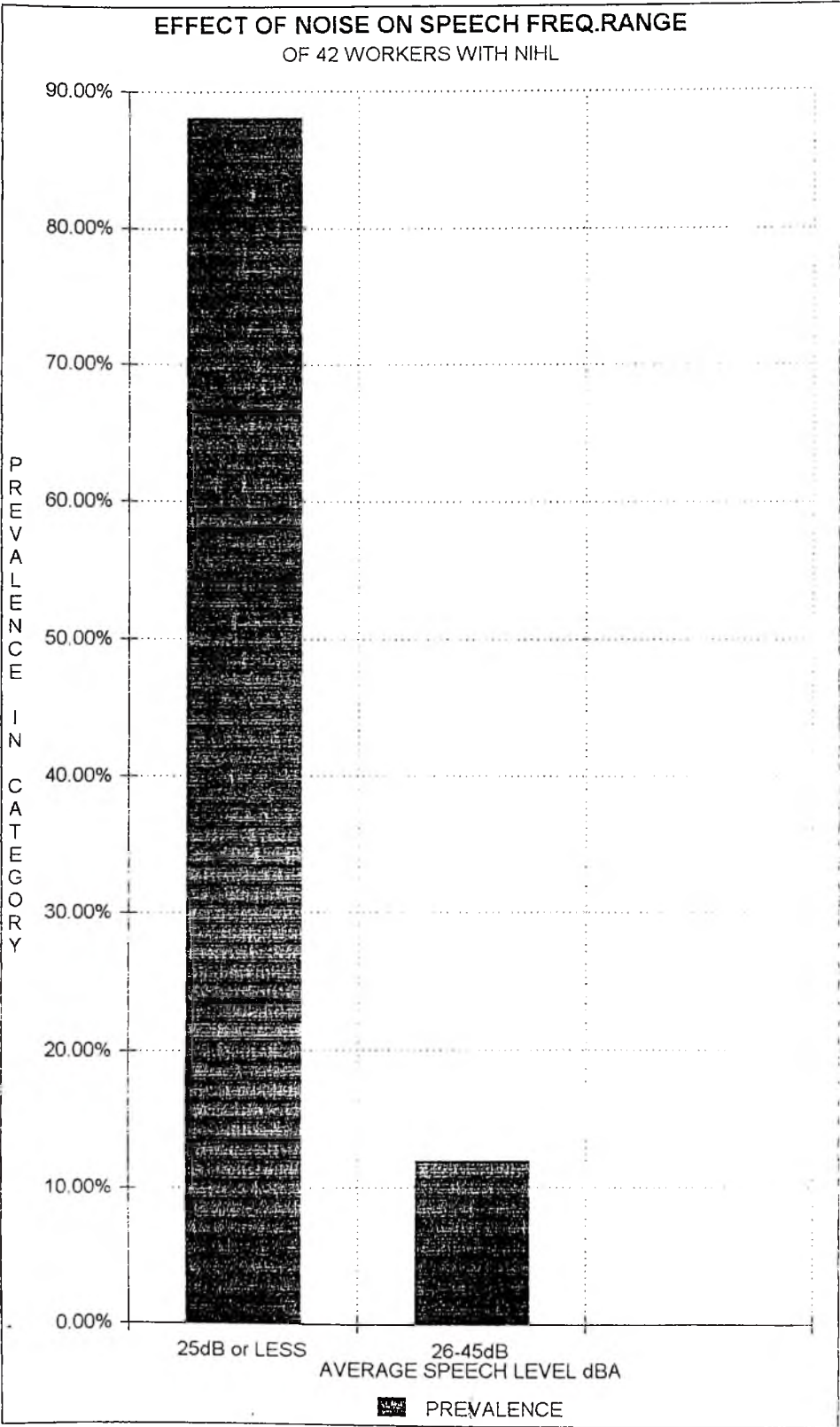


Figure 8

## CHAPTER 5

### DISCUSSION

#### TABLE 1

The noise levels in the production division were far above the threshold limit value of 85 dBA set by the United States Occupational Health and Safety Administration (OSHA). The noise in this section is excessive and hazardous, and likely to damage the hearing of the workers if they do not use the right personal hearing protection equipment (ear-plugs and earmuffs).

As with all biological insults it is difficult to predict for an individual the level of noise required to cause hearing damage. Although noise-induced hearing loss is felt to be extremely unlikely at sound levels below 80 dBA, noise damage becomes increasingly likely as the sound levels rise above this.<sup>11</sup>

As sound levels increase, the safe time of exposure decrease. This is embodied in the equal energy principle where successive 3 dBA increase in noise levels above a "safe" level (85 dBA) for an 8-hour working day require a corresponding halving of the exposure time.<sup>12</sup> Therefore the workers at the production division where noise levels range between 89 and 108 dBA are supposed to work for between 1/8 hour and 4 hours depending on the location and the noise level after which they have to be moved to quieter job for the rest of the period. Since this looks impractical moving workers to quieter places the one way out is to provide them with protective hearing equipment which is comfortable and has a good fit. Another way is for the workers to move away from the noise

until their next inspection of the machines.

The workers in the engineering department also are exposed to the same risk because they carry out maintenance activities in the production department for very long hours whilst the other machines are working.

In the questionnaire administered 94% of the workers selected reported that their workplace are noisy and only 6% said it was not noisy.

#### Table 2

The age group that works at the production section is relatively younger than those of the other sections and the mean duration of stay in the section is 11 years. This young age-group can leave the industry easily when they became intolerable to the noise because they have nothing to lose when they leave for less noisy jobs.

#### Table 3

The prevalence of noise-induced hearing impairment among the study group was 42%.

This compares favourably with work done in one of the major industries in the United Kingdom which has been doing audiometric screening for several years. There was evidence that 40% of the noise expressed workforce had noise damage at least in one ear.<sup>7</sup>

This also compare favourably to a recent survey done in small

factories by Foo et al 1985. Among the workers surveyed in Singapore and the Phillipines, 40% and 74% respectively had a hearing loss in excess of 30 dBA.<sup>8</sup>

This goes to confirm that noise is really a problem in the factory and so there is the need to put a hearing conservation programme in place.

Occupational health survey undertaken at Ghacem in July 1990 showed that 33% of exposed workers suffered from NIHL and 20% were on the verge of developing a hearing defect.<sup>23</sup>

#### Table 4

The trend in figure 4 shows an increase in NIHL with age. Hearing normally declines with age. The effect of age and noise exposure are thought to be additive. Consequently the prevalence of NIHL increase with age.

This trend has been observed in surveys conducted by Dr. A.B. Quainoo in the various factories where noise is a problem.<sup>25</sup>

#### Table 5

It is generally agreed that noise injury develops at first rapidly and later move slowly and may come to a standstill at a given stage depending on the noise level.

In the study, 35.5% of workers who had worked for duration between 0 and 5 years had noise induced hearing loss. This compares with the findings of Dr. A.B. Quainoo in 1992, that 40-45% of workers employed in industry develop noise induced hearing loss

within the first 5 years.

Kylin also studied workers exposed to continuous noise and found out that when the loudness exceeds the damage risk criterion of 85 dBA and above, even three months suffice for an injury to develop. He stated that the major part of the injury develops during the first five to ten years, after which continuous noise affect hearing to a less extent than does age.

The least number of workers were found in the group who had worked duration between 6 and 10 years and only 23.1% had noise induced hearing loss, the small number may be due to the fact that for the first five years workers who realized that their hearing capacity has reduced and could no longer tolerate the noisy job left for less noisy jobs, leaving behind those who could not gain any other employment elsewhere.

The rate of leaving the job after 10 - 15 years of work was not as much as the 6 - 10 years because workers might have conditioned themselves and accepted conditions as it were, may be they were well motivated. This accounts for the 28.6% of NIHL exhibited in this group who had worked between 11 and 15 years.

For those who worked over 16 years and above, they were particularly motivated to stay because of the expected retirement benefits and the prevalence of NIHL in this group was the highest (62.9%).

Regrouping the workers in 10 years duration showed that for the first 10 years 31.8% had NIHL, whilst 50% showed NIHL for 11 years and above.

Consequently the prevalence generally shows an increase of NIHL to duration of noise exposure.

Ilse Rop and Alfred Raber of the Austrian Workers Compensation Board, Vienna conducted a study on hearing impairment as a function of years of noise exposure. The study which investigated the relation existing between the amount of exposure to noise and its effect on hearing loss showed that the effect of noise exposure on hearing impairment increases with the number of years of pathogenic exposure.<sup>26</sup>

#### Table 6

Shows that there is no difference in the prevalence of noise induce hearing loss between workers in the engineering and the production departments. This goes further to confirm the fact that workers in these sections are equally exposed to the hazardous noise at the production section. Since these workers from the engineering department carry out maintenance works for long hours, without using hearing protection devices, which in actual fact is only supplied to workers in the production department.

#### Table 7

The speech range classification in table 7 shows the prevalence of NIHL on the speech frequency range, it is of value in this study because with continuous noise exposure in excess of 85 dBA the high frequencies are affected first and with time it starts spreading to the lower frequencies including the speech frequency

range. This makes it difficult for workers to execute verbal instructions and fulfil their tasks efficiently, this could lead to low productivity, and even lead to social isolation.

In theory the intelligibility of speech is not very much affected by hearing loss at frequencies higher than 2 KHz, since most of the speech sounds have low component frequencies, on the other hand the essential speech range extends from 500 to 4000 Hz. Thus there may be a slight impairment of speech discrimination. The "critical speech area" lies between 30 and 40 dB in the range from 1000 2000 Hz. If hearing loss is in excess of this, the intensity of the ordinary spoken voice is no longer a sufficient stimulus.

In general, however workers exposed to noise have surprisingly good hearing for speech .<sup>27</sup>

In the study group out of the 42 (42%) who exhibited noise induced hearing loss. 37 workers (88.1%) had no defect in the speech frequency range whilst 5 (11.9%) had a slight hearing loss within the speech frequency range. This 11.9% of workers with defect in the speech frequency range is slightly higher compared with work done in a United Kingdom factory which has been doing audiometric screening for several which reports 8% having hearing threshold levels (averaged over 0.5, 1.2 KHz) of 25 dB or more in at least one ear.

There is therefore the need to put a hearing conservation programme in place to stop the loss from spreading into the speech

frequencies.

## CHAPTER 6

### 6. RECOMMENDATIONS

The problem of occupational hearing loss is easily conceptualized. The agent and the effects are identifiable and measurable. Effective means to limit the deleterious consequences of excessive noise exist.

On account of the study the following recommendations are therefore made to

- (1) Government
- (2) Management of Factory
- (3) Labour Unions of the factory

#### 6.1 GOVERNMENT

(A) The government should update the existing legislations and provide statutory regulations and codes of practices for the control of noise in all industries (small and large).

(B) The Workmen's Compensation Scheme operated by the labor department is unsatisfactory from the view point of fairness to victims or their dependants. It only covers silicosis and silicotuberculosis.

The scheme should be updated to cover all other occupational diseases.

(C) The government agency in charge of health should establish an occupational health service with a fully equipped industrial hygiene laboratory. The occupational health personnel of the service should work in collaboration with the occupational hygienists from the Ministry of Labour. The occupational health service should be organised such that it covers all the industries throughout Ghana.

Since resources for providing health services in the industrial sector will be scarce, one low cost alternative makes the Primary Health Care services an obvious choice.

The W.H.O programme on "health for all by the year 2000" could be the target for our country to provide occupational health services. Primary Health Care workers are already available in the countryside. With additional training in occupational health, they could be used for the delivery of services to workers in their areas of responsibility especially in the rural areas. Special problems which cannot be handled should be referred to centres where facilities and expertise are available.

Government health facilities can be used at areas where small factories are located, all that will be needed is to train health personnel who work in these facilities in occupational health and to upgrade equipment.

Reasonable financial contribution from the enterprises using the services of government clinics can be pooled to buy additional equipment and to pay for training of health personnel.

General medical practitioners are already being used by the many small factories. These doctors can be trained and oriented towards the principles of occupational health and safety by short training courses, making them more effective in the provision of occupational health care services to workers in the factories. On a smaller and less costly scale establishment of satellite clinics in the industrial areas and the use of mobile clinics could be utilized in the rural areas using local resources.

To reduce cost only the bare essentials in laboratory and monitoring equipment could be included in the facilities. The most sophisticated equipment could be located in a regional occupational health centre.

When the occupational primary health care service is provided, services such as pre-placement and periodic medical examinations and environmental and health monitoring, directed at particular hazards such as noise.

## 6.2 MANAGEMENT

6.2.1 Management should plant very thick hedge between the production and the engineering departments so as to reduce the

noise intensity reaching the workers working in these areas. Also the windows at these sections should be double glassed so as to reduce the noise intensity reaching the workers.

6.2.2 A hearing conservation programme should be put in place, the basic elements of which comprise:

- (a) assessment of exposure of the worker.
- (b) use of hearing protection by all workers.
- (c) an industrial audiometric testing programme.
- (d) acquisition and training of occupational health personnel.

The details of the hearing conservation programme can be found at the annex 3.

6.2.3 Should organise pre employment medical examinations for every worker and routine annual and termination audiometric assessment should the need for compensation arise.

6.2.4 Management should organise occasional meetings to discuss occupational health and safety problems with the trade unions and supervisors.

6.2.5 Management should team up with other managements to pool resources together to provide or set up a well equipped occupational health service. The service should take care of their occupational health needs to be provided for by a full or part-time

industrial physician and nurses with a local physician on call to attend to normal clinical ailments.

6.2.6 Management should establish a health and safety committee which is answerable to the Chief Executive or a senior manager appointed by him. This will ensure that health and safety of workers will be discussed at board and management level and will therefore be taken seriously by all personnel throughout the industry.

### 6.3 TRADE UNIONS

6.3.1 They should hold regular educational seminars on occupational health and safety for workers.

6.3.2 They should serve as the watchdogs ensuring good occupational health and safety practices by workers. In addition they should ensure that management provide all the necessary protective hearing equipment.

They should ensure that newly employed workers go through initial orientation and training and ensure that workers go through pre employment audiometric assessments.

6.3.3 They should meet regularly with management on problems of occupational health and safety.

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ANNEX 1  
OCCUPATIONAL HEALTH QUESTIONNAIRE  
FOR AUDIOLOGICAL ASSESSMENT  
1995

1. Name ..... 2. Age .....
3. Section:..... 4. Length of Service:.....
5. Is your workplace noisy? Yes [ ] No [ ] (Tick)
6. Do you use ear plugs? Yes [ ] No [ ]
7. HOBBIES:
- (a) Do you do hunting? Yes [ ] No [ ]
- (b) Do you visit discotheques Yes [ ] No [ ]
- (c) Do you attend church which use musical instruments?  
Yes [ ] No [ ]
8. OCCUPATIONAL HISTORY
- (a) Military Service Yes [ ] No [ ]
- (b) Textile Industry Yes [ ] No [ ]
- (c) Mining Yes [ ] No [ ]
- (d) Construction Yes [ ] No [ ]
- (e) Musician Yes [ ] No [ ]
- (f) Others.....
- 8b. How long did you serve? ..... years
9. MEDICAL HISTORY
- (a) Tinnitus Yes [ ] No [ ]
- (b) Discharging ears Yes [ ] No [ ]
- (c) Painful ear Yes [ ] No [ ]
- (d) History of Injury to ear Yes [ ] No [ ]

10. AUDIOLOGICAL ASSESSMENT

FREQUENCY	0.5 KHz	1 KHz	2KHz	3KHz	4KHz	6KHz	Average	Hearing Acuity
RIGHT EAR								
LEFT EAR								

## ANNEX 2

**AUDIOLOGICAL ASSESSMENT OF WORKERS IN A CEMENT  
FACTORY 1995  
MILL DEPARTMENT**

NAME	EAR	.5K	1K	2K	3K	4K	6K	A V E R A G E	A G E	Y E A R S	R E M A R K S
G.V	R	10	10	5	5	5	10	8	36	15	A
	L	10	10	5	5	5	10	8			
D.L	R	10	5	10	5	15	20	8	37	17	B
	L	10	10	15	15	20	15	12			
I.A	R	15	15	30	40	20	30	20	41	5	B
	L	15	15	20	15	10	15	17			
G.M	R	10	10	10	20	20	40	10	32	14	B
	L	10	10	20	15	20	20	13			
D.S.N	R	15	15	15	15	10	10	15	41	15	B
	L	20	15	15	15	15	20	17			
E.E.B	R	25	20	15	15	15	10	20	43	12	B
	L	20	15	15	10	15	20	17			
C.A	R	10	10	15	15	20	15	12	40	7	B
	L	10	10	15	20	20	10	12			
C.K.N	R	15	10	10	10	15	25	12	46	22	B
	L	10	10	10	10	15	15	10			
F.K.S	R	15	10	20	20	15	20	15	35	10	B
	L	15	15	20	15	20	20	17			
S.O	R	15	15	20	20	25	30	17	51	24	C
	L	15	10	15	20	25	30	13			
P.K	R	15	10	15	20	15	25	13	30	8	C
	L	20	15	25	20	25	25	20			

B.H.	R	10	10	20	55	65	70	13	54	13	D
	L	10	10	30	35	30	40	17			
P.K.T.I	R	10	15	15	40	45	65	13	42	20	D
	L	15	15	15	25	35	30	15			
B.A	R	20	15	20	30	20	25	18	41	13	D
	L	20	10	25	40	30	25	18			
S.O.B	R	20	15	20	20	20	25	18	50	23	D
	L	25	20	20	25	30	20	22			
D.G.K	R	25	15	25	30	30	35	22	48	14	D
	L	15	15	25	30	30	35	18			
D.K.Y	R	15	10	25	25	40	35	17	49	10	D
	L	15	15	25	25	40	45	18			
O.B	R	25	25	40	60	55	70	30	50	2	D
	L	35	35	45	50	60	80	38			
R.A	R	15	15	25	25	35	30	18	54	28	D
	L	15	15	25	30	30	30	18			
K.O	R	10	15	30	35	30	30	18	27	1	D*
	L	10	15	30	35	30	30	18			
A.G	R	10	15	20	20	30	30	15	53	27	D
	L	15	10	20	15	40	30	15			
	R										
	L										
PACKING DEPARTMENT	R										
	L										
KI.O	R	20	15	10	15	5	5	15	39	15	A
	L	10	10	10	5	5	5	10			
A.A	R	15	10	15	15	5	15	13	28	5	A
	L	10	10	10	10	5	5	10			
N.S	R	10	10	10	20	15	5	10	35	1.5	B
	L	20	15	10	25	15	25	15			

F.D	R	25	20	15	15	20	15	20	36	14	B
	L	20	15	10	15	20	15	15			
E.D	R	15	20	25	20	15	15	20	27	5	B
	L	15	20	20	20	15	15	18			
J.M	R	15	15	15	15	15	20	15	27	1	B
	L	10	10	10	20	15	20	10			
S.A.B	R	20	10	10	5	20	15	13	43	17	B
	L	10	10	15	10	15	15	12			
R.A	R	15	10	15	25	20	20	13	32	1	B
	L	10	10	15	25	20	20	12			
S.Q	R	20	20	15	15	20	25	18	41	1	B
	L	10	10	15	15	15	15	12			
S.A	R	15	10	25	20	20	15	17	44	18	B
	L	10	15	25	30	15	10	17			
J.S	R	15	15	15	20	20	25	15	28	1	B
	L	20	15	15	20	20	30	17			
A.B	R	15	20	20	15	20	25	18	33	8	B
	L	25	20	20	20	20	20	22			
J.A	R	15	10	15	15	15	20	13	29	4	B
	L	10	15	20	20	15	10	15			
K.S	R	20	15	15	25	25	20	17	26	5	C
	L	20	15	15	20	20	20	17			
JO.A	R	15	15	20	25	25	25	17	27	8/ 12	C
	L	20	20	15	15	15	20	18			
KW.A	R	15	15	25	20	25	20	18	50	28	C
	L	20	15	20	15	20	25	18			
S.D.L	R	20	20	20	20	25	25	20	53	28	C
	L	25	30	30	30	20	40	28			
J.Y	R	20	15	20	25	25	30	18	34	2	D
	L	10	10	15	25	40	30	12			

F.H	R	15	15	30	25	30	25	20	24	6/ 12	D
	L	15	10	25	15	15	15	17			
M.B	R	10	15	20	30	35	40	15	43	18	D
	L	20	20	30	35	50	60	23			
SH.A	R	15	20	15	20	35	30	17	48	22	D
	L	20	15	20	15	15	20	18			
S.M	R	10	20	25	30	45	40	18	50	18	D
	L	25	20	30	30	45	40	25			
P.D	R	15	15	10	25	30	15	13	27	5	D
	L	15	10	10	15	20	30	12			
E.K	R	15	10	10	20	15	5	12	27	1. 5	D
	L	25	40	50	50	40	15	38			
E.O.W	R	20	15	25	30	40	50	20	50	11 / 12	D
	L	15	10	25	35	40	40	17			
EM.A	R	15	15	20	20	30	45	17	40	19	D
	L	20	20	15	25	30	20	18			
F.T	R	10	10	15	30	35	35	12	28	4	D
	L	15	10	10	15	25	30	12			
N.B	R	20	15	35	35	45	55	25	39	5	D
	L	15	15	40	40	45	55	23			
E.K.L	R	15	10	20	40	45	25	15	52	20	D
	L	20	20	30	35	40	40	23			
MAINTENANCE DEPARTMENT	R										
	L										
G.K.D	R	10	10	10	5	5	15	10	32	5	A
	L	10	10	15	15	5	20	12			
L.A	R	20	15	20	20	15	20	18	47	4	B
	L	15	10	20	20	15	15	15			

R.N	R	15	15	20	20	20	20	17	36	6	B
	L	15	15	20	20	20	10	17			
EM.K	R	10	10	10	15	15	30	10	39	1	B
	L	15	10	15	15	20	30	13			
M.J.J	R	10	10	15	15	15	15	12	43	6	B
	L	15	10	10	10	15	20	12			
A.P	R	15	15	15	15	10	10	15	37	9/ 12	B
	L	10	10	15	20	10	10	12			
G.A	R	10	10	10	20	15	20	10	41	18	B
	L	15	10	10	10	15	15	12			
KO.A	R	10	10	10	25	25	25	10	48	15	C
	L	15	10	20	25	25	15	15			
E.Y.L	R	15	10	10	15	15	30	12	39	6	C
	L	20	15	15	15	25	20	17			
E.P	R	20	15	20	45	65	40	18	53	18	D
	L	15	20	35	45	45	15	23			
S.M	R	15	15	20	15	30	25	17	40	20	D
	L	15	15	20	20	30	20	17			
SA.A	R	15	15	30	65	60	50	20	58	13	D
	L	10	15	30	50	50	40	18			
J.K.O	R	20	20	20	25	40	35	20	48	19	D
	L	20	20	25	30	35	35	22			
JO.A	R	10	15	65	65	70	85	28	43	17	D
	L	15	35	65	60	65	75	38			
D.N.P	R	15	15	30	30	35	45	20	58	17	D
	L	20	15	30	30	30	35	22			
D.Q	R	15	10	10	15	20	25	12	40	6	D
	L	20	20	25	25	35	20	22			
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	L	20	15	20	25	35	25	18			

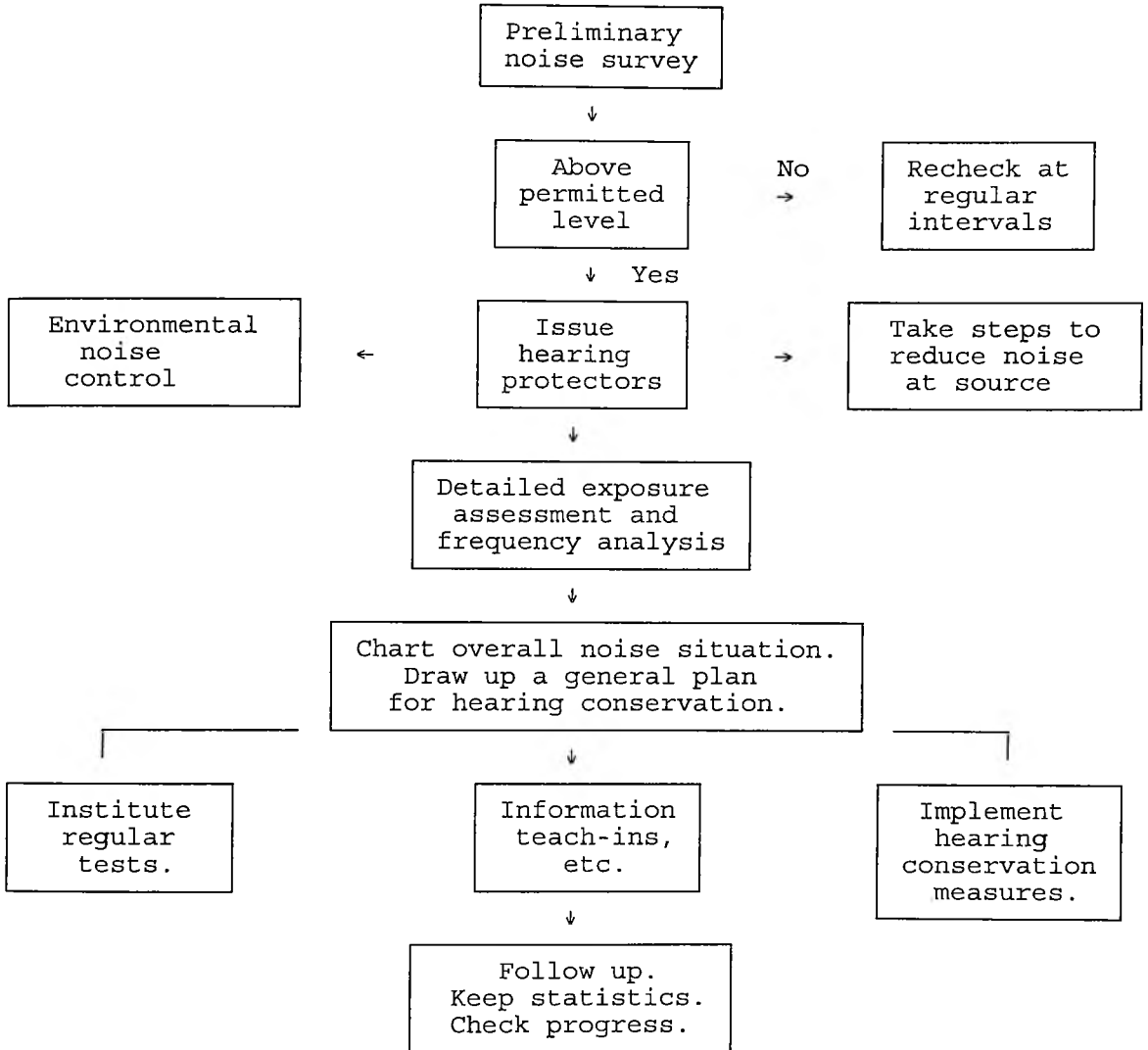
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A.T	R	20	20	35	35	45	40	25	55	24	D
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	R										
	L										
MECHANICAL WORKSHOP	R										
	L										
P.R.W.A	R	10	10	10	15	5	30	10	41	15	A
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W.E.E	R	25	25	25	25	20	25	25	34	11	B
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AL.B	R	15	15	15	15	20	10	15	34	4	C
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G.W	R	15	15	10	25	25	30	13	39	16	C
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E.O.B	R	20	20	25	25	25	20	22	36	12	C
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AK.T	R	15	10	20	15	20	30	15	41	13 / 12	C
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	L	15	15	20	25	30	25	17			
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	L	10	10	30	35	35	25	17			
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	L	15	15	30	35	30	40	20			
E.Z	R	20	20	15	20	30	20	18	30	7	D
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D.A.A	R	20	15	20	30	30	25	18	59	18	D
	L	20	20	25	35	35	25	22			
	R										
	L										
<u>ADMINISTRATION</u>	R										
	L										
D.A.AY	R	15	15	15	20	20	25	15	44	13	B
	L	15	20	20	15	15	15	18			

G.T	R	20	15	20	20	15	30	18	52	13	B
	L	15	15	20	20	20	30	17			
S.V.O.Q	R	10	15	15	15	15	15	13	48	10	B
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TH.A	R	10	10	20	20	20	25	13	45	20	B
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J.K.A	R	20	25	30	25	20	30	25	45	10	B
	L	20	25	30	25	20	35	25			
S.B.O	R	20	20	20	20	25	20	20	47	28	C
	L	25	20	15	25	20	25	20			
A.K	R	15	10	15	20	15	25	13	49	14	C
	L	20	25	20	20	25	35	22			
P.K.B	R	20	20	45	55	45	40	28	47	15	D
	L	30	30	50	60	55	50	37			

ANNEX 3A

FLOW CHART OF SYSTEMATIC APPROACH TO HEARING  
CONSERVATION PROGRAMME IN INDUSTRY



ANNEX 3B

NOISE SURVEY CHECKLIST

1. Measure noise exposure levels for
  - factory premises
  - boilerhouses, generator
  - vehicle yards, goods handling areas  
vehicle, truck and machine cabs  
packing plants
  - offices with noisy equipment (line printers, etc.)  
mobile workers entering noise areas from time to time  
mobile workers using noisy equipment (drills, etc.).
2. List areas of
  - hearing hazard (noise level > 85 db (A) or statutory limit)
3. Issue personal dosimeters to employees exposed to
  - intermittent noise
  - varying levels of noise  
to obtain data for calculation of equivalent continuous  
noise exposure levels.

## NOISE SUPPRESSION CHECKLIST

1. Identify and list  
    individual noise sources.  
    noise transmission paths from source to surroundings.
  
2. Investigate feasibility of suppression noise at source by  
    replacing noisy equipment with new, quieter  
    alternatives  
    fitting quieter moving parts  
    fitting noise-absorbent linings
  - fitting anti-vibration mounts
  - instituting tighter maintenance schedules.
  - enclosing or screening noisy equipment.
  
3. Investigate feasibility of reducing noise exposure by
  - sound absorbent wall and ceiling materials
  - baffles plates and screens.
  
4. Investigate feasibility of reducing noise exposure by
  - constructing insulated control booths for machine operators.
  - relocating workplaces farther from noise sources (remote control)
  - changing job schedules
  - rotating personnel.
  
5. Establish priorities for measures that can achieve  
    significant noise reduction in a short time at  
    relatively low cost.
  - major noise reduction but only with substantial  
    input of time, effort and money.
  - marginal improvement only.

## HEARING PROTECTOR SELECTION CHECKLIST

1. All protectors must be

- able to assure adequate attenuation at all sound frequencies to which the wearer will be exposed (check supplier's literature and packages for attenuation spectrum tables).
- comfortable enough to be accepted and actually worn at all times of exposure to noise.

2. Disposable ear plugs should be

- soft and compressible enough to fit any ear without discomfort and without having to be moulded or rolled between the fingers.
- easy and quick to insert without holding in place.
- hygienic to insert without the need to reshape with fingers that could transfer foreign substances into the ear canal.
- available in a suitable range of packing: dispensers for issue at entrances to noise areas, sealed pocket packs for people who need to carry them around.

3. Reusable ear plugs should be

- available in a choice of sizes to ensure a good fit in all ears.
- resilient enough to fit securely without risk of falling out (and preferably provided with safety cords).
- washable and non-allergenic.

4. Ear muffs should be

- durable with non-deformable headbands.
- designed with flexible cup attachments to fit any size or shape of head.
- provide with resilient, hygienic, easily replaceable cushions.

5. Ear muffs for helmet mounting should also be

provided with adapters that fit the type of helmet normally worn and can preferably also be used for attachment of face protection if required.

- easy to move to an out-of-the way storage or rest position and simple to return to the protection position without removing the helmet.

## LAUNCH CHECKLIST

### 1. Write an outline company policy

- delineate responsibilities.
- give a time scale of exposure to noise.

### 2. Materials

- Order hearing protectors.
- Order motivational materials (posters, films booklets)

### 3. Information

Organize lectures/demonstrations/film showings for all employees not only those directly exposed to noise in their daily work. (It carries more clout if you can bring in an outside expert to do the talking.)

- Put up posters, distribute literature.
- Organize special briefings for 'pressure groups':
  - top management
  - production management
  - building and machine maintenance management
  - personnel management
  - medical and nursing staff
  - supervisors and foremen
  - Trade Union leaders and safety reps.
- Consider, if feasible, a system of bonuses/penalties for wearing/not wearing hearing protectors.

### 4. Distribution

- Set up a scheme for issuing hearing protectors.
- Establish who is responsible for issuing ear muff spares and refilling ear plug dispensers of head.

## FOLLOW-UP CHECKLIST

### 1. Hearing protectors

- Check regularly that hearing protectors are available to all who need them.  
Review suitability and user acceptability of types in use from time to time.

### 2. Compliance

Check regularly that hearing protectors are worn by all who need them.

### 3. Noise abatement measures

Repeat the noise environment survey at regular intervals.

- Check all new machinery from the point of view of potential noise hazard.

### 4. Information

- Establish routines for education of new employees.
- Renew displays of motivational material from time to time.
- Keep issuing reminders.

### AUDIOMETRIC TESTING CHECKLIST

- Organize facilities for testing.
- Arrange with consultants or have in-house personnel (e.g. nursing staff) trained to run tests.  
Have all new employees tested on recruitment.
- List employees working in noise hazard areas who should be tested regularly.
- if feasible, arrange annual test schedule for other employees too.

### CAMPAIGN ASSESSMENT CHECKLIST

#### 1. **Employees hearing condition status**

Keep records of compliance with hearing protection rules.

Keep records of audiometric tests.

Institute an alarm system to detect cases of progressive hearing loss. Transfer the individuals concerned to less exposed workplaces or start frequent hearing tests on them to check that they are using their hearing protectors effectively.

- Check trend in hearing loss (allowing for age).

#### 2. **In-plant noise status**

- Check progress of measures to reduce emission/transmission of noise.
- Recheck sound levels periodically; be alert for new problems areas.  
Keep records.

#### 3. **Reporting**

- Review hearing protection and noise control records annually.  
Plot trends and compare with sickness and absenteeism statistics.  
Report results to management.  
Inform personnel of results.  
Make recommendations for new, modified or intensified campaigns if judged necessary.