OCCUPATIONAL SAFETY AND HEALTH STATUS OF JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY: A CASE STUDY OF ENGINEERING WORKSHOPS

DANIEL OMONDI ONYANGO

MASTER OF SCIENCE

(Occupational Safety and Health)

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Occupational safety and health status of Jomo Kenyatta University of Agriculture and Technology: A case study of Engineering Workshops

Daniel Omondi Onyango

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

Signature: ……………………………………… Date: ……………………….

Daniel Omondi Onyango

This thesis has been submitted for examination with our approval as University Supervisors.

1. Signature: ……………………………… Date: ……………………….

Prof. (Eng.) Abel N. Mayaka

MOI UNIVERSITY, Kenya

2. Signature: ……………………………… Date: ……………………….

Mrs. Margaret Gichuhi

JKUAT, Kenya

DEDICATION

This thesis is dedicated to my mother, Margaret Atieno Onyango, dear wife Roseline Adhiambo Atieno, and loving children Sharon Awino, Rowland Oduor and Kelvin Ochien'g for their prayers, support and understanding during the course of this work.

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LIST OF ABBREVIATIONS AND SYMBOLS

APHA	American Public Health Association
ACGIH	American Conference of Governmental Industrial Hygienists
BNEL	Basic Noise Exposure level
BNL	Background Noise Level
CPE	Collective Protective Equipment
COPD	Chronic Obstructive Pulmonary Disease
dB	Decibels
dB(A)	A-weighted average decibel
DOSHS	Directorate of Occupational Safety and Health Services
EPA	Environmental Protection Agency
GOK	Government of Kenya
IES NA	Illumination Engineering Society – North America
ILO	International Labour Organization
ISO	International Organization for Standardization
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KEBS	Kenya Bureau of Standards
MOL	Ministry of Labour
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Agency
OS&H	Occupational Safety and Health

PEP	Program Evaluation Profile
PPE	Personal Protective Equipment
SC	Sound Characteristics
SN	Sources of Noise
SPR	Source, Path, Receiver
S&H	Safety and Health
TL	Transmission Loss (dB)
TLV	Threshold Limiting Value
c	Speed of sound in air (ms^{-1})
f	Frequency (Hz)
m	Superficial mass of partition (kg)
ρ_a	Density of air (kgm^{-2})
θ	Angle of incident sound (degrees)
ω	Superficial weight of sound barrier (kgm^{-2})

ABSTRACT

Indicators of safety and health at work provide the framework for assessing extents to which workers are protected from work-related hazards and risks. These include indicators of outcome, capacity, capability, and activities. This research aimed at evaluating the occupational safety and health status of Engineering Workshops of Jomo Kenyatta University of Agriculture and Technology. The objectives of the study were to identify and evaluate significant hazards and establish their association with the safety management system. The methodology used involved literature review, fieldwork, and analysis of research findings. The fieldwork involved data collection using questionnaires, physical inspections, interviews, program evaluation profile and site measurement of major hazards within Engineering Workshops.

Research findings showed that the management system was at developmental stage, noise levels in classrooms were above 50dB(A) compared to recommended 35dB(A), while noise mapping around the standby generator gave an average of 79.7dB(A) against recommended 55dB(A). Dust levels were 17.7mg/m^3 and 19.1mg/m^3 for respirable and environmental, which were above recommended values of 5mg/m^3 and 10 mg/m^3 respectively. Lighting was less than 750lux in marking out areas while classrooms experienced disability glare at above 1000lux.

From the results, it was deduced that the state of occupational safety and health management system predisposed workers to adverse hazards. It was

recommended that an evaluation be made of the entire university to establish the overall status in order to develop uniform safety policies for the entire university.

CHAPTER 1

1.0 INTRODUCTION

Changes in the world of work have created new risks arising from the use of new technologies and new patterns of work (Tayyari and Smith, 1997). These changes demand that organizations adopt best practice principles and new strategies for the effective management of safety and health risks.

As a result of numerous industrial accidents that lead to loss of life and property (Reese, 2003), a lot of work has been done to develop systems to protect workers against work-related sicknesses, disease and injury (ILO-OSH, 2001). This put a lot of pressure on manufacturing industries as is evident from a number of conventions developed in conjunction with labour organizations, and occupational safety and health acts in different countries.

Very little considerations have been made for non-industrial type workplaces as far as occupational safety and health of workers is concerned. Literature relating to research on workers' safety and health especially in universities as workplaces and institutions of higher learning is very scanty and thus the need to carry out this study. Universities are generally expected to carry out training, research and innovation to improve humanity and generate knowledge. In the process, hazards and hazardous situations develop which if not controlled may lead to loss of life, human and capital resources.

Some of the technological developments emanating from university research such as the use of nano-particles for manufacturing may be fatal if safety considerations are not part of the research (Gwinn and Vallyathan, 2006).

1.1 Problem Statement

Underdeveloped safety management systems results in escalation of hazards and hazardous situations that adversely affects occupational hygiene. In the Engineering Workshops, there are no properly defined safety management structures that would ensure safe working environment devoid of accidents and incidents. Further, lack of documentation on issues related to workplace accidents points to the fact that it becomes difficult to control dangerous or potentially dangerous situations that have not been measured. The problem is worsened by lack of budget, trained personnel and follow-up audits to ensure compliance with safety standards.

1.2 Objectives

1.2.1 General Objective

- To establish the association between the occupational safety and health management system at Jomo Kenyatta University of Agriculture and Technology and the existence of adverse situations and hazards injurious to health.

1.2.2 Specific Objectives

1. To identify and document major hazards and their causes at the Engineering Workshops at Jomo Kenyatta University of Agriculture and Technology.

2. To determine the magnitude of the significant hazards and estimate their impact to health.
3. To evaluate the organization and management of occupational safety and health system at the Engineering Workshops at Jomo Kenyatta University of Agriculture and Technology.

1.3 Hypotheses

Null hypothesis

- Current occupational safety and health management system does not influence the levels of hazards and hazardous situations at Jomo Kenyatta University of Agriculture and Technology

Alternative hypothesis

- Current occupational safety and health management system does influence the levels of hazards and hazardous situations at Jomo Kenyatta University of Agriculture and Technology

1.4 Research Questions

This research sought to provide answers to the following questions;

a. What hazards exist in the study area?
b. How significant are the hazards identified?
c. Where are the locations of the significant hazards?
d. Is the current occupational safety and health management system able to reduce the significant hazards to acceptable levels?

1.5 Significance of Study

The study would be useful in laying the foundation for further studies and improvement in management of issues relating to Safety and Health at Jomo Kenyatta university of Agriculture and Technology by modeling workplace hazards, accidents, incidences and occupational safety and health management systems. Results obtained from this work will form a basis for development of uniform evaluation criteria that could be applicable to the rest of the universities.

In the short term, the study would be useful in protection of the environment in terms of air pollution and destruction of vegetation, and protection of workers who are likely to be adversely affected with the current status of occupational safety and health.

1.6 Conceptual Framework

An important consideration in conceptualizing an approach to occupational health and safety is an understanding of the many various personnel and workplace factors that interact to cause exposures and accidents. Any strategy to control these exposures and accidents should consider a range of factors and their influences on each other. Salvendy (1982) proposed a model of human – workplace interaction as shown in Figure 1.1.

Elements of this model interact to produce hazardous exposures. Work task assignments give rise to decision to use machines or tools. The different applications of machines or tools expose persons to hazards and hazardous situations. This happens in various ways between the person and the machine or tool, the person and the work task, and between the person, the machine or tool and work task depending on a number of factors that include vulnerability (e.g. education and experience), length of exposure, laws and regulations, the complexity of the machines and work tasks, and the by-products of the work processes.

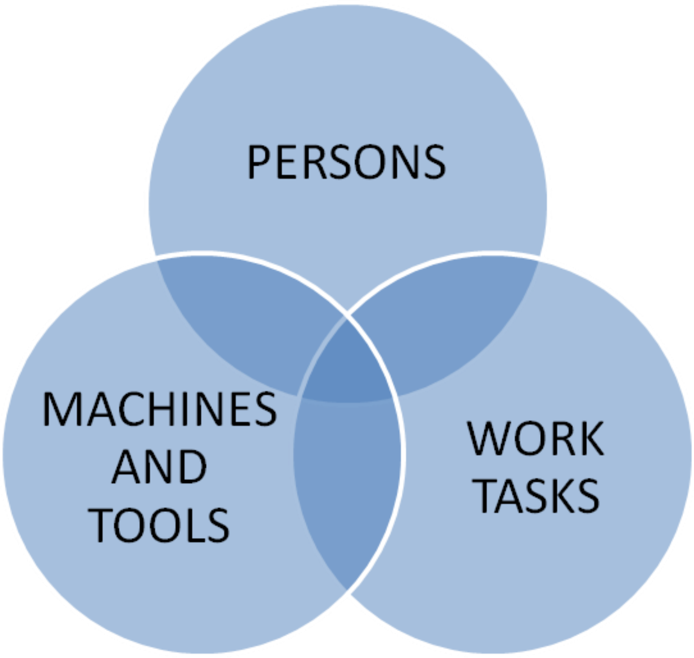

Figure 1.1 Model of employee interaction with machines and tools, and work tasks at the workplace to potentiate or mitigate hazards and hazardous situations

Each one of these factors has specific characteristics that can influence exposure to hazards and accident potential or disease risk. At the same time, each interacts with the other to potentiate or mitigate exposure.

The conceptual framework used in this work was based on Salvendy's (1982) model. It set out to determine potential risks and hazards within the physical work environment. Leading indicators of these risks and hazards were identified and data collected to assess exposure values. The results of analysis of the exposure values were then compared to permissible exposure limits in order to determine the best combination of actions that would constitute the best solution. This is illustrated in Figure 1.2.

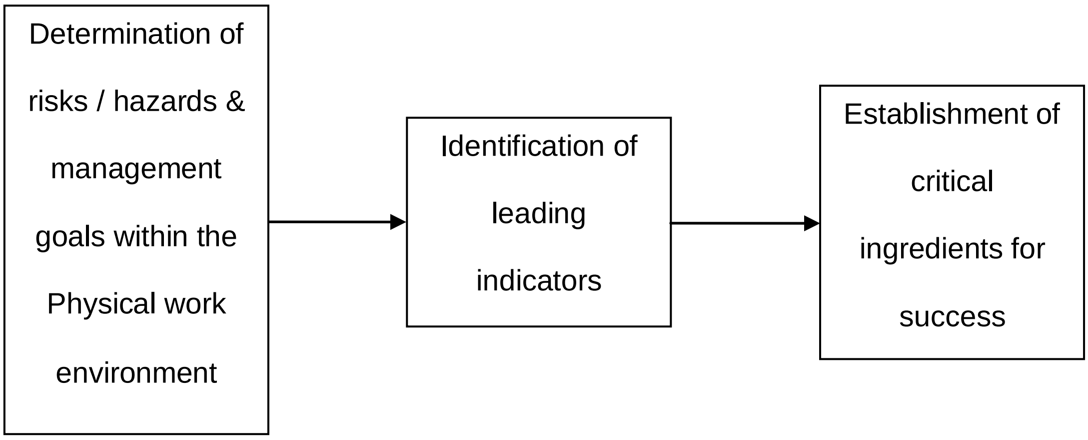

Figure 1.2 Conceptual framework model for the research work

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 Introduction

Indicators for safety and health at work provide the framework for assessing the extent to which workers are protected from work-related hazards and risks. They are used by enterprises, governments and other stakeholders to formulate policies and programs for the prevention of occupational injuries, diseases and deaths as well as to monitor the implementation of these programs, and to signal particular areas of increasing risk such as particular occupation, industry and location (ILO, 2008). These include indicators of outcome such as number of occupational injuries and diseases and number of workers involved, indicators of capacity and capability that is number of inspectors or health professionals dealing with occupational safety and health; and indicators of activities such as number of trainee days and number of inspections (ILO, 2008).

According to the International Labour Organization (ILO) department of statistics, no data was available on Kenyan Education sector regarding rates of occupational injuries that resulted in fatalities, or cases of injury with lost work-days between 1999 and 2008. For the same period of time, Japan registered 70 fatalities with 0.06 injury cases with lost work-days per 1,000,000 hours worked, while Germany had 41 fatalities and 24.82 injury cases with lost work-days per 1,000,000 hours worked. Comparing these with other African countries, Nigeria like Kenya had no data available while South Africa had 1073 fatalities and no data on injury cases with lost work-days. Egypt had 19 fatalities with 9 cases of injury with lost work-days per 1,000,000 hours worked. Most of the other African countries did not have any data on occupational injuries and fatalities (ILO, 2010).

From these statistics, Africa, and in particular Kenya lacks the necessary occupational safety and health data in the education sector which makes it difficult to manage health and safety in institutions of learning due to lack of indicators that would otherwise inform decision making, hence the need for this research. The Health and Safety Executive's (HSE) guide to measuring health and safety performance stresses that measurement is a key step in any management process and forms the basis of continual improvement (HSE, 2001). If measurement is not carried out correctly, the effectiveness of the health and safety management system is undermined and there is no reliable information to inform managers how well the health and safety risks are controlled.

2.2 Models for managing safety and health at work

The work environment is an important determinant of health. It can influence health positively or negatively (Danna and Griffin, 1999). Hazards and hazardous situations exist in all workplaces but these may be reduced to safe levels with proper occupational management systems. Some hazards are introduced by people while more often than not hazards arise from engineering activities such as planning, design, production, operations and maintenance. Several approaches have been developed for recognizing hazards and selecting controls. Brauer (2006) in developing principles of hazard control suggested that one should recognize hazards, define and select preventive actions, assign responsibility for implementing preventive actions and provide a means for measuring effectiveness. He further gave a set of five priorities for selecting controls which included eliminating the hazard, reducing the hazard level, providing safety devices, providing warnings and providing safety procedures (for protecting equipment).

The complex relationships among people, machines, environments and organizations can make hazard control difficult. Using only one means for control may not be sufficient. In the process of hazard recognition and control, one must identify the complexities of contributing elements. One must consider the hazard in their use environment. A number of conceptual models have been proposed to help one think of the many elements that are involved in accidents. One conceptual model is the “four M’s”; man, media (environment), machine and management (Brauer, 2006) illustrated in Figure 2.1.

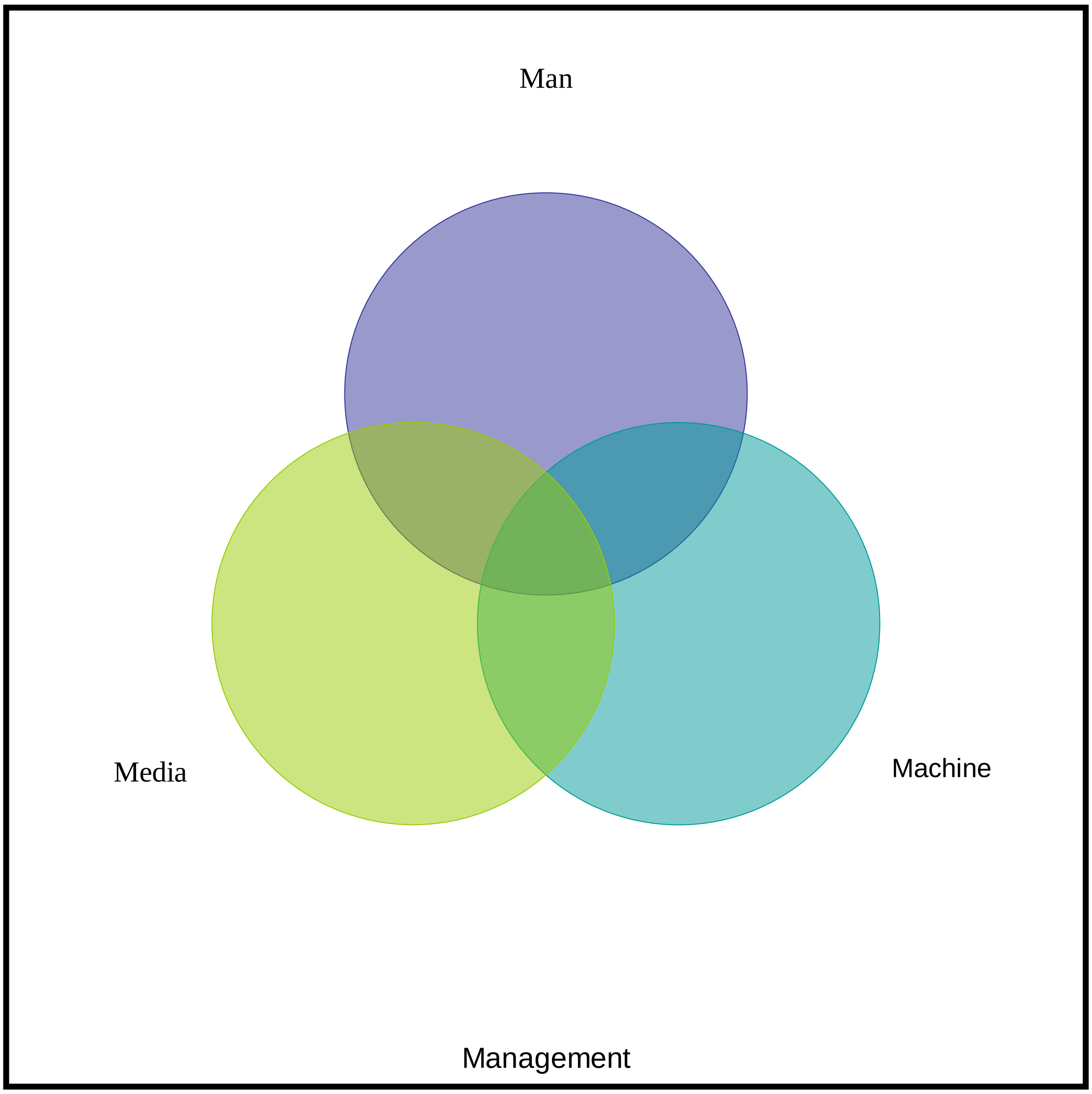

Figure 2.1 Four system safety factors conceptual model indicating the interactions between management, media, man and machine to potentiate or mitigate hazards (Brauer, 2006)

In this model, man interacts with the machine and media (environment) under a management structure to mitigate or potentiate hazards or hazardous situations.

Another important conceptual model is the goal accomplishment model illustrated in Figure 2.2. (Brauer, 2006). This model assumes that people and organizations are goal oriented. The model includes nine factors (Table 2.1) that are typically involved in accomplishing a goal. People perform activities and use equipment to help them achieve goals. People perform activities in some place or facility under constraints of physical, social and regulatory environments. There are time-and-cost limits for the activities. Each of these elements has many characteristics that can affect the achievement of the goal.

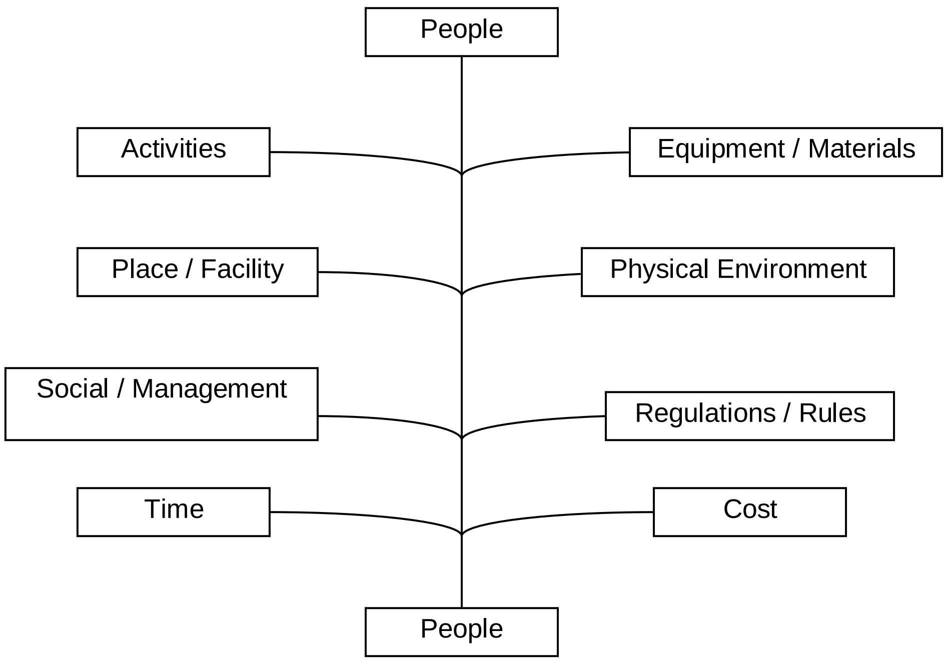

Figure 2.2 A goal accomplishing model for identifying and controlling hazards (Brauer, 2006)

Table 2.1 Factors influencing occurrence of accidents in the goal accomplishment model (Kariuki and Lowe, 2007)

Factor	Typical Characteristics
People	Age, gender, size, strength, training, knowledge, emotion, state of health, culture, attitudes
Activities	Sensory and motor skills, actions taken
Equipment	Machines, vehicles, systems, materials, supplies, containers
Place	Facility, building, land area, road, air space, waterways and characteristics of these
Environment	Thermal, electrical, sound, chemical, illumination, radiological, biological
Social / Management Environment	Organizational and work climate, interpersonal relationships, communication, language
Regulatory / Procedural Environment	Laws, regulations, procedures, policies, work rules and practices, rules of the road, etc (both written and unwritten)
Time	Time available, rates, shifts, work hours, changes in shifts
Costs	Initial cost, operating costs, rent, houses, medical cost, repair cost, replacement costs, demolition or decommissioning costs

Accident theories have been developed to give insight into preventive actions. Lehto and Salvendy, (1991), and Dewees et al. (1996) proposed the idea that many accidents and injuries involve the transfer of energy and using the energy transfer as the accident-injury model, he suggested strategies for preventing or reducing losses. The single factor theory assumes that when one finds a cause, there is nothing more to find out. Single factor theories have limited use in prevention, because contributing factors and corresponding corrective actions will be overlooked. The single factor theory is a very weak tool in the arsenal of accident prevention and safety management.

Multiple factor theories are those in which accidents are deemed to be caused by many factors acting together. The immediate cause may be an unsafe act or an unsafe condition acting alone. In multiple causation theories, factors combine in random or other fashion and cause accidents (Lehto and Salvendy, 1991).

Brauer (2006) presented two approaches (Figure 2.3 and 2.4) for using data from accidents to prevent them from occurring in the future. Regardless of the methods used, the causes of accidents are identified and corrective actions are taken to prevent future accidents of the same type. The strategies are based on frequency, severity and cost. Each has merit, depending on preventive goals.

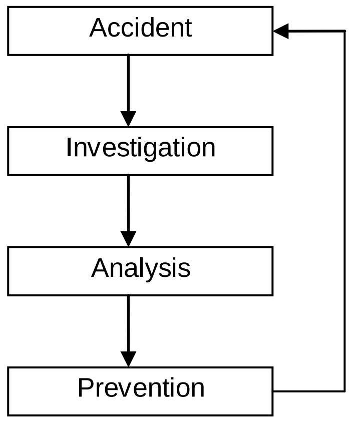

Figure 2.3 A reactive approach for deriving preventive actions from accidents (Brauer, 2006)

The reactive approach requires that at least one accident must occur to identify preventive actions. The other approach is the proactive approach in which the goal is keeping accidents from occurring the first time.

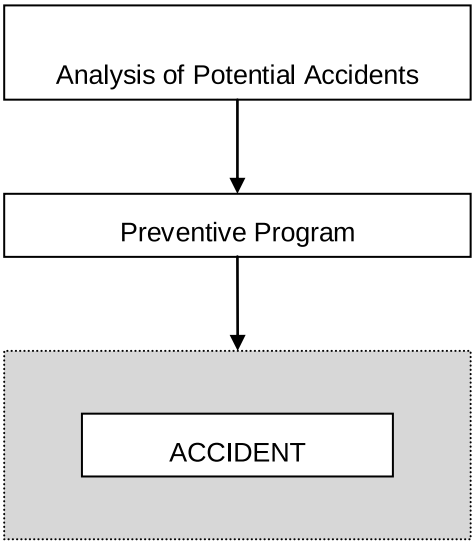

Figure 2.4 A proactive approach for developing preventive actions before accidents occur (Brauer, 2006)

Another concept for selecting preventive actions can be structured around the "three E's of safety": engineering, education and enforcement (Brauer, 2006). Engineering includes such actions as substituting less hazardous materials, reducing the inventories of hazardous materials, modifying processes, designing out hazards, incorporating fail-safe devices, using working devices and prescribing protective equipment. Education includes training people in safe procedures and practices, teaching people how to do a job correctly, how to use a product safely, what hazards exist in a product, process or task and how to take appropriate protective actions. It also involves training engineers about hazard recognition, hazard evaluation, compliance with safety standards and legal responsibilities (Michaels et al., 2007). Enforcement is achieving compliance with state and local laws and regulations, with consensus standards and with company rules and procedures.

What is accepted as safe is not constant or absolute. Each person and society establishes what level of safety and health is acceptable. Every activity has some risk. The level of risk society finds acceptable is a moral issue, not just a technical, economic, political or legal one. As illustrated in Figure 2.5, there is a region of uncertainty between that which is acceptably safe and that which is unacceptably dangerous or unsafe (Fishhoff et al., 1981).

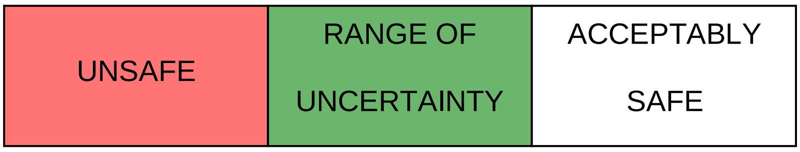

Figure 2.5 Range of uncertainty between unacceptably dangerous and acceptably safe activities (Fishhoff et al., 1981)

Engineers face a dilemma in dealing with this middle region because they cannot depend on their own intuition to decide what is safe enough (Starr et al., 1976). To achieve acceptably safe products and environments, engineers must be able to recognize hazards and apply correct standards of safety found in laws, regulations and meet public expectations.

Management style can affect results of workplace safety and that of related activities. It is not enough to have safety carefully structured into an organization, nor is having policies, procedures, training and specialists enough. The way safety culture is introduced to and developed by the workers can significantly affect their performance. Organizational, management or leadership style strongly influences safety on the job. Making safety part of a supervisor's or manager's performance appraisal is one means of achieving safety in an organization. Levitt (1976) found that top management can affect safety by knowing the safety records of field managers and use this knowledge for promotion and salary increases.

2.3 Hazards at institutions of higher learning in Kenya

There are a number of institutions of higher learning in Kenya. These include six public universities that operate under Acts of parliament that created them, and several private universities granted chatters by the Commission for Higher Education (GOK, 1989). Middle and top level manpower requirements for the industry and other sectors of the economy are provided by these institutions. Some of the training in these institutions includes humanities, sciences, engineering and agriculture that require laboratories and workshops for the training to be effective.

Within these work environments, various hazards exist in the six major classifications that include physical (e.g. noise, dust, lighting), biological (e.g. micro organisms, pathogens), mechanical (e.g. crushing, drawing in, piercing), chemical (e.g. reactive chemicals, reactive solids, heavy metals), physiological (e.g. poor ergonomic design), and psychological (e.g. gender harassment, age, work pressure). During the course of teaching and learning, both the lecturers and the students and other staffs involved are predisposed to these hazards that may affect their health. Some of the hazards may have long-term effects to health while others may have an immediate impact depending on the concentration and length of exposure.

The Occupational Safety and Health Act (2007) places the greatest responsibility of ensuring safe workplaces on the occupier (GOK, 2006). According to the Act, the occupier is mandated to register the workplace with the Directorate of Occupational Safety Health and Services (DOSHS), cause to be carried out safety audits and risk assessments, report any occupational accidents to the directorate and provide measures to keep the workplace and those employed safe at all times.

2.4 Noise at Workplaces

Noise-induced hearing loss has been recognized as “the most prevalent, irreversible industrial disease” (Swuste, 2007). Actually noise at work can cost much more than hearing loss (Clark and Bohne, 1999). It can be a causal factor in accidents, contribute to work-related stress, and may act together with other workplace hazards to cause ill health (Denison, 2005).

In the Global burden of disease (WHO, 1999) between occupational factors noise-induced hearing loss ranks second (16%) after low back pain (37%), but before chronic obstructive pulmonary diseases (COPD) (13%), asthma (11%), traumatic injuries (10%), lung cancer (9%) and leukemia (2%). These data testify to the significance of noise hazard for workers and the whole population.

Noise causes severe health hazards (Burns and Lippincott, 2008). Such effects may be physical or mental, which would have long term consequences on communication, working efficiency, personal comfort and can lead to industrial accidents. The physical health problem may be acute or chronic (Henderson and Hamernik, 1995). The acute effects depend upon frequency. 120 – 150dB noise can cause permanent deafness. If a person is exposed to 90 dB noise for 40 hours a week for say 30 years, he is bound to be deaf at the end of his career. A low level noise causes nausea, loss of physical control and physiological changes caused by stress.

The important chronic effect is loss of hearing. The loss starts at a frequency of 4000 Hz, with more damage done by sudden impulsive noises. The noise causes prolonged loss of sleep. The mental effect causes lack of concentration and mental disorientation (Sharit and Salvendy, 1982). Regarding communication, noise interferes with communicability and causes proneness to commit error in judgment (Cohen and Weinston, 1981). The personal comfort no doubt gets affected, destroying peaceful life and enjoyment of leisure. It contracts blood vessels, thereby supplying less blood to the heart and brain. It causes digestive disorder due to hyperacidity (Dijk, 1987).

An impulsive noise is much more dangerous than a continuous noise. A sudden noise generated with high pitch or intensity but with a life-time of less than one second is called an impulse. An unexpected thud of sound with a short life has high impulse and is dangerous.

Noise is classified based on the sound level, frequency, duration and distribution over a given area. It may be characterized as wide band with continuous spectrum and with a width more than one octave, or as scattered spectrum with defined discrete tones. Noise may also be rated as constant noise for eight working hours per day (working shift) fluctuating with time by or less than five (5) dB(A), or irregular noise for eight working hours per day (working shift) fluctuating with time more than five (5) dB(A) (Shaikh, 1999).

The characteristics of a constant noise at the working place is the level of sound intensity in decibel in octave bands with average geometrical frequency of 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz, calculated from the following expression (Berger et al., 2003).

$$L_p = 20\log_{10}\left(P/P_o \right) \quad = \quad [dB] \ldots\ldots\ldots(1)$$

where, P is the average quadratic value of sound density in N/m^2, and P_o is the source value of sound density in air, ($P_o = 2 \times 10^{-5}$ Pa)

The characteristics of fluctuating noise at the work place is the integrated parameter of equivalent in energy of noise level in dB(A) and is defined by equation (2)

$$L_p = 20log_{10}\left(\frac{P_A}{P_O}\right) [dB(A)] \qquad (2)$$

where, P_A is the effective value of noise intensity with the consideration of correction “A” of noise level meter in N/m^2.

The other methodology for estimating the noise levels in other similar work places is by taking a number of representative noise sample measurements and arithmetical average value as the nominal exposure level. This average is the Background Noise Level (BNL). The Basic Noise Exposure level

(BNEL) is the background Noise level multiplied by the duration in hours of the exposure to the background noise. The BNEL is calculated from equation (3),

$$BNEL \quad = \quad BNL + 10\log_{10}\left\{ T/8 \right\} \quad = \quad [dB] \qquad (3)$$

where BNL is the average of the sampled background noise levels in the working environment; and T is the total exposure time in hours over the work shift;

The division by eight (8) normalizes the BNEL to an equivalent $L_{Aeq,\,8h}$. If a particular individual carries out a task that increases the total noise exposure by a significant degree then this added exposure is included. It is suggested that the overall exposure ($L_{Aeq,\,8h}$) should be increased by at least 3 dB (i.e. doubling the exposure) if the particular activity is to be included. The choice of an increase of a minimum of 3dB has been selected because a doubling of exposure is a significant increase and because measurements less than this are in the order of magnitude of the expected measurement error. Other significant sources of noise are included in the summation by use of equation (4) (Berger et al., 2003).

$$BNEL = 10\log_{10}\left[\left\{ \sum i \left(Ti\,x10^{0.1\left(L_{Aeq,Ti}\right)} \right) \right\} / T \right] \; + \; 10\log_{10}\left(T/8 \right) \qquad (4)$$

where

$L_{Aeq,\,Ti}$ is the noise level of the particular task;

T_i is the duration in hours of the individual noise source(s) including the BNL;

T is the total noise exposure time in hours (the sum of the T_i).

For the majority of large and medium sized workplaces there will only be the background noise with occasionally one or perhaps two significant extra noise sources. For small sized workplaces there will be a low BNL but this will usually be relatively unimportant compared to individual significant noise sources that provide the majority of the workplace noise hazard (Vihma and Nurminen, 1983).

Take for example a large production line. For individual machine operators or process workers on the line, their noise hazard will come directly from the line as their job tasks do not include any operations away from the production line. In a small manufacturing workshop however, the main background noise will come from the ever present radio and the occasional noise from specialized (noisy) tasks by other workers, perhaps some metal grinding or hammering. Thus for estimating the exposure hazard in the first case equation (3) will suffice while in the second case equation (4) will be required (Berger et al., 2003).

The BNEL could be expected to provide reasonable results for large and medium sized work places and for small sized workplaces perhaps with some modification as necessary. Note that the BNEL is an A-weighted dB value.

Most small workplaces that are noisy typically have a single workshop area where noisy functions are performed and they are not usually performed on a continuous basis. Thus if a longer term background noise level was measured, for example for 30 minutes, this could represent a starting point. If there are particularly noisy activities undertaken that could add significantly to the daily noise exposure by at least 3 dB these must be included (Vihma and Nurminen, 1983).

Permissible level of noise intensity in octave band of frequency, noise level and equivalent noise level at the workplace in a production environment and within the territory of an industry is summarized in Table 2.2.

Table 2.2 Permissible level of noise and equivalent noise level at the workplace in a production environment

S. No.	Type of workplace	Level of Sound Density in dB in Octave Band with Average Geometrical Frequency, Hz									Equivalent Sound Level dB(A)
		31.5	63	125	250	500	1000	2000	4000	8000	
1.	Art work, supervision with high concentration, scientific design and construction works, programming, teaching and studying rooms, medical works, working offices for director, at the hospitals and clinics etc.	86	71	61	54	49	45	42	40	38	50
2.	Highly qualified jobs demanding concentration administration works measuring and analysis laboratories, control room in the workshops , laboratories	93	79	70	63	58	55	52	50	49	60

3.	Operators' works, working place at the dispatch machine rooms, room for supervisors, and computer rooms	96	83	74	68	63	60	57	55	54	65
4.	Work in workshops requiring concentration work, concentrated work process monitoring and remote control in laboratory with noisy machines	103	91	83	77	73	70	68	66	64	75
5.	Performing all types of works (excluding the ones above under 1 – 4 and similar to them) at constant place of work in production environment and within the industry	107	95	87	82	78	75	73	71	69	80
6.	Note: It is allowed in cases characterized by high levels of noise that requires the use of special safety measure in reducing it	110	99	92	86	83	80	78	76	74	85

For the purpose of improving the conditions of work it is necessary to reduce the levels of noise for different types of work (professions) considering the category of loading and stresses of work (Miranda et al., 2002). The recommended loading is given in the table below.

Table 2.3 Categories of stress and loading of workers for different types of work (Miranda et al., 2002)

Category of stress of work	Category of loading (% of muscles used)			
	High I	Medium II	Heavy III	Very heavy IV
Less stress I	80	80	75	75
Average stress II	70	70	65	65
Stressed III	60	60	-	-
Very much stressed IV	50	50	-	-

The quantitative evaluation of loading and stress is based on muscle loading (dynamic and static loading) and neural loading.

Table 2.4 Sound levels resulting from various activities

Activity	**Sound level**
Hearing threshold	10dB(A)
Whisper	20 dB(A)
Office (Average)	55 dB(A)
Power saw	90 dB(A)
Chain saw	90 dB(A)
Textile loom	103 dB(A)
Lawn mower	92 dB(A)
Power drill	100 dB(A)
Circular saw	115 dB(A)
Metal cutting machines	90 – 110 dB(A)
Hammer mills	95 – 100 dB(A)
Fettling	over 100 dB(A)

Allowable noise exposure levels vary widely depending on the receiver situation. If one tries to sleep in a very quiet country environment, a dripping faucet or noise from a cricket could be intolerable. In the United States of America (and in most other industrialized nations), the Occupational Safety and Health Agency (OSHA) and the Environmental Protection Agency (EPA) have set limits on allowable noise exposure levels. Based on considerable research, these limits are generally indicative of the levels at which hearing loss will likely occur, or at which the noise will mask warning sounds (Azizi, 2010). Primarily these are safety limits; annoyance limits are substantially lower.

OSHA establishes the periods of time to which an individual may be exposed to different levels in excess of 90 dB(A) – Table 2.5 below. If a worker is exposed to several different noise levels during an 8-hour work day, the accumulative exposure for the day must be calculated or measured by a dosimeter (i.e. a cumulative measure of noise levels over time). Note that the OSHA limit is in effect 85 dB(A) for 8-hours to have audiometric testing on yearly basis.

Table 2.5 Allowable OSHA noise exposure levels (Harris, 1991)

Noise Level dB(A)	Allowable daily exposure
85	8 hours
Audiometric testing of workers required	
90	8 hours
92	6 hours
95	4 hours
97	3 hours
100	2 hours
102	1.5 hours
105	1 hour
110	0.5 hours
120	1 minute or less

Noise exposures that exceed the criteria established by OSHA must be reduced below these limits to be in compliance. The methodology for reducing the noise may be "Engineering Controls" or "Management Controls". "Temporary Measures" such as personal ear protectors may be employed under certain circumstances for limited periods until engineering or management controls are implemented or in cases where there are no other practical methods. Engineering controls are the most common technique.

Sound pressure level is a logarithmic quantity expressed in decibels (dB). It is related to the intensity or loudness of the sound. Table 2.6 lists typical sound pressure levels.

Table 2.6 Typical sound pressure levels for different noise sources (Harris, 1991)

Sound source or environment	**Decibels(dB)**	**Listener's perception**
Jet aircraft at takeoff	120	Threshold of pain
Boiler factory	110	Deafening
Noisy factory, loud street	90	Very loud
Noisy office, average factory	70	Loud
Average office, noisy home	50	Moderate
Private office, quite conversation	30	Faint
Whisper	10	Very Faint

2.4.1 Protection facilities and methods of protection against noise

A noise hazard has three parts; the source, the path, and the receiver. There are three basic elements to be considered in controlling noise. These include controlling or attenuating noise at its source, controlling or attenuating noise along its path from source to listener, and controlling or attenuating noise at the receiver (listener). Thus, in industrial noise control, reference is made to SPR (Source, Path, Receiver) control. Any noise control problem may require that one, two or all three of these basic control elements be taken into consideration (Fahy et. al., 2002).

Firstly, to controlling noise at source may involve enclosing the source, altering acoustic design, substituting equipment, making alterations to existing equipment, or changing the process. The noise can be selected, redesigned or modified to operate more quietly, and / or resiliently supported to prevent the transmission of vibration. Secondly, to control noise along its path may involve increasing the distance from the receiver or improving acoustic design of the path. Sound energy can be absorbed by a porous acoustical material, or blocked along its path. Thirdly, controlling noise at the receiver may call for enclosure of the worker, use of Personal Protective Equipment (PPE) and Collective Protective Equipment (CPE), or changing job schedules. In this case, sound energy can be confined to, or excluded from, an enclosure.

2.4.2 Sound barrier materials and systems

A wall or heavy enclosure can serve as a very effective barrier against airborne sound transmission. While any surface will reflect some of the sound which reaches it, only heavy, acoustically designed materials and systems with airtight surfaces are significantly effective in “stopping” sound. The effectiveness of a barrier depends on the weight, stiffness, mounting, damping, the use of single or multiple panels, the spacing of these panels, and the use of absorptive material in the cavities.

The function of a sound barrier is to provide a means of maintaining a difference in sound level between spaces. If a high level, say 60 dB, exists on one side of a wall, while an acceptable level on the opposite side is not more than 20 dB, the wall must provide at least 40 dB isolation or noise reduction (also called sound transmission loss) to keep out the intruding sound. If the wall provides 40 dB of noise reduction, the intruding sound will be at a level of 20 dB or 5 dB below a receiving room ambient sound level of 25 dB. A barrier that reduces the sound source to a level that is lower than the existing ambient level in the receiving room will not be heard (e.g. the level is said to have a zero (0) signal to noise ratio if intruding sounds are masked by the background sounds. By contrast, source sounds that are well above the background noise are clearly heard and have a positive signal to noise ratio). Thus, a sound barrier, be it a wall, floor, or partition, should provide enough noise reduction or sound transmission loss to keep intruding sound below the desired level in the space it is protecting.

When a sound wave strikes a barrier, the barrier is set into motion. The barrier then becomes a sound source and sets into motion the air on the other side. Some of the energy is reflected back towards the source, and some is lost in moving the partition.

2.4.3 Sound transmission loss

Sound transmission loss is an inherent characteristic of a barrier and is essentially independent of the location of the barrier. Since the barrier moves with an oscillating and accelerated motion, it obviously requires force to initiate and sustain the motion. The partition has mass; it is accelerated by the force or pressure of the impinging sound wave. Therefore, it is possible to analyze its motion mathematically (Yahya, 2009).

If the barrier were a "limp" mass, and moved only back and forth (like the end of a piston), the sound transmission loss for energy randomly incident on the barrier (excluding losses at the edge of the panel and any "leaks") would be calculated as;

$$TL = 10\log_{10}\left[1+\frac{\pi f m\cos\theta}{\rho_a c}\right]^2 \qquad (5)$$

where TL	=	Transmission Loss (dB)
f	=	Frequency (Hz)
m	=	superficial mass of the partition (kg)
ρ_a	=	density of air (kg/m^2)
c	=	speed of sound in air (m/s)
π	=	3.14
θ	=	angle of incident sound (degrees)

This equation shows that the transmission loss of a barrier is dependent on the frequency of the sound, the angle of incidence of the sound wave, and mass of the barrier. Note that the Transmission Loss is greatest for sound incident normally on the surface ($\cos 0^0 = 1$) and least for sound impinging on the surface at grazing incidence ($\cos 90^0 = 0$). For most practical applications, the sound is incident over a large range of angles and this equation can be integrated over a range of angles for any given sound situation. Generally, however, one can assume a common range of angles of incidence (e.g. $0^0 – 78^0$), in which case the expression for Transmission Loss reduces to;

$$TL = 20\log(f\,w) - 47.5\,dB \qquad (6)$$

where *f* is the frequency in Hz, and

w is the superficial weight of the barrier in kg/m^2.

From this formula it is easy to recognize that for a doubling of either the frequency or the mass the Transmission Loss will increase 6 dB. This is the well known form of the “mass law”. Unfortunately, few materials or systems of construction conform to mass law principles. Masonry and lead are about the limit. Composite wall systems exhibit a complex sound transmission loss characteristic.

2.4.4 Measurement of noise

The basic measurement instrument in acoustics and noise control is the sound level meter. With a hand-held sound level meter, the overall sound level is measured in accordance with pre-selected weighting networks, i.e. A, B & C. The C scale provides rather flat response from 50 to 5000 Hz, and the A and B scales sharply reduce the incident sound in the frequency range below 1000Hz. The A and B scales follow closely the response characteristics of the human ear and also the rate at which noise-induced hearing loss occurs. As such, all regulatory measurements involving health and safety or the acoustical environment (EPA) are obtained in the A scale mode of operation.

There are several devices that can be used to measure noise. These may include dosimeters and noise level meters. The chief objective of noise measurement is to reduce its level, so as to enjoy it as music, carry out scientific analysis to reduce its annoying effect, to ascertain its capability to cause hearing damage and to serve as powerful diagnostic tool to reduce it.

In order to assess the impact of noise on human health, it is necessary to undertake a survey of noise levels in different parts of a locality (Harris, 1991). To do this sound maps are prepared. The areas which are prone, like dwellings around industrial establishment are selected for sound mapping. Noise topographs are usually obtained by connecting lines drawn between the points of equal sound levels to exhibit sound distribution patterns. A topograph indicates zones of noise danger and is a first step to mitigate or abate sound nuisance.

Noise measurement may also be categorized into two – short-term and long term measurements (Wong and Mak, 1985). Short term measurements include assessment of day-time noise levels in various locations, chosen because of their established characteristics and nature. Due to the varying noise levels over the day, the measurements should ideally be conducted to reflect temporal changes. Long-term noise measurements are usually statistically analyzed in problem areas over 24-hour periods to quantify the temporal effects.

It is recommended for proper assessment of the status of noise and vibration management for a given environment to use a questionnaire (Appendix A5).

2.5 Air Pollution at Workplaces

Air pollution involves any atmospheric condition in which certain substances are present in such concentrations that they can produce undesirable effects on man and his environment (Rao, 1995). These substances include gases (sulphur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons), particulate matter (smoke, dust, fumes, and aerosols), radioactive materials and others. Most of these substances are naturally present in the atmosphere in low concentrations and are usually considered to be harmless.

Pollutants are usually divided into two categories, that is, primary and secondary (Godish, 2004). The primary pollutants are those that are emitted directly from the sources, and include particulate matter such as ash, smoke, dust, fumes, mist and spray; inorganic gases such as sulphur dioxide, hydrogen sulphide, nitric oxide, ammonia, carbon monoxide, carbon dioxide and hydrogen fluoride; olefinic and aromatic hydrocarbons; and radioactive compounds. The secondary pollutants are those that are formed in the atmosphere by chemical interactions among primary pollutants and normal atmospheric constituents.

Of the large number of primary pollutants emitted into the atmosphere, only a few are present in sufficient concentrations to be of immediate concern (Godish, 2004). These are the five major types – particulate matter, sulphur oxides, oxides of nitrogen, carbon monoxide, and hydrocarbons. Carbon dioxide is generally not considered an air pollutant, but because of its increased global background concentration, its influence on global climatic patterns is of great concern.

2.5.1 Properties of air pollutants

Pollutants can be suspended droplets or solid particles or mixtures of the two. Particulates can be composed of inert or extremely reactive materials ranging in size from 100µm to 0.1µm and less. The inert materials do not react readily with the environment nor do they exhibit any morphological changes as a result of combustion or any other process, whereas the reactive materials could be further oxidized or may react chemically with the environment.

Particulates may be in form of dust, smoke, fumes, mist, fog, or aerosols. Dust contains particles of the size range from 1 to 200µm. These are formed by natural disintegration of rock and soil or by the mechanical processes of grinding and spraying. They have large settling velocities and are removed from the air by gravity and other inertial processes. Fine dust particles act as centres of catalysis for many of the chemical reactions taking place in the atmosphere.

Smoke contains fine particles of the size range from 0.01 to 1µm which can be liquid or solid, and are formed by combustion or other chemical processes. Smoke may have different colours depending on the nature of material burnt. Fumes are solid particles of the size range from 0.1 to 1µm and are normally released from chemical or metallurgical processes. Mist is made up of liquid droplets generally smaller than 10µm which are formed by condensation in the atmosphere or are released from industrial operations. Fog is mist in which the liquid is water and is sufficiently dense to obscure vision. Aerosols include all airborne suspensions either solid or liquid; these are generally smaller than 1µm.

Particles in the size range of 1 to 10µm have measurable settling velocities but are readily stirred by air movements, whereas particles of size 0.1 - 1µm have small settling velocities. Those below 0.1µm – a submicroscopic size found in urban air – undergo random Brownian motion resulting from collisions among individual molecules.

The chemical composition of particulate pollutants varies over a wide range. The actual composition is very much dependent upon the origin of the particulate (Friedlander, 1973). Particles from soils and minerals primarily contain calcium, aluminum and silicon compounds. Smoke from combustion of coal, oil, wood and solid waste contains many organic compounds.

Sources of air pollution are numerous, though they can be grouped according to a variety of methods, including types of source, number and spatial distribution of sources and type of emissions (Rossano, 1971).

Source type refers to natural and anthropogenic sources, as well as to additional sub-classifications within each group. Natural sources include wind-blown dust, pollen, sea salt nuclei, volcanic ash and gases, smoke and trace gases from forest fires and terpenes from forests.

Air pollution sources can also be grouped according to number and spatial distribution. These include single or point sources such as steel mills, power plants, oil refineries, and pulp and paper mills, multiple or area sources such as an entire residential area, and line sources which include highways carrying moving vehicles. Another source grouping is by the type of emissions with particulate and gaseous emissions being the two major divisions.

2.5.2 Behaviour and fate of air pollutants

Although large amounts of pollutants are discharged annually into the atmosphere, the very fact that their ambient levels have remained very much the same throughout the world suggests that there are certain pathways of exchange from the atmosphere to the Earth, whereby the pollutants are continually removed. These pathways or the scavenging processes may be grouped as follows for both particulates and gases; wet removal by precipitation or dry removal by sedimentation, impaction and diffusion for particulates. For gases, the scavenging processes include wet removal by precipitation, chemical reaction in the atmosphere to produce aerosols and / or absorption on aerosols with subsequent removal, or absorption or reaction at land and ocean surfaces.

Air pollution may cause acute or chronic effects to health (Seaton et. al., 1995). Acute effects manifest themselves immediately upon short-term exposure to air pollutants at high concentrations, and chronic effects become evident only after continuous exposure to low levels of air pollution (Englert, 2004). The chronic effects are very difficult to demonstrate and are consequently less obvious. Hence, much of the knowledge of the effects of air pollution on people comes from the study of acute air pollution episodes.

Pollutants may enter the body by a number of ways, and may cause eye and skin irritation; certain particulates may be swallowed as a result of internal respiratory cleaning action or certain pollutants could even be ingested (Lioy, 1990). But the primary mode of pollutant transfer into the human body is through the respiratory system. Particulate matter inhaled may be deposited in various regions of the respiratory system depending on particle size. Particles above 10µm are almost wholly retained in the nose. Those below 10µm escape entrapment and generally pass through the upper respiratory system. Fine particles in the size range of 0.5 to 5µm are deposited as far as bronchioles, but few reach the alveoli. The walls of the bronchi and bronchioles are lined with fine hair-like structures called cilia. These are responsible for removing such fine particles along with the mucous by moving them up to the larynx where they may be eliminated by swallowing. The health risk is primarily from the deposition of the particles smaller than 0.5µm in the alveoli where they cause damage to the respiratory organs. Pollution may also result in death (WHO, 2005).

The toxic effects of particles can be grouped into three categories (Kampa and Castanas, 2008). The first involves the interference of inert particles with the cleaning mechanisms of the respiratory tract. This effect includes a slowing of ciliary beat and mucus flow in the bronchial tree. In the second category, particles act as carriers of adsorbed toxic gases such as SO_2 and produce synergistic effects, while in the third category, particles may be intrinsically toxic because of their physical or chemical characteristics. Such particles belong to metals which are usually found in the atmosphere in trace quantities but may constitute a great health hazard because of the possibility of their concentrations increasing beyond normal levels (0.01 to 3.0 percent of all particulate air pollution).

2.5.3 Sampling methods for aerosols

There are six methods for sampling of aerosols (Abdel-Salim, 2006). These are inertial, gravitational, gradients, diffusional, sieving and filtration. Filtration is the most widely used single technique of removing particles from air. Usually membrane filters are used, which have small pore size. For dust and particulate matter sampling, this is the most efficient sampling technique. Dusty air is sucked along a vertical channel, and the particles separated according to their settling velocities.

Various studies have shown that gravimetric sampling can simulate dust deposition in workers' lungs (ACGIH, 1971). Further, gravimetric samplers provided a single dust concentration value while the unit was operated. They are used by occupational hygienists for compliance measurements to determine a worker's respirable dust exposure over the entire work day.

2.5.4 Air pollution analysis

The control measures for the abatement of pollution cannot be properly devised unless there is awareness of the extent or level of pollution. Such level can be ascertained by precise measurement and analysis of the environmental pollution. There are numerous methods for the measurement of pollution (Khopkar, 1995). They consist of classical methods of analysis like gravimetric or volumetric methods. These methods are generally applicable at milligram concentrations. Several of the pollutants are present in environment at microgram levels and include dust and particulate matter, while few metal pollutants like beryllium having their threshold limiting value as 2µg/m^3. Spectral methods or electro-analytical methods are best suited of analysis for such pollutants

Several methods exist for quantitative analysis of pollutants using conventional techniques. The most suitable method used for dust analysis is the gravimetric method – which involves simple weighing before and after exposure respectively to find the amount of pollutant present (Khopkar, 1995). Suspended particulate matter like dust from the air is deposited on mili-pore filter paper. This residue is collected by sampling procedure involving a volume sampler that sucks air at a given rate through the filter element. Data collected is then extrapolated to obtain equivalent of threshold limiting value (TLV) representing time weighted average concentration for 7 to 8 hours work day or 40 hours per week.

Temperature and humidity affects dust measurements and therefore these values must be recorded over the sampling periods. Variation in air temperature influences dispersal of pollutant at ground level, but when temperature of surrounding air decreases with height, the pollutant does not accumulate. The rising parcel of pollutant air expands as it rises and cools also. Other important parameters usually considered are climate, direction of wind, frequency of certain type of weather, lapse rate and humidity in air.

Table 2.7 lists ambient air quality standards for different countries

Table 2.7 Ambient air quality standards for total suspended particulates for different countries (Liu et al., 2008)

Country	Concentration ($\mu g/m^3$)	Exposure
USA	60 150	Yearly 24 hours
Japan	100 200	24 hours Hourly
France	150 300	“Long term” exposure “Short term” exposure
Sweden	40 120	October – March (six months) 24 hours not to be exceeded more than 2% of the time during the above session.

2.6 Lighting in Workplaces

To evaluate the adequacy of light in workplaces, the object or task can- not be isolated, but must be viewed in relationship to its surroundings and function [(OOSHD, 2001) and (ASTM, 1980)]. An evaluation must take into account two important factors: quantity (the intensity of the light) and quality. The code for illumination (437-136-065) allows for the consideration of both these factors in judging "the effectiveness of illumination." In order to apply the evaluation to a compliance citation, the effectiveness must then be related to a potential safety or health problem.

While a light survey can be conducted to evaluate the effectiveness of illumination, interviews may also be necessary to determine the existence of a safety or health problem. Interviews should solicit signs and symptoms such as eye fatigue, eye strain, headaches and a history of safety problems such as incidences of falling, tripping, or bumping. The lighting survey should contain information on the quantity of light (measured through the use of a light meter) and should be used at the point on the plan that the task is performed. The illumination code allows for the comparison of these values with the ANSI/IES – RP – 7 – 1991 Practices of Industrial Lighting Standards. The survey should also indicate the quality of light since, poor illumination, glare, shadows and visual fatigue are qualities that can contribute to a safety problem.

Also to be covered to complete the light survey, aspects of the worker that include age and equipment such as goggles or full face respirators that may necessitate greater illumination need to be looked at. The object or task also needs to be detailed in terms of the difficulty of the task, time taken to see or viewing or inspecting the work, the contrast or how the object differs with its surrounding and its size. The environment and the light source is also an important factor in terms of orientation, the size of the room and the light source. Other considerations include glare, alternate light and dark areas, harsh shadows and maintenance of the light fixtures.

The standard used today to determine the acceptability of a lighting installation is a measure of the light falling on an environment (Nuckolls, 1983). However, the eye does not react to incident light; it responds to reflected light (which is expressed in lux). Lux is simply a calculable quantity indirectly used in developing light levels for seeing. Incident light is modified by the effects of object size, simultaneous contrast, viewing time, and colour before we perceive the visual response of light as it is directly involved in the seeing process.

Tolerance variations of the eye to differing levels of reflected or transmitted light are phenomenal. Under controlled circumstances, the eye can perceive minimum variations in brightness of approximately 2 to 1, and variations between the brightest and darkest areas of a seeing task can range from a maximum of 100 down to 1, respectively. However, extreme contrasts between high and low areas of brightness can strain the eyes and slow the seeing process, particularly if the viewer is subjected to these conditions for long periods of time or engaged in detailed tasks (Bennett et al., 1977). On the other hand, some contrast is essential (both physiologically and psychologically) if seeing is to be comfortable and effective (Shapley and Reid, 1985). The problem is to control reflected light for optimum effects.

Standard tables are available that gives recommendations for optimum lighting for different activities as indicated in the Table 2.8 (ASTM, 1981).

Table 2.8 Recommended illuminance categories and illuminance values for generic types of activities in interiors (ASTM, 1981)

S.NO.	CATEGORY	RANGE OF ILLUMINANCES	TYPE OF ACTIVITY AND CATEGORY REFERENCE WORK PLANE
1.	A	20 – 30 – 50 lux	Public spaces with dark surroundings
2.	B	50 – 75 – 100 lux	Simple orientation for short temporary visits. Reference; general lighting throughout spaces
3.	C	100 – 150 – 200 lux	Working spaces where visual tasks are only occasionally performed
4.	D	200 – 300 – 500 lux	Performance of visual tasks of high contrast or large size
5.	E	500 – 700 – 1,000 lux	Performance of visual tasks of medium contrast or small size. Reference; illuminance on the task

6.	F	1,000 – 1,500 – 2,000 lux	Performance of visual tasks of low contrast or very small size
7.	G	2,000 – 3,000 – 5,000 lux	Performance of visual tasks of low contrast and very small size over a prolonged period. Reference; illuminance on task, obtained by a combination of general and local (supplementary) lighting
8.	H	5,000 – 7,500 – 10,000 lux	Performance of very prolonged and exacting visual tasks. Reference; illuminance on task, obtained by a combination of general and local (supplementary) lighting.

9.	I	10,000 – 15,000 – 20,000 lux	Performance of very special visual tasks of extremely low contrast and small size. Reference: illuminance on task, obtained by a combination of general and local (supplementary) lighting.

Note: The middle value in the range of illuminance column indicates the normal value for the particular category or work activity.

2.7 Management of Occupational Safety and Health at JKUAT

Safety and health management at JKUAT has not fully developed since basic safety provisions and aspects are only to be found in laboratories and workshops. This may be noted from the fact that the university has no structures to support the development and maintenance of safety programmes (JKUAT, 2009). The 2009 – 2012 JKUAT strategic plan clearly states the need for safe work environment for both the students and staff, and provides for measures to achieve this objective. One of these measures includes the mounting of an Occupational Safety and Health training at the Institute of Energy and Environmental Studies to provide postgraduate personnel. Currently, there are no uniform policies that inform decisions at the departmental levels, top management involvement is challenged by lack of qualified personnel to provide informed decisions relating to occupational safety and health.

In comparison to other universities in the country, no substantial data is available to indicate that provisions of safety and health are present. Universities in the developed world have fully functional departments that co-ordinate all aspects of safety and health of both workers and students. Such universities, which include Oxford, Leeds, Chicago State and Illinois University, have independent departments in charge of campus environment, health and safety. These ensure that all issues related to safe workplaces are addressed adequately.

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was conducted at Jomo Kenyatta University of Agriculture and Technology – Juja campus – which is located in Juja along the Nairobi – Thika Highway (Plate 1), approximately 35km East of Nairobi City (Additional site maps of JKUAT are attached in Appendix A6). The study period was between June to October 2009.

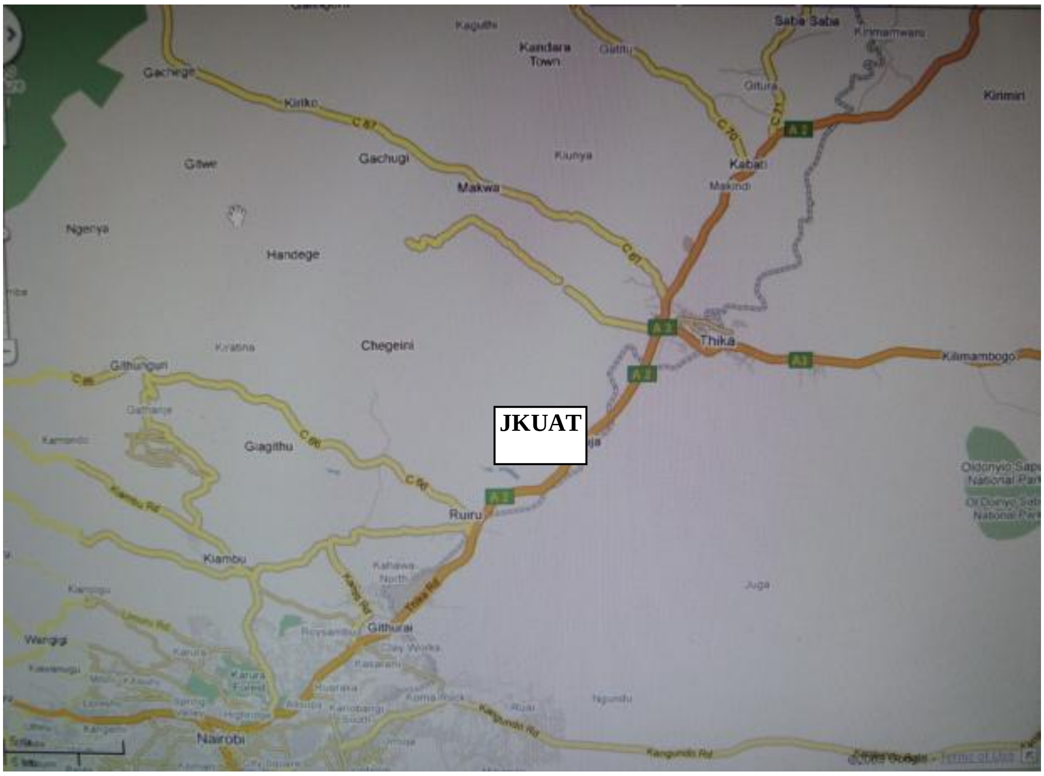

Plate 1 Location of JKUAT along the Nairobi – Thika highway A2 (Source: Google Maps, 2009)

The sampling procedure concentrated on specific academic activities (workshop practice) and focused on areas of similar risks where the cost-benefit return would be the greatest. Sampling was carried out after an initial evaluation and based on predetermined selection criterion. These isolated the Engineering Workshops department for further evaluation.

The study area consisted of a population of sixteen (16) workplaces in the Biomechanical and Environmental Engineering, Food Science and Post Harvest Technology, Farm machinery, Engineering Workshops and Transport departments. The sites are mainly used for educational purposes in the dissemination of theoretical and practical knowledge and the study was conducted when the learning process was in progress.

Sample sites were selected based on inclusion criteria that required workplaces that had low-potential high-consequences of hazards or accidents. Also, workplaces that involved other non-academic activities that exhibited a high hazard potential were included. However, worksites that exhibited less than 25% hazardous processes or situations during the initial evaluation, or those which fell under management structures were excluded from the study.

Based on the selection criteria for the sample sites, eleven worksites were selected within the Engineering Workshops precincts (Figure 3.1) that consisted of the generator housing and power substation being under the jurisdiction of the Estate's Manager, while the rest were under the control of the Workshop Manager.

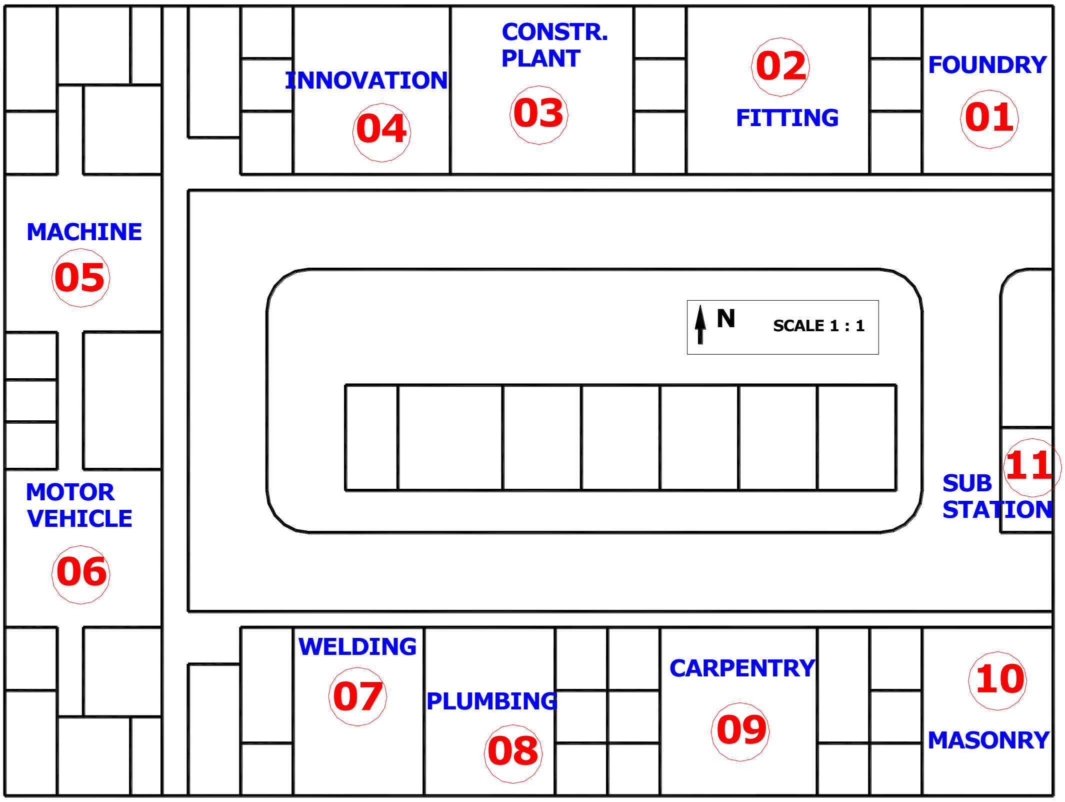

Figure 3.1 A schematic drawing of Engineering Workshops

3.2. Evaluation of Employer's Safety Management Program

The target population for the evaluation of the management program consisted of eleven (11) section heads of the specific worksites, the chief technologist – Engineering Workshops, and two (2) heads of departments. Since the total population was only thirteen, all the thirteen subjects being agents of management in each selected area constituted the respondents as the population to be sampled was small.

The evaluation process begun with a preliminary hazard survey, conducted by the researcher for the sample departments (Brauer, 2006). Based upon these results and an initial examination of the systems in place for OS&H, a checklist (Fuller and Vassie, 2004) of key compliance areas was then developed along with an evaluation program to test management and operational practices (Reese, 2004). Elements (compliance areas) to be scored in the program evaluation profile included Management Leadership and Employee Participation, Workplace Analysis, Accident and Record Analysis, Hazard Prevention and Control, Emergency Response, and Safety and Health Training. The program evaluation profile questionnaire was administered to the respondents by the researcher.

Each of these elements was divided into factors that were objectively scored by selecting descriptors that best fitted the worksite. The score for the Management Leadership and Employee Participation element would be whichever is the lowest of the following;

a. The score for the “Management Leadership” factor, or
b. The score for the “Employee Participation” factor, or
c. The average score for all four factors

For the sixth element, Safety and Health Training, the level (1 – 5) that best fitted the worksite was determined and considered as the score, while for each of the other four elements an average score was obtained.

In each department visited, walkabouts were conducted to verify compliance items and physical observation of workplace hazards and preventive measures.

Risk scorecards were then developed based upon interviews with a sample of managers of potential significant risk areas and non-significant risk areas.

3.2.1 Data analysis for the management program

The initial assessment results was verified and modified by the researcher based on information obtained in interviews by a representative number of employees (20%) and by observation of actual safety and health conditions during the evaluation process. Subjective methods were used in the analysis of data. Various scales built into the survey questionnaire assessed the attitudes and opinions toward safety in determining if safety programs changed management and workers' views towards safety and their potential behaviour. The final analysis was done through a rated questionnaire (Appendix A4) (Reese, 2004)

From the program Evaluation Profile, the six individual element scores, in sequence constituted a rating for purposes of tracking improvements in the department's safety and health program. This sequence formed a basis for evaluation of the management of safety and health issues within the department and could be used in future to determine whether there was improvement or decline in specific aspects of safety.

An overall score for the worksite was obtained by averaging the six individual scores for elements, rounded to the nearest whole number. This constituted the "level" at which the department's safety and health program was scored.

3.3 Safety Sampling of Incidents and Accidents

Induction of research assistants for the safety sampling was carried out one week prior to data collection. This was important in order to ensure that they understood the sampling procedures and predispositions to look for.

The target population for safety sampling was 240 second-year engineering students taking internal practical attachment. The sampling area – the fitting workshop (Plate 2) – was divided into sections (workbenches accommodating four subjects each) that were assigned to an observer. Data was collected through random sampling of subjects working in the area to be sampled and this took fifteen minutes. Sampling commenced after half an hour of commencement of the morning and afternoon sessions respectively, and data recorded for each session. The study wished to determine how often students on workshop practice assignments involving similar tasks made errors that would lead to accidents. The data collected was to serve as a baseline for a corrective program if the error rate was to be found to be excessive.

Plate 2 Fitting workshop – the safety sampling site

During the sampling, safety defects were noted on a safety sampling sheet which had several points to be observed (incorrect use of tools; incorrect clamping of work; incorrect posture during working; injury to the fingers through cuts, abrasion or crushing; and talking while working.). The results of the inspections paved way for a detailed safety and health analysis.

To determine the baseline within 15% accuracy of the real behavior, the number of work cycles (observations) to be included to achieve this accuracy at a 95% confidence level, a preliminary study found a 24% error rate. The number of observations *N* required was obtained by use of the formula (Tarrents, 1987)

$$N = 4\ (1 - p)\ /\ s^2 p \qquad (7)$$

where *p* is the proportion of safe or unsafe acts observed during the study

s is the desired accuracy (% per 100 readings).

The upper and lower bounds are represented by two horizontal lines, one above and one below the mean and each some distance from the mean number of errors or unsafe behavior that would lead to an accident, recorded over a period of eight (8) weeks. The limits were based on 95% level of significance (two standard deviations from the mean).

The upper limit was computed using the formula (Salvendy, 1982);

$$UCL = p + 1.96\left[p\frac{(1-p)}{n}\right]^{0.5} \qquad (8)$$

while the lower limit by the formula;

$$LCL = p - 1.96\left[p\frac{(1-p)}{n}\right]^{0.5} \qquad (9)$$

where p = mean proportion of observed behaviours that are unsafe or safe for all observation periods

n = the number of observation periods

These details were used to develop a control chart that was useful in analysis of the data collected and their implications as far as safety was concerned.

For accidents, accident statistics were sort to establish their frequencies, nature and severity of resulting injuries. The objective was to determine if the safety program in place had any effect on accident or severity rates by comparing data obtained before and after the sampling periods.

3.3.1 Data analysis for safety sampling of incidents and accidents

Before analysis, data collected was first subjected to Grubbs Test to establish outliers (GraphPad, 2002-2005), which also gave the mean and standard deviation at the selected significant level of 0.01.

Data was then plotted in a Control chart which was used to evaluate the effects of the Engineering Workshops Safety Program on errors or unsafe behaviour that would result in accidents. Control charts provide a statistical basis for determining whether results of one sampling period were truly an indicator of change or whether the results were due to random variations.

3.4 Hazard Identification and Sampling

The target population for the hazard identification process consisted of the eleven sample sites singled out in the initial selection process. A preliminary workplace evaluation form (Appendix A2) was used to identify the major processes carried out at the various workplaces. Based on the results of the preliminary evaluation, an occupational safety and health survey was then carried out by the researcher using the form in Appendix A3. This was done to establish existence of hazardous situations, identification of significant hazards, levels of protection available, the mode of entry of major hazards and existence of controls that included policies, monitoring, auditing and record keeping and existence of a feedback mechanism on the effectiveness of existing safety measures.

3.4.1 Data analysis for hazards identified

From the preliminary evaluation form the major activities carried out in each workplace were noted and a number of factors considered. These included estimating the number of people that would be affected or exposed to resulting hazards, the exposure substance for each of the major activities, the form of the hazard, the route of entry of the hazard into the body, and the control methods available to mitigate against adverse effects of the hazards (Salvendy, 1982). These factors were tabulated so as to enable analysis to be carried out. The activities were expressed as percentages of the total number of major activities recorded. These gave an indication of the major hazards present and which required further analysis.

The exposure substances for each of the major activities were also evaluated in terms of their form, route of entry to the body and control methods, and each of the elements of these parameters expressed as a percentage to identify significant parameters. Significant parameters in the form (type of hazard) category – including noise, dust and lighting – were further analyzed to establish their levels of exposure, and the information obtained used to evaluate consequences to health (Reese, 2004). This was done by establishing for the significant hazards the severity (maximum possible degree of harm (DPH)), the likelihood of occurrence (LO), the frequency of exposure (FE), and the number of people at risk at any given time (NP). A hazard rating number (HRN) – which provided justification to carry out further evaluation – was then computed for each major hazard using the formula;

$$HRN = LO \times FE \times DPH \times NP \qquad (10)$$

3.5 Evaluation of Significant Hazards

Significant hazards identified in the initial assessment stages were further subjected to detailed evaluation to determine the magnitude of the hazards. These included noise, dust and lighting, which were individually sampled and data obtained analyzed.

3.5.1 Noise sampling

The target population included machines that were perceived to be generating high noise levels in all the eleven study sites. This perception was based on the simple test that when near noisy machinery, one must raise his or her voice in order to communicate to colleagues within the work environment. Readings were also made in the immediate neighbourhood of the noisy machines / equipment / processes and at distances where learning activities would be affected by the noise. Noise levels were taken using a sound level meter serial number A19760FE manufactured by Cirrus Research Plc, Great Britain.

3.5.1.1 Procedure for noise sampling

The instrument was assembled for calibration (Plate 3) by locating and locking in place the pre-amplifier onto the meter, and then attaching the acoustic calibrator to the end of the pre-amplifier by gently pushing and twisting it clockwise.

Plate 3 Calibration setup for the sound level meter

The calibration process was accomplished by switching on the meter and then the acoustic calibrator. The calibrator was switched to the 94 decibels level setting, and upon pressing the calibration key, the instrument self calibrated and display changed to show the calibration level. The calibration output was 93.7 decibels, the difference of 0.3 decibels denoting the correction to compensate for the difference between the microphone's free field response of 'zero degrees' or 'head-on' incidence and the pressure level generated by the calibrator. After calibration, the calibrator was then removed by gently pulling and twisting it clockwise simultaneously.

The instrument was then prepared for noise measurement by replacing the acoustic calibrator with a microphone (Plate 4). In order for the sound pressure level and frequency to stabilize after replacing the calibrator with the microphone, a period of at least three seconds was provided.

Plate 4 Sound level meter set for noise measurement

To take measurements for noisy machines with the noise meter, the correct measuring range was selected using the range selector keys. The instrument was then set to display results in the broadband mode – because of its ability to store the overall values of average equivalent continuous sound levels at a frequency of 1000 hertz ±15% as well as storing a noise profile at the end of the sampling period (preferred over the octave band measurement mode which provided a repeating sequential sweep through the filter bands and gave readings for each of the band frequencies). Three readings of 8-hour weighted averages of noise levels were made at horizontal distance of one metre from the noise source and at a height of 1.2 metres from the floor and the average computes per measuring location. The sampling duration was approximately one minute for the machinery and other work environments.

Plate 5 A typical noisy activity that provided noise sampling data in a high noise generation workplace

Sampling was also done to establish background levels before and after the work shift (8.00 a.m. to 5.00 p.m.). Plate 5 shows a typical noisy activity used in the collection of noise data.

3.5.1.2 Data analysis for noise measurements

The background noise levels recorded before and after the work shifts were compared with values obtained within the work shift period, and against recommended values for workplaces and learning environments.

Individual noise levels for the various machines were compared against established international standards in order to establish whether the levels were injurious to health of the workers within the study area. The findings were assessed together with the type and levels of personal protection available for mitigating against adverse effects to health, available management controls, and the level of awareness of workers regarding the inherent dangers.

Noise levels for individual machines and processes were recorded and used to plot a noise map for the study area and its neighbourhood. This data was compared with a similar noise map plotted for the same area to indicate the impact of the loudest noise source (the standby generator) on the study area. It is worth mentioning that during the research period, the generator provided electrical power only to other parts of the university and all machines within the study area were not in use.

Details of the noise map were used to indicate the average noise levels to the neighbourhood, which was also compared with established standards for the time of the day of the work shift, and the effect of the offending noise to the neighbouring facilities. The noise maps also indicated by how much the background noise levels were higher than expected values for effective teaching and learning in classrooms adjacent to the workshops.

Identification was done of workers requiring hearing protection, workers to be placed on an audiometric program, and those to be given training and education. Results of individual noise exposures were expressed in terms of daily exposure values which were compared with recommended limit values stipulated by the World Health Organization and American National Standards Institute.[WHO, 1999 & ANSI, 2002] and determination made whether workers were over exposed or under exposed to noise.

3.5.2 Dust sampling

The target population included workstations and workshops that had significant particulate dust particles. These included the Welding and Fabrication shop where grinding of metals takes place, the Foundry shop where silica and other types of dusts were in use, and the Carpentry and Joinery shop where cellulose dust was generated. Samples were only collected from the Carpentry and Joinery shop due to the readily available dusty environment and the high cost of sampling cartridges and filters. This also limited the number of sampling frequencies which were fewer for the personal sampling. Grinding of metal in the welding shop was a one off operation and this would not have given sufficient data for the research, while the dust in foundry consisted of many elements and it was difficult to sample only one element with the available dust sampling equipment and filters.

3.5.2.1 Dust sampling equipment

The instrument used for dust sampling was the Universal sampling pumps model 224 – PCXR4 (serial numbers 827954, 827947, 827868, 827862 and 827945) manufactured by SKC Inc, Illinois United States of America. The instrumentation consisted of a universal sample pump shown in Plate 6, a calibrator (Plate 7), a 3-piece cyclone / filter cassette assembly sampling unit (Plate 8), and a strap belt to hold the sampling unit and the sampling pumps at the correct locations.

Plate 6 Universal sampling pump for dust collection

Plate 7 Calibration setup for the universal sampling pump

Prior to use, the battery of the sampling pump was charged until full. The pump was then connected to the calibration unit and calibrated by adjusting the flow using the flow adjusting screw on the calibrator until the inbuilt rotameter read 2.0 litres per minute on the sampling pump. The sampling pump was then connected to the intake of the sampling medium and the battery check button pressed to start the pump and set the flow rate to 2.5 litres per minute using the flow adjusting screw. After the flow rate had been set, the flow and battery check button was pressed to place the pump on hold. The flow meter was then disconnected. The sampling media used for calibration was then replaced with unexposed media for sample collection.

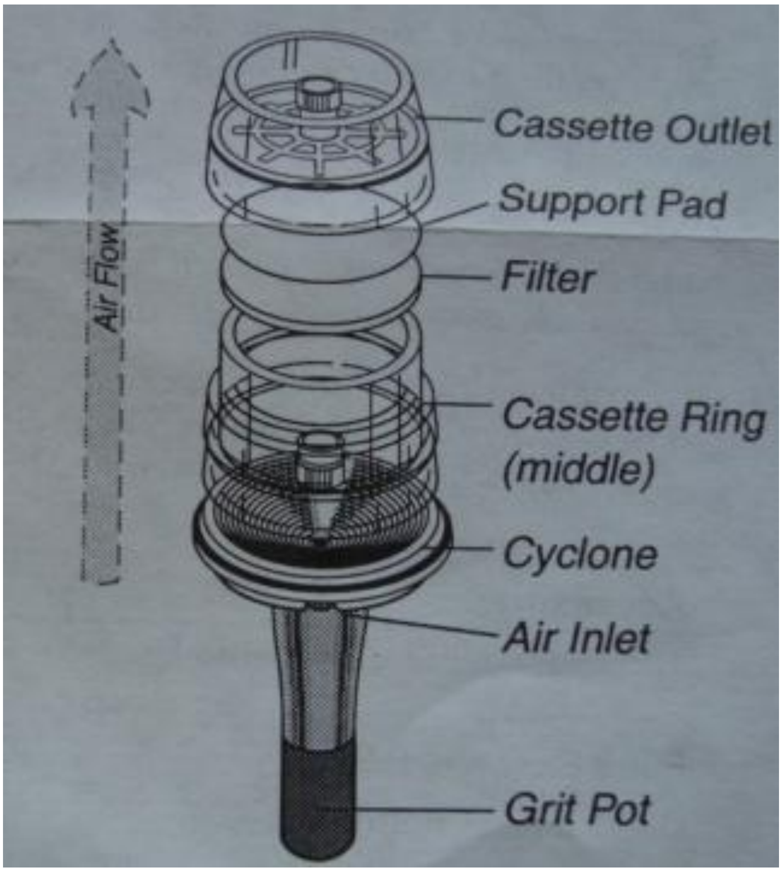

Plate 8 Exploded view of a 3 – piece 37mm cyclone / filter cassette assembly unit for respirable dust sampling

Particulates collected through sedimentation were also analyzed to determine their shape and size using a Mitutoyo Profile Projector serial number PJ-311 model made in Tokyo, Japan by Mitutoyo Precision Instrument Company.

3.5.2.2 Dust sampling procedure

This was done over a number of days with average conditions of 25^0C ambient temperatures, atmospheric pressures between 830 and 850mbar, and relative humidity between 36 and 54%. The sampling period spanned through August and October 2009 during which time the location of the study site had a dry spell. These conditions provided a conducive observation period where adverse health effects resulting from dust could be studied.

Dust sampling was done in three ways; the first being personal sampling of respirable air where dust was drawn from close to the nose of a worker using a sampling unit conveniently attached to him. A random sample of thirty (30) exposed workers participated in the study. Inhalable dust measurements were taken from each individual on four different days. In all, twelve (12) full shift (8 hours) personal inhalable dust samples were collected over a broad range of job tasks including wood sawing, planning, sanding and during manual cleaning of the workshop. Measurements were taken between 8.00 a.m. and 5.00 p.m.

For the personal sampling, the dust sampling pump was clipped to the worker (Plate 9) using the strap belt and the pre-weighed sampling unit attached within the breathing zone. The sampling pump was started by pressing the Start / Hold key to initiate the sampling process. The display indicated that sampling was in progress and an inbuilt time function automatically tracked the sampling period time elapsed. The start time was recorded at the beginning of the sampling period, and at the end, the pump stopped and the stop time recorded. Respirable air was sucked into the sampling unit through the cyclone. The purpose of the cyclone was to remove heavier dust particles which would normally be removed by the hair in the nose. The smaller particles of the airborne dust that would normally find their way into the respiratory system remained trapped in the filter medium. Particles having an aerodynamic diameter of 4.0 µm or less were separated and collected on the filter for analysis, while larger particles fell into the grit port and were later discarded.

After sampling, the sampling unit was again weighed (using a Shimidzu LIBROR Electronic Balance serial number AEC 229 model made in Japan) after the removal of the grit pot, and readings recorded for each measurement taken (Plate 10).

Plate 9 Equipment setup on worker for personal dust sampling procedure

Plate 10 Pre and post sample weighing of dust sampling unit to determine the amounts of respirable dust collected

The second sampling method was environmental dust sampling, where four specific locations within the identified workplace had samples drawn over defined durations of time. The sampling procedure resembled the personal sampling only that the sampling unit was placed at the designated locations. An initial baseline data of three samples per location was collected for the four locations, so that results of the actual sampling could be compared with this to establish any variations. In the actual sampling, a total of forty eight (48) samples were collected to establish the total environmental dust.

In the third sampling method, glass jars having mouth diameters of 100mm each were mounted on one metre high wooden stands at four locations adjacent to those used for the environmental sampling within the Carpentry and Joinery shop. Two of these locations were at two meters away from a circular bench saw and a surface planner respectively, while the other two were located one metre away from the corner walls at the extreme ends of the shop away from the entrance. Dust from wood processing machines settled in the collection jars for six hours a day for four days during which time windows were closed so that maximum dust could be collected without interference of moving air across the shop (Figure 3.4).

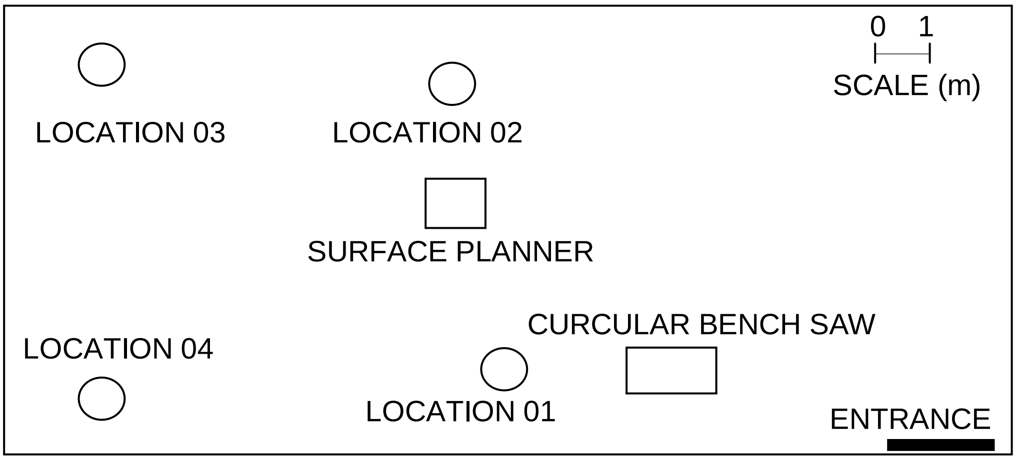

Figure 3.2 Location of environmental sampling jars for environmental dust sampling in the carpentry workshop

3.5.2.3 Analysis of dust sampling results

From the personal sampling data, the averages of respirable particulate matter were computed. The sampling and analytical data were used to calculate the time weighted averages (TWA's). Comparisons were made with exposure standards for wood dust methods. The current recommended standard levels of 8-hour of wood dust exposure, proposed by the American

Conference of Government Industrial Hygienists (ACGIH) threshold limit value (TLV) is 5mg/m^3 (ACGIH – TLV, 2002).

For the total environmental dust, the means and standard deviations of the baseline and sampling data were computed, and F and T tests established for the two sets of data to establish the difference in variability. The environmental exposure level obtained was then compared to the recommended threshold limit value as proposed by ACGIH of 10mg/m^3 of respirable air.

For the dust collected through sedimentation process, the sampling jars were collected and the particulate dust analyzed for size and shape to an accuracy of 1µm using a 100X magnification zoom lens on the Profile Projector. Individual particles were zoomed at and measured using vernier scales attached onto the viewing screen. Micrometer screws in the X and Y planes of the slide table were used to index the particles within the field of view to enable measurements to be taken.

Plate 11 Size and shape analysis of dust particles using the Profile Projector

In evaluating the dust results, the following four primary errors were expected; dust analysis 11%, instrument variability 5%, weighing5%, air flow rate 6%. This gave an overall error factor of 14% that was applied to the threshold limit values to determine the concentration above which it could be concluded that the respirable dust standards had been violated. Human errors were not considered because they could be minimized or eliminated by proper care, calibration and standard procedures.

3.6 Luminous Intensity Sampling

The target population for lighting sampling was the critical areas where lack of adequate lighting would affect the accuracy of activities being carried out or cause adverse health effects. Areas that required controlled light intensity to enable specific tasks to be carried out included classrooms where lectures are conducted, precision machine environments such as high speed metal and non-metal cutting equipment, tool-room grinding and inspection areas, assembly tables for motor vehicle and mobile plants, and marking out tables where minute dimensions are transferred to work pieces or inspection of work pieces for dimensional accuracy carried out. Measurements were done using a TOPCON IM – 2D model Lux meter, serial number 255 manufactured by Topcon International, Japan (Plate 12).

Plate 12 Setup for measurement of light intensity using the lux meter

To take readings, the calibrated Lux meter was allowed 10 seconds upon switching on to stabilize. Calibration of the Lux meter was done on request in the Electrical Engineering Department at JKUAT. Readings were then taken by pressing the ‘Record’ button on the side of the instrument. The display indicated the reading for specific locations (Plate 13). Three readings were taken and an average computed to represent the measured value for each sampled location recorded.

Plate 13 Location of the lux meter on a wood working machine work surface during a luminous intensity sampling procedure

3.6.1 Analysis of luminous intensity sampling data

Data collected for the various sampling locations were compared with established standards for similar workplaces and specific tasks to determine whether the measured values were adequate, insufficient or too much as to affect the health of those exposed.

CHAPTER 4

4.0 RESULTS AND DISCUSSIONS

4.1 Safety Management Program

Table 4.1 summarizes the results obtained from the Program Evaluation Profile for Engineering Workshops. These scores represented rated descriptors that best fitted the workplace under study.

Table 4.1 Summary of the safety and health management program elements rating for the Engineering Workshops of JKUAT

S.NO.	Item	Score	
		Possible	Earned
1.	**Management Leadership and Employee Participation**		
	• Management Leadership	5	3
	• Employee Participation	5	2
	• Implementation (tools provided by management)	5	2
	• Contractor Safety	5	1
	Average Score for item 1	**5**	**2**
2.	**Workplace Analysis**		
	• Survey and Hazard Analysis	5	1
	• Inspection	5	1
	• Hazard Reporting	5	1

	Average score for item 2	**5**	**1**
3.	**Accident and Record Analysis**		
	• Accident Investigation	5	1
	• Data Analysis	5	1
	Average score for item 3	**5**	**1**
4.	**Hazard Prevention and Control**		
	• Hazard Control	5	2
	• Maintenance	5	1
	• Medical Program	5	1
	Average score for item 4	**5**	**1**
5.	**Emergency Response**		
	• Emergency Preparedness	5	2
	• First Aid	5	3
	Average score for item 5	**5**	**3**
6.	**Safety and Health Training**		
	• Safety and Health Training	5	2
	Score for item 6	**5**	**2**

These scores were essential in establishing some reference for the purposes of future comparisons with the current status in relation to safety and health issues.

From the Program Evaluation Profile (PEP) results, the program rating of the Engineering Workshop's safety and health program was found to be 2-1-1-1-3-2. The six individual element scores, in sequence (2-1-1-1-3-2) constituted a "rating" for the purposes of tracking improvements in the Safety and Health Program. This information could be used at a future date to evaluate the program after major changes have been effected to see whether any positive or negative effect resulted in the change and appropriate action taken to correct the situation. From the program rating, an overall score of 2 was derived by taking the average of the individual elements.

Based on the overall score, the program level signifying the level of safety and health program in place was obtained. On a scale of 1 – 5, that is;

a) a score of 1 to indicate no program or ineffective program in place Totally Unacceptable)
b) a score of 2 to indicate the program at developmental stage (Poor)
c) a score of 3 to indicate a basic program (Average)
d) a score of 4 to indicate a superior program (Very Good – needs some improvement)
e) a score of 5 to indicate an outstanding program (Excellent)

The results of the study site (rating of 2) indicated that the program in place was at its developmental stage and a lot had to be done to ensure a safe workplace. This called for policy development and implementation, and active involvement of all levels of all stakeholders.

Though this is a relatively informal way of evaluating the effectiveness of a safety program, the results obtained pointed to the need for a thorough investigation to establish non-compliance with statutory requirements. This may also be justified by results of survey findings, which indicated that organization and leadership on issues of safety and health at JKUAT were inadequate (Manpower, 2009). The report also recommended that the university should train employees on safety and health and setup a committee to address matters regarding safety.

4.2 Safety Sampling of Incidents and Accidents

An evaluation of the effectiveness of available safety controls to positively influence student behaviour during practical sessions was carried out. It was noted that as part of introduction prior to any practical lesson, a briefing of workshop safety must be given to any new group of students using any workshop facility. The frequencies of errors or unsafe behaviour that would lead to occurrences of hazardous situations over a period of 80 sessions of 3-hours each were recorded and tabulated as in Table 4.2. The morning sessions were taken between 9.00a.m. to 12.00p.m., while afternoon sessions run from 2.00p.m. to 5.00p.m.

Table 4.2 Count of errors or unsafe behavior that would result in accidents at the Fitting workshop

WEEK DAY	1	2	3	4	5	6	7	8
MONDAY	28	23	22	28	25	24	24	19
	14	21	13	14	20	17	19	18
TUESDAY	28	22	22	18	30	22	28	25
	11	13	15	18	19	20	13	18
WEDNESDAY	23	20	22	28	20	30	21	28
	17	21	17	11	11	14	14	11
THURSDAY	23	28	18	20	27	19	21	30
	18	14	21	17	11	11	20	18
FRIDAY	24	27	18	26	29	30	20	26
	20	14	20	19	12	15	19	12
TOTALS	**206**	**203**	**188**	**199**	**204**	**202**	**199**	**205**
Average	**20.6**	**20.3**	**18.8**	**19.9**	**20.4**	**20.2**	**19.9**	**20.5**
Largest Value	**28**	**28**	**22**	**28**	**30**	**30**	**28**	**30**
Smallest Value	**11**	**13**	**13**	**11**	**11**	**11**	**13**	**11**
Range (R)	**17**	**15**	**9**	**17**	**19**	**19**	**15**	**19**

For the data in the table above, the average and the range were computed for each of the eight weeks (ten sessions per week). Other details of the data computed included identification of outlier values and standard deviation as indicated below.

Outliers	None
Mean:	20.08
Standard deviation	5.45
Significance level	0.01 (two sided)

The control chart in figure 4.1 summarizes data on errors or unsafe behaviour.

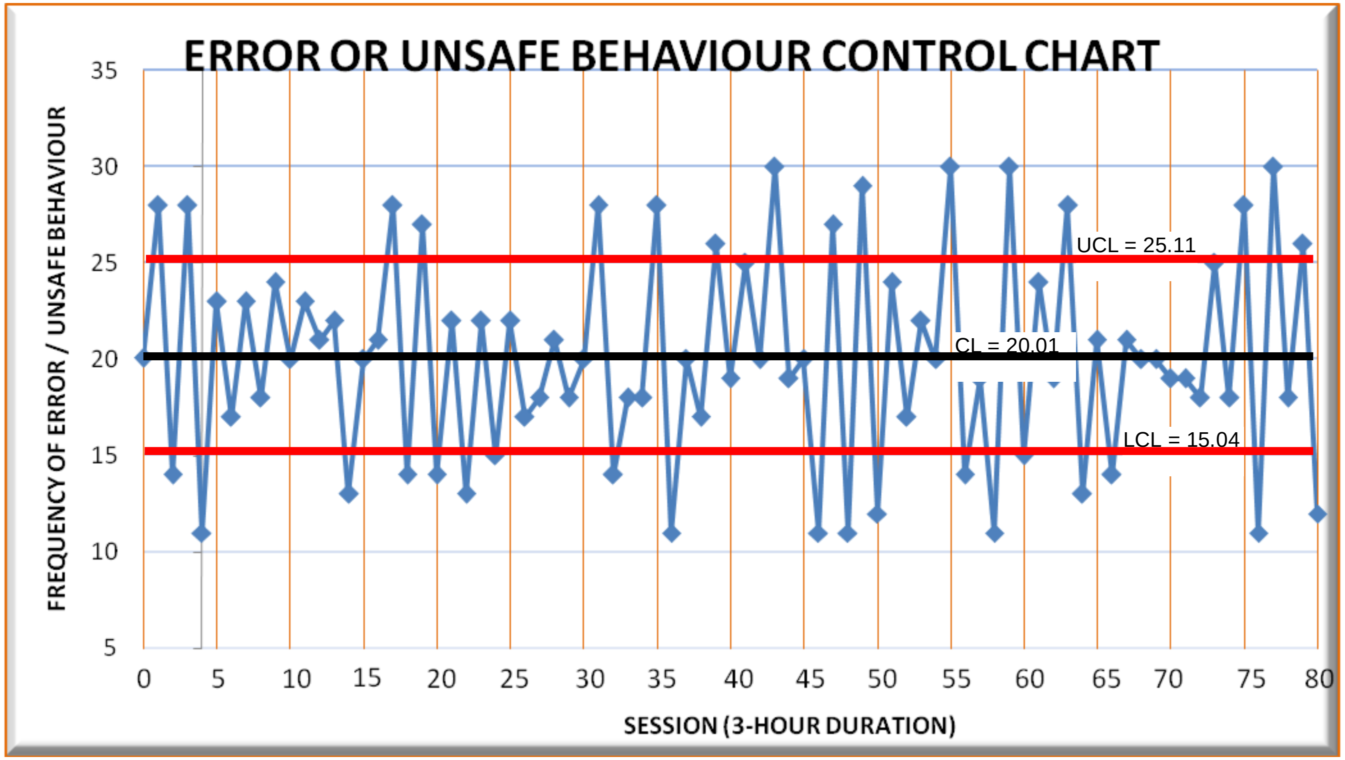

Figure 4.1 Control chart for evaluating errors or unsafe behavior of students in a practical session in the Fitting Workshop in the Engineering Workshops

The aim was to establish whether if after the implementation of the safety program the unsafe acts reduced and exceeded the control limits. This would indicate that the program had a positive effect. If on the other hand the occurrences were beyond the limits, then this would indicate that the variation was due to something other than random effects.

A look at the results indicates that there seemed to be compliance at the beginning of the program but as the sessions progressed, there seemed to be lack of follow-up by those in charge to ensure compliance with the set safety rules. This led to carelessness on the part of the students and a higher chance of occurrence of dangerous situations that may have resulted in accidents. This was despite the fact that posters and safety signs and rules had been posted in specific areas to help cultivate a positive safety culture among the students. The presence of these posters by themselves did not influence students' attitudes towards personal safety.

The exception noted on the control chart towards the end of the training session was attributed to the fact that during that particular time, most of the students were not present and therefore close supervision may have led to the high compliance rate.

4.3 Hazard Identification and Sampling

Preliminary hazard identification and sampling results are summarized in the Table 4.3.

Table 4.3 Preliminary hazard identification summary indicating the number of employees exposed to the different hazardous substances identified, routes of entry of hazards and available control methods

Employees exposed	Activities	Exposure substance	Form (type of hazard)							Route of Entry				Control of Entry					
			Dust	Liquid	Vapour	Gas	Fume	Mist	Other	Skin	Inhalation	Injestion	Other	Local Ventilation	General Ventilation	Respirator	Gloves	Face Protection	Other Controls
40	Combustion and burning	Combustion products		√	√	√	√	√		√	√			√	√	√		√	
		Heat							√	√							√		√
		Noise							√				√						√
		Hot sparks							√	√							√		√
300	Cold bending, forming, metal & non-metal cutting	Lubricants		√			√		√								√		√
		Chemicals	√	√	√		√		√								√		√
		Solid particles	√						√	√	√		√	√	√	√		√	√
		Noise							√				√						√

Employees exposed	Activity	Exposure substance	Form (type of hazard)							Route of entry				Control of entry					
			Dust	Liquid	Vapour	Gas	Fume	Mist	Other	Skin	Inhalation	Injestion	Other	Local Ventilation	General Ventilation	Respirator	Gloves	Face Protection	Other controls
20	Handling of mobile plant / equipment	Vibrating parts							√				√						√
		Noise							√				√						√
		Heat							√	√							√		√
200	Handling of portable electric tools / equipment	Vibrating							√				√						√
		Heat							√	√							√		√
		Noise							√				√						√
		Exposed wires							√	√			√				√		√
80	Handling small parts	Part size							√				√						√
		Sharp edges							√	√			√				√		√

The skin appeared to be the most common route of entry for most of the hazards at 54.5% compared with other routes such as inhalation and ingestion. This could have occurred through actions like handling of sharp edges which may pierce the skin; burns from hot surfaces or objects, radiation or naked flames; electric shock as a result of handling portable equipment with naked electrical wires or uncovered parts of an electric circuit; and pollutants and other agents including dust and chemicals that penetrate the skin pores.

Between gloves, local ventilation, respirator and face protection, 38% of the protection method commonly used was found to be the hand gloves. However, this method was inadequate in protection of all available hazards that may have got to the body through the skin, thus the need to popularize the use of other methods of protection against hazards.

Further analysis of the hazardous operations revealed that operations related to handling of mobile plants and cold working posed the greatest challenge in terms of safety and health at the Engineering Workshops at 22% chance of occurrence respectively. This is illustrated in the pie chart in Figure 4.2.1. Despite the fact that activities relating to melting of metal constituted only 9% of the total activities, it posed the greatest challenge due to the fact that there was a low chance of occurrence of molten metal hazards with corresponding high consequences should an accident occur. This means that activities with low chances of occurrence and high consequences needed also to be given special consideration when designing hazard safety control and management procedures.

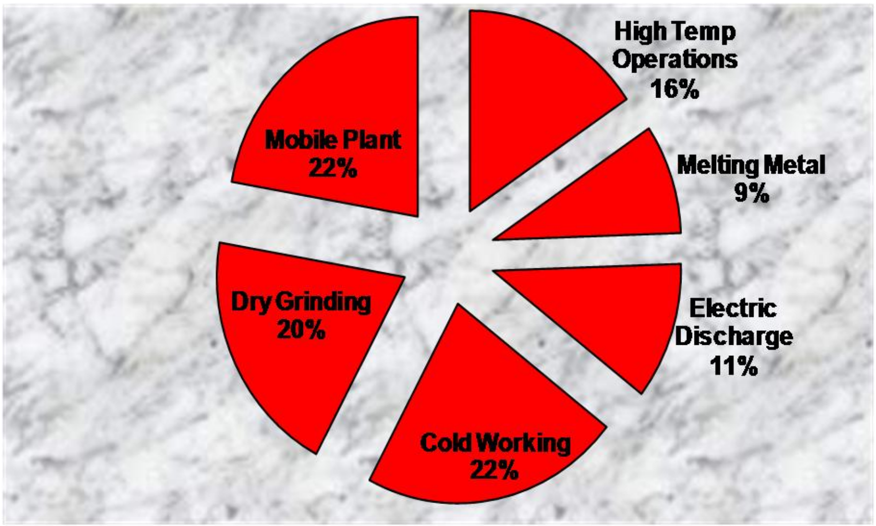

Figure 4.2 Likely percentage occurrences of hazardous situations from major activities in the Engineering Workshops

These major processes together with activities listed in Table 4.3 led to the presence of hazards in the six major classifications, thus;

i. Physical (e.g. noise, dust, lighting)
ii. Biological (e.g. micro organisms, handling of plants and pathogens, exposure to carcinogens)
iii. Mechanical (e.g. crushing, piercing, friction)
iv. Chemical (e.g. reactive chemicals, reactive solids, heavy metals)
v. Physiological (e.g. poor ergonomic design, unnatural motions)
vi. Psychological (e.g. age, gender harassment, ambient temperature)

Analysis of these hazard classifications – through data collected from the administered questionnaire (Appendix A2) – revealed that there existed a higher risk of occurrence of physical hazards at 43% in the study area than the other five (Figure 4.3 below). Biological hazards were found to constitute the smallest percentage of risk at 4%.

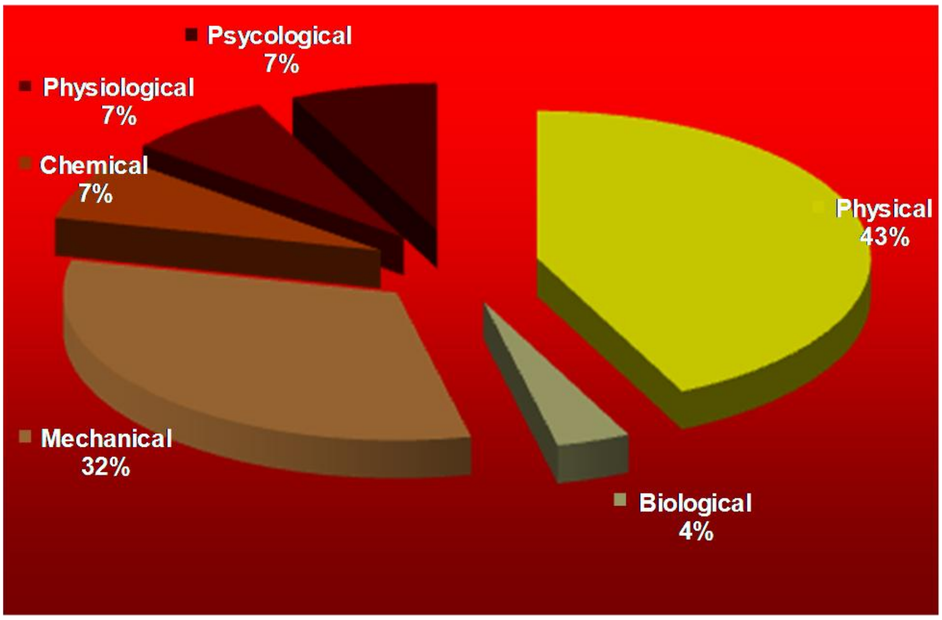

Figure 4.3 Percentages of Risk of occurrence of major hazards within the Engineering Workshops

Table 4.3 further indicated that noise was a common exposure element and appeared in 83% of all the six major categories of activities identified. Though dust was recorded in only 33% of the major activities, and since the most preferred method of hazard protection (the gloves) did not prevent dust exposure, further analysis was important to determine the risk. Artificial air pollution control methods were available (Plate 14), but were not being put to use due to poor management controls (there were no dust collecting bags thus rendering the equipment not useable).

Plate 14 Dust extraction equipment in the carpentry workshop set aside due to lack of dust collection bags

The initial hazard evaluation also indicated existence of too much light from the sun especially in the five classrooms used by students. This was especially so due to the orientation of the classrooms in relation to the path of the sun during the day and thus a need for further analysis to determine the extent of the hazard posed as a result of the natural light.

Other hazards identified included exhaust smoke that was discharged across the road (Plate 15) and into an adjacent building, hot fumes that destroyed vegetation around the generator exhaust pipe (Plate 16), and risks of exposure to asbestos fibers from the cladding over the workshop structure (Plate 17).

Plate 15 Dense smoke from the standby generator likely to block vision of road users on an adjacent road

Plate 16 Adverse environmental effect of exhaust heat and fumes on vegetation and structures adjacent to the generator housing

Plate 17 Asbestos cladding covering the Engineering Workshops likely to impart long-term adverse health effects to workers

Further analysis was carried out on significant hazards that included noise, dust and lighting. Though exposure to asbestos was suspect due to the fact that the cladding was more than thirty years old and there were visible cracks due to aging and the effect of the sun that would lead to the release of fibres, further analysis was not carried out due to lack of equipment.

4.4 Evaluation and Analysis of Significant Hazards

Based on results obtained from the initial hazard identification and sampling, noise dust and lighting were found to be significant hazards that required further analysis to establish their magnitude and effects on occupational health.

4.4.1 Results of noise measurements

Noise measurements prior to commencement of activities and at the end of a working day were recorded as tabulated in Table 4.3.1. These represented background noise levels when activities of the workshops were at a minimal. It was observed that the background noise levels in the mornings were lower than those taken in the evenings.

Table 4.4 Background noise level ranges before and after a typical work-shift

S.NO.	RANGE OF L_{eq} [dB(A)]	Runtime average [min]	Time of day
1.	28.0 – 35.0	5.00	Morning
2.	40.0 – 45.0	5.00	Evening

It was observed that before the days work shift, noise levels throughout the sampling period ranged between 28.0 and 35.0 decibels on the A weighted average scale, while levels after the shift ranged between 40.0 and 45.0 decibels. The background noise was largely due to birds nesting on surrounding trees and traffic along the adjacent roads.

Since learning involved both listening and talking, a high background noise level interfered with delivery of lectures and the students' interpretation of certain concepts. It could also lead to accidents as a result of failure to perceive warning sounds and fatigue due to high noise levels (Lazarus, 1998). For effective learning processes, the background levels of off-work noise – especially in the mornings – would be most ideal, and this would mean that no machinery or generator should be operated within the workshops during the learning periods. However, this was not the case since during working hours, machines and equipment have to operate. The alternative would be to transfer the classrooms to some other quieter place as there are only five classrooms compared to eleven shops all generating noise of different magnitudes.

The results of noise levels of 8-hour weighted averages of different machinery during normal work shift are tabulated in Table 4.3.2. These indicated that 73% of machines and equipment produced noise levels in excess of 85.0 decibels. Further, depending on the material being processed – for example hard wood as compared to soft wood of the same moisture content – using the same machine, noise levels varied. The highest noise level recorded was 105.5 decibels produced by a standby generator located near the power house.

It was also observed that when machines run simultaneously in a given workshop, there were locations within the workshops that had higher noise levels than those of individual machines measured alone. This is attributed to the fact that the amplitude of sound waves at specific locations were additive and these values could be higher due to the influence of noise from different sources.

Table 4.5 Average noise levels for different machinery and equipment within the study area

S.NO.	Machinery / equipment	Room / location	L_{eq} [dB(A)]	Remarks
1.	Hand tractor	03	86.6	Maximum throttle
2.	Pedestal grinder	07	75.5	Grinding mild steel
3.	Surface planner	09	88.0	Grinding mild steel
4.	Thicknesser	09	92.3	Processing hard wood
5.	Thicknesser	09	78.3	Processing soft Wood
6.	Hand Planner	09	84.1	Processing soft wood
7.	Circular Bench Saw	09	89.6	Processing soft Wood
8.	Circular Bench Saw	09	96.0	Processing hard Wood
9.	Assorted	05	70.7	All major machines in use
10.	Hand Grinder	07	86.4	General grinding work
11.	Standby Generator	11	105.5	Running at Full Load

Data obtained for the different machinery were used to plot a noise map, with all machinery – with the exception of the generator – were running at the same time. Results of this plot indicated that the average noise was 70 dB(A) with the epicenter being almost entirely within the study area as opposed to the latter case where the average level is 79.7 dB(A). The most affected location as a result of the machinery was found to be the Manager's office which experiences a noise level of 82 decibels on a daily basis. The generator thus provided a greater risk especially to the learning processes within the study area than when the machines operated alone due to their different locations and structures surrounding them.

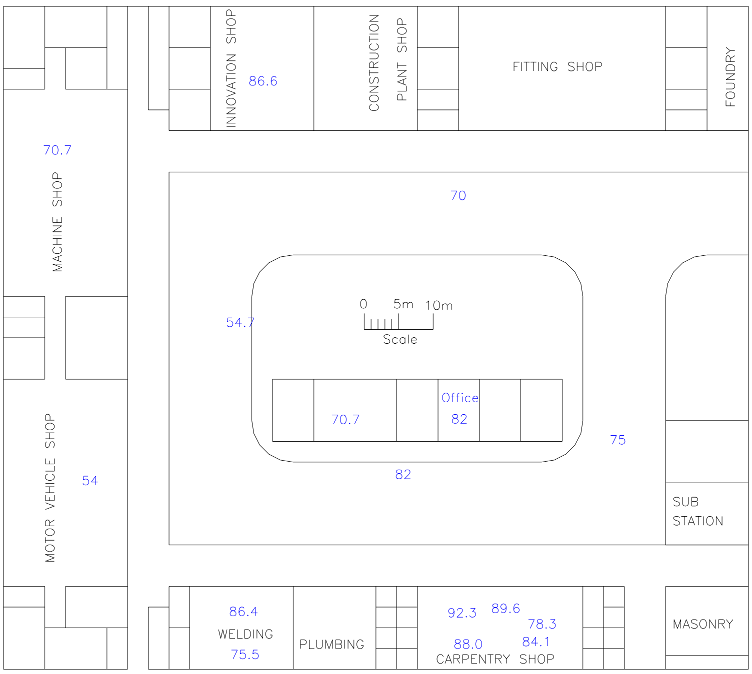

Figure 4.4 Noise map showing noise levels as a result of machinery operating in the Welding, Carpentry, Innovation, and Machine workshops

In comparison, the effect of noise generated by the standby generator on the surrounding – all other machinery not running – was analyzed. Data was collected with the generator running at full load for the purposes of plotting a second noise map. Results (Table 4.6) indicated that one of the classrooms had noise levels of 79.7 dB(A) while the other four had over 50 dB(A). The noise to the surrounding was also beyond the recommended 55 dB(A) thus interfering with activities in the adjacent designated noise free tuition block.
Noise readings average runtime was 5 minutes and 40 – 110 dB instrument range used to collect data. The classifications of workplaces in this table are according to designations as indicated in Table 2.2 on permissible noise levels.

Table 4.6 Noise readings for noise mapping around the standby generator within the study area

S.NO.	Location / Room	Classification of area	Measured L_{eq} [dB(A)]	Recommended sound level dB(A)
1.	Workshop Manager's Office	1	82.0	50 – 65
2.	ENW 13 - Computer room	3	64.3	10 – 30
3.	ENW 13 – Office	1	59.5	30 – 55
4.	ENW 02 – Classroom	1	79.7	10 – 30
5.	ENW 04B – Classroom	1	54.4	10 – 40
6.	ENW 04C – Classroom	1	53.2	10 – 40
7.	ENW 05B – Classroom	1	59.2	10 – 40
8.	ENW 05C – Classroom	1	65.5	10 – 40
9.	Location 11 - Standby Generator Housing 1m away	6	105.5	85– 107

10.	Location 01 - Students' Registry	1	55.8	50 – 65
11.	Location 02 - Outside Civil Engineering Computer Room	1	65.6	10 – 40
12.	Location 03 - Opposite and across road from outside generator room	1	76.3	45 – 55
13.	Location 04 - Junction to hospital from Engineering Workshops		60.7	45 – 55
14.	Location 05 - At entrance of Horticulture / Food Science new building		53.4	10 – 55
15.	Location 06 - Food Science / Transport yard junction		65.6	10 – 55

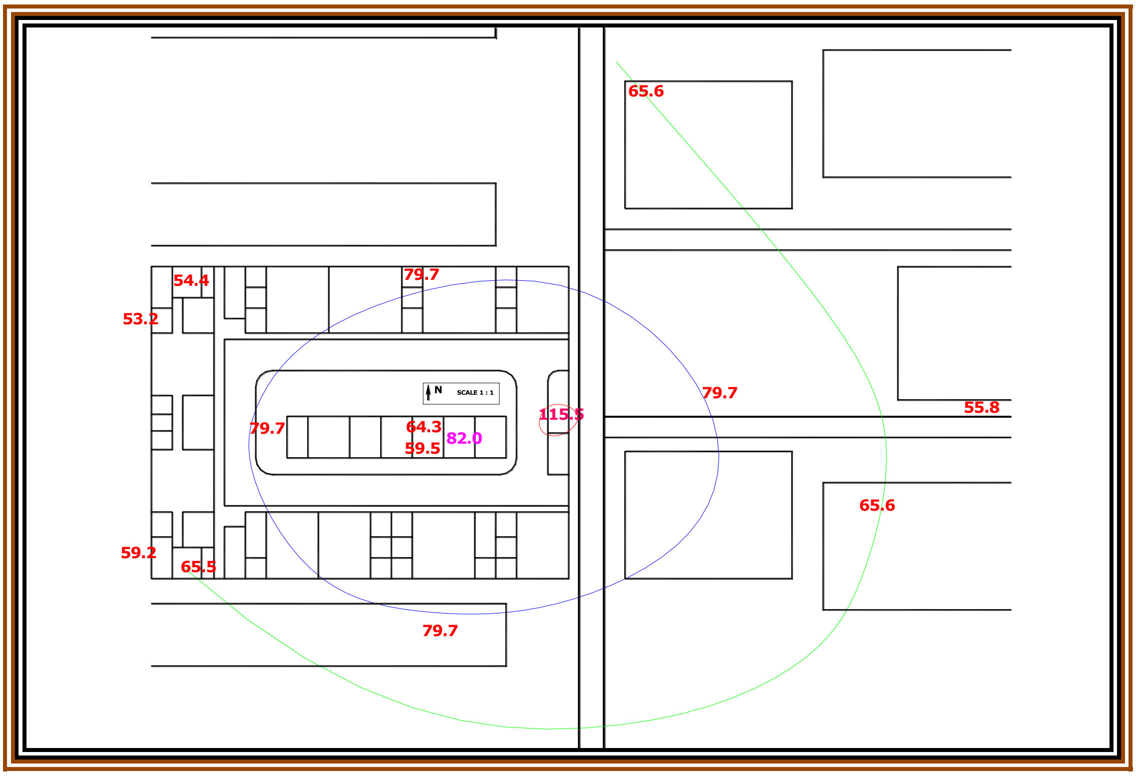

Figure 4.5 Noise mapping around the standby generator

The noise map indicates an average of 79.7 decibels and 82.0 decibels background noise level in the administrative office of the Workshop manager. The Occupational Safety and Health Act (2007) requires that where noise levels exceeds 85 dB(A) a noise reduction program must be developed and in areas with levels exceeding 85dB(A) the use of ear protectors be mandatory and appropriate signage be adequately posted (GOK, 2006). Audiometric tests also need to be carried out on those exposed to noise levels in excess of 80 dB(A) in any 8-hour work shift to assess the effect of the noise, and to act as an aid to job relocation or reassignment. In 2002, the American National Standards Institute ANSI issued a voluntary Standard S12.60, "Acoustical Performance Criteria, Design Requirements, and

Guidelines for schools" which calls for a maximum ambient noise level of 35 dB(A). The World Health Organization (WHO) also specifies the 35 dB(A) in order to assure speech intelligibility (WHO, 1999). These standards may well apply for universities as they are also institutions with the similar learning environments.

None of these measures were found to be in place in the shops evaluated. Noise mapping data (Table 4.6) indicated that one of the classrooms was seriously affected by noise from the standby generator which was found to be above 75 dB(A). This is very high for a classroom compared with standard requirements of the same of 35 dB(A) (ANSI, 2002). The other four classrooms were found to experience noise levels between 54 to 66 dB(A) which is reasonably high compared to the (10 to 40)dB(A) range suitable for teaching and learning activities.

The noise level of 105.5 dB(A) produced by the standby power generator indicated lack of planning when purchasing and installing the equipment as the machines catalogue (Caterpillar, 2009) indicated the equipment could be operated at noise levels below 40dB(A) measured at a distance of 1m away. This could further be reduced through appropriate noise barrier (housing) to a level of 20 dB(A) as illustrated in Plate 18. In comparison with the Oxford University's exposure limits and action levels, noise in the range of 85 to 105.5 dB(A) experienced in the JKUAT Engineering Workshops is well above their daily or weekly exposure limit and action value of 80 dB(A) (Oxford, 2005). The upper action value for the daily or weekly exposure of 85 dB(A) would imply that JKUAT takes the necessary precautions to guard against noise-induced hearing loss.

The noise could have been reduced by erecting an acoustic barrier around the generator with a superficial weight of 237.14 kg/m^2 (DIN 4109, 1989). This is so if the noise produced had to be reduced by 60 decibels, assuming an average offending noise frequency of 1000Hz. The wall must be made of bricks 280mm thick with 56mm cavity, expanded metal ties, outer faces plastered 12mm thick.

Plate 18 Recommended sound – proof housing for a power generator to reduce noise levels to acceptable values

Also, from personal sampling data on noise, it was established that workers in the Innovation workshop, carpentry and joinery workshop and the generator housing were exposed to noise levels above 85 dB(A). This calls for a more detailed survey and fulfillment of other requirements of the noise provisions as specified in the OSHA Act, including education on the effects of noise on hearing and training on the use of hearing protectors. However, from the noise map of all machines, the 82 – 85 dB(A) noise levels requires that workers be informed of the noise monitoring results, the minimum risk of hearing loss, and the roles of hearing protection and audiometric testing.

4.4.2 Results of dust measurements

4.2.2.1 Personal sampling

In all, twelve (12) samples were analyzed for dust levels. None of the dust samples had a concentration below the detection limit of 0.3mg/m^3. The average concentration levels of data collected over the four days on three workers in the carpentry and joinery workshop was 19.1mg/m^3 of respirable air with a standard deviation of 1.84 and a confidence limit of ± 1.37 at 95%. This amount was far beyond the recommended threshold limit value of 5mg/m^3, possible because of the experimental conditions where free flow of air within the study area was controlled. Available measures to reduce the adverse health effects due to the dust particles included dust extractors and respiratory protective equipment. The dust extractors were not being used due to lack of dust collection bags. This would have been the best mitigation for air pollution due to wood dust compared to respiratory protection which must only be used as final measure when all other methods are unable to protect against the hazard.

Respiratory protective equipments available were inadequate in quantity as some students were observed to work without them. It was also not possible to establish the quality of the respirator filter element from the packaging since material safety data sheet had not been provided by the supplier. For those using the respirators, the fit did not provide uniform protection for all since only one size was supplied.

4.4.2.2 Environmental sampling

In all, sixty (60) samples were analyzed, giving a mean of 17.6 mg/m^3 of respirable air and a standard deviation of 2.62 for 12 determinations for the baseline data, while for the actual sampling the mean was 17.7 mg/m^3 of respirable air and a standard deviation of 2.13 for 48 determinations. An F – test was carried out to compare the two sampling processes by comparing their variability. This test confirmed that there was no difference in variability or variation about the central tendency and that the means were not significantly different. Also, a T-test revealed that there were no systematic errors in the two sets of data.

From the results of the environmental dust levels, an average of 17.7 mg/m^3 of respirable air against the recommended value of 10 mg/m^3 is high. The high value could have been attributed to the fact that windows within the workshops were closed during data collection to minimize the effect of wind on dispersal of dust particles. Also, the differences in quantities of dust particles collected indicated the different locations away from dust generating machinery.

4.4.2.3 Dust particle size

In order to further determine the effect on health of the dust particles collected in the carpentry workshop, particle sizes were measured. It was found that they varied in size and it was possible to identify 1 to 8µm particles using the profile projector at 100X zoom lens magnification. An average aerodynamic particle diameter was found to be 10 µm – 77% of these being inhalable. Of the fraction that is respirable, 50% or the Thoracic Fraction is hazardous to health (ACGIH, 2002).

The table below summarizes the results discussed above.

Table 4.7 Summary of results of dust sampling data compared with recommended values

S. No.	**Item**	**Measured value**	**Recommended value**	**Standard**
1.	Personal sampling	19.1mg/m^3	10mg/m^3	ACGIH – TLV, 2002
2.	Environ. sampling	17.7mg/m^3	15mg/m^3	ACGIH – TLV, 2002
3.	Av. Particle size	10µm	> 10µm	ACGIH, 2002

4.4.3 Results of Lighting Measurements

Table 4.8 presents the luminous intensity measurements for the various workstations that had critical operations requiring control of light.

Table 4.8 Light intensity measurements for different workstations within the study area

S.NO.	**Location**	**Activity and equipment**	**Lux**	
			Measured	**Recommended**
1.	03	Marking out on marking out table	417.5	3,000
2.	02	Shop floor + Filing and general fitting work on work bench + Marking out on marking out table	559.2 654.0	1,500 3,000
3.	03 - Class	Classroom – lectures and briefing before practical activities	1,350.0*	450
4.	03	Shop floor + Work bench for assembly / dismantling	750.5	1,500

		tasks		
5.	05 - Class	Classroom – lectures and briefing before practical activities	1,250.0*	450
6.	05 - Class	Classroom – lectures and briefing before practical activities	1,200.0*	450
7.	05	Shop floor + Surface grinding on surface grinder + Cylindrical grinding on cylindrical grinder + Marking out on marking out table + Drilling on Radial drill + Machining on Lathe machine	185.5 173.7 380.0 2,000.0 1,450.8	7,500 7,500 3,000 2,000 1,000
8.	06 - Class	Classroom – lectures and briefing before practical activities	1,150.2*	450

9.	06 - Class	Classroom – lectures and briefing before practical activities	1,135.0*	450
10.	06	Shop floor	750.0	1,500

Note: Values in asterisks indicate locations with too much light intensity

Since most metal and wood working machinery are designed to operate at very high speeds (in excess of 3000 revolutions per minute) in order to accomplish the cutting process, lighting is very important if accidental contact with rotating cutters is to be avoided. Nakagawara (1990) observed that insufficient or too strong, and particularly, glaring illumination causes visual inefficiency, resulting in fatigue, headache, dizziness and increased accident risk. Also, the type of luminnaire installed to provide artificial lighting should not create additional hazards due to stroboscopic effects which have the ability of creating the impression that a high speed rotation cutter is stationery.

Generally it was established that lighting was adequate (Table 4.8) in most of the workshops apart from specific activity areas that required artificial lights to supplement the natural light from the sun. The marking out table was singled out to be inadequately lit to ensure that dimensions to the accuracy of 0.02mm could be accurately transferred from a primary standard to a secondary standard and then to a work piece. The current arrangement relies heavily on natural light from the sun which makes it difficult to achieve the required accuracy. The primary and secondary reference instruments presently in use were also observed to lack maintenance since aids like magnifying glasses meant to aid in dimension transfer were lacking due to mishandling or rough use.

The roof structure in the Engineering Workshops allows for natural lighting from the sun to reach the shop floors. This provides adequate general lighting though it also gives rise to disability and discomfort glare when the sun is almost overhead. The orientation of the classrooms in relation to the position of the sun past noon presents conditions that make it difficult to see writings on chalk boards or white boards that could lead to fatigue and lack of concentration.

CHAPTER 5

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Results obtained from this research indicated that the management of occupational safety and health at Jomo Kenyatta University of Agriculture and Technology, especially in the Engineering Workshops was not adequately developed to control the adverse effects resulting from existence of hazards. This was evident from the major hazards identified including noise, dust and light, and results of further analysis which indicated values that may adversely affect the health of about 700 persons.

Specifically, the workgroups that are likely to be affected by excessive noise included those engaged in the Carpentry and Joinery, and the Innovation workshops, who were exposed to noise levels in excesses of 85 dB(A) on an 8-hour weighted daily average. The other group was the electricians working near the standby generator and exposed to 105.5 dB(A) noise levels during power blackouts. This level of exposure is likely to lead to occupational deafness. As for the dust, the specific workgroup likely to be adversely affected was that engaged in the Carpentry workshop as exposures of 17.7mg/m^3 and 19.1mg/m^3 for respirable and general environmental dust levels far exceeded recommended values of 10mg/m^3 and 15mg/m^3 respectively. This is likely to result in respiratory disorders.

Regarding hazards related to lighting, the workgroup most likely to be adversely affected was the students in the classrooms who experienced glare of the magnitude of 1200 lux compared with the recommended 450 lux. Lighting values of 380 to 420 lux were recorded in marking out operations compared to the recommended 3,000 lux. These are likely to result in straining of the eyes and lack of concentration.

5.2 Recommendations

The management of occupational safety and health within the Engineering Workshops need to be improved through training and education, development of relevant policies and assignment of responsibilities. Also, for management to succeed, budgetary provisions need to be factored in so as to provide the necessary controls to ensure implementation is successful.

Noise levels of 105.5 dB(A) should be addressed urgently as the hazard rating and thus the potential to cause harm is high. Noise conservation and hearing protection programs need to be put in place to reduce the average noise levels of 79.7 dB(A) to the surrounding to 55 dB(A), while the physical dust control methods need to be activated to reduce possibility of adverse health effects. It is therefore recommended that health surveillance and medical examinations be carried out to establish starting points for mitigation measures.

As far as lighting is concerned, supplemental lighting should be provided in all marking out areas, while curtains to reduce the effect of discomfort and disability glare be provided in all the affected classrooms.

Further studies on hazards and safety management in other departments within the entire university need to be carried out. This would be useful in evaluating the overall hazard potential in the university in order to develop appropriate controls.

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PRELIMINARY EVALUATION FORM

Department: ______________________________ Workshop No. __________

Workshop Name _________________________________ Date: ___________

Identification of Major Processes: (tick appropriately)

Y	**N**	Combustion and burning
Y	**N**	High temp operations with/without combustion
Y	**N**	Heating and using microwaves
Y	**N**	Melting metal
Y	**N**	Electric discharge into the air (Arcs / sparks etc.)
Y	**N**	Electric discharge in a vacuum (x-rays, electron beam)
Y	**N**	Operations that might lead to contact with electric current
Y	**N**	Mixing dry material
Y	**N**	Mixing wet material
Y	**N**	Cold bending, forming, metal & non-metal cutting
Y	**N**	Hot working, forming, metal and non-metal cutting
Y	**N**	Handling small parts
Y	**N**	Coating operations preceded by solvent degreasing – painting
Y	**N**	Dry grinding
Y	**N**	Handling of mobile plant and equipment

Y	**N**	Chemical reactions
Y	**N**	Other ______________________________
Y	**N**	______________________________
Y	**N**	______________________________

HAZARD IDENTIFICATION AND RECORD FORM

To cover general working conditions, house keeping, equipment, ergonomics and environment.

Department: ______________________________ Workshop No. __________

Workshop Name __________________________________ Date: __________

Identify existence or potential of the following hazards and determine their levels of acceptability:

1. Physical hazards: **Acceptable?**

Y	**N**	Collisions	**Y**	**N**
Y	**N**	Confined spaces	**Y**	**N**
Y	**N**	Falls from height	**Y**	**N**
Y	**N**	Slips and trips	**Y**	**N**
Y	**N**	Electricity	**Y**	**N**
Y	**N**	Falling on a pointed object	**Y**	**N**
Y	**N**	Noise	**Y**	**N**
Y	**N**	Vibration	**Y**	**N**
Y	**N**	Lighting	**Y**	**N**
Y	**N**	Pressure extremes	**Y**	**N**
Y	**N**	Steam	**Y**	**N**

Y	**N**	Waste / Waste disposal	**Y**	**N**
Y	**N**	Fumes (noxious gases/vapors)	**Y**	**N**
		Other/s (please specify)		
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**

2. Biological hazards: **Acceptable?**

Y	**N**	Micro organism	**Y**	**N**
Y	**N**	Handling of plants and animals	**Y**	**N**
Y	**N**	Exposure to Pathogens	**Y**	**N**
Y	**N**	Exposure to Carcinogens	**Y**	**N**
Y	**N**	Pests and insects	**Y**	**N**
		Other/s (please specify)		
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**

3. Mechanical hazards: **Acceptable?**

Y	**N**	Crushing	**Y**	**N**
Y	**N**	Cutting	**Y**	**N**
Y	**N**	Grinding	**Y**	**N**
Y	**N**	Draw in	**Y**	**N**
Y	**N**	Entanglement	**Y**	**N**
Y	**N**	Friction and abrasion	**Y**	**N**
Y	**N**	Impact	**Y**	**N**
Y	**N**	Shearing	**Y**	**N**
Y	**N**	Stabbing and puncture	**Y**	**N**
		Other/s (please specify)		
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**

4. Chemical Hazard: **Acceptable?**

Y	**N**	Highly reactive Chemicals	**Y**	**N**
Y	**N**	Carcinogens	**Y**	**N**
Y	**N**	Reactive solids	**Y**	**N**
Y	**N**	Chemical reactions	**Y**	**N**
Y	**N**	Radioactive isotopes	**Y**	**N**
Y	**N**	Explosive environment		
Y	**N**	Heavy metals	**Y**	**N**
		Other/s (please specify)		
Y	**N**	______________________________	**Y**	**N**
Y	**N**	______________________________	**Y**	**N**
Y	**N**	______________________________	**Y**	**N**
Y	**N**	______________________________	**Y**	**N**

5. Physiological Hazards: **Acceptable?**

Y	**N**	Poor ergonomic design	**Y**	**N**
Y	**N**	Unnatural motions / postures	**Y**	**N**
Y	**N**		**Y**	**N**
Y	**N**		**Y**	**N**

Y	**N**		**Y**	**N**
		Other/s (please specify)		
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**

6. Psychological Hazards: Acceptable?

Y	**N**	Gender harassment	**Y**	**N**
Y	**N**	Work pressure	**Y**	**N**
Y	**N**	Age	**Y**	**N**
Y	**N**	Ambient temperature extremes	**Y**	**N**
		Other/s (please specify)		
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**
Y	**N**	______________________	**Y**	**N**

<u>Notes for use with risk assessment form:</u>

Occupational Safety and Health Risk Assessment to be done only on major hazards identified.

Appendix 2

a) Severity (the maximum Degree of Possible Harm or loss that could occur)

Category Explanation	**Score / Rating**
Fatality (Death)	15
Loss of limbs, eyes, or serious permanent occupational illness	8
Loss of one limb, one eye, or serious (temporary) occupational illness	4
Break of major bone, or minor permanent occupational illness	2
Break of minor bone, or minor temporary occupational illness	1
Laceration or mild ill-health effect	0.5
Scratch or bruise	0.1

b) Likelihood of Occurrence (LO)

Category	**Explanation**	**Score / Rating**
Certain or Imminent	No doubt	15
Likely	To be expected	10
Probable	Not surprised if it did	8
Even Chance	Could Happen	5
Possible	But unusual	2

Unlikely	But could occur	1
Highly Unlikely	Though conceivable	0.5
Almost Impossible	Possible in extreme circumstances	0.1
Impossible	Cannot Happen	0

c) Frequency of Exposure (FE)

Category	**Score / Rating**
Constantly	5
Hourly	4
Daily	2.5
Weekly	1.5
Monthly	1
Annually	0.2
Infrequently	0.1

d) Number of people at risk at any one time (NP)

Number of persons	**Score / Rating**
> 50	12
16 – 50	8
8 – 15	4
3 – 7	2
1 – 2	1

e) Hazard Rating Number (HRN)

Evaluate the risk by calculating the Hazard Rating Number (HRN = LO x FE x DPH x NP) and compare against the following scale;

S.NO.	**HRN**	**RISK**	**ACTION / TIMESCALE**
1.	0 – 1	Negligible	Accept Risk
2.	1 – 5	Very Low	< 1 year
3.	5 – 10	Low	< 3 months
4.	10 – 50	Medium	< I Month
5.	50 – 100	High	< 1 Week
6.	100 – 500	Very High	< 1 Day
7.	500 – 1000	Extreme	Immediate
8.	> 1000	Totally Unacceptable	Stop Activity

Appendix 3

EVALUATION OF OCCUPATIONAL SAFETY AND HEALTH STATUS QUESTIONNAIRE

Consent to participate in the **JKUAT Occupational Safety and Health Status Evaluation**

This is an academic research being conducted by a postgraduate student in the Institute of Energy and Environmental Technology (IEET) as part of requirements leading to the award of M.Sc. Occupational Safety and Health. The institute invites you to participate in the evaluation exercise, whose mission is to establish the university's current status and inform the management on the findings.

Before completing the questionnaire, note that;

- Your participation is entirely voluntary.
- You will receive no benefits from taking part in the research. However, information provided may help the university improve your Occupational Safety and Health status and greatly improve your work environment.
- No confidential information provided will be used for any other purpose other than for the research.
- The physical risks of participating in this exercise are anticipated to be minimal.
- The burdens associated with participating in the evaluation exercise are;

- Being contacted by IEET about your willingness to participate in research projects approved by the Institute
- Being sent additional questionnaires and follow-up surveys on continuing basis.

I agree to participate in the **JKUAT Occupational Safety and Health Status Evaluation**

Designation: ______________________________ Section: _______________

Signature of participant: ______________________________ Date: _________

Please return the filled questionnaire to:	Daniel Omondi Onyango M.Sc. Occupational Safety and Health (IEET)	Phone: 0720 910 397 E-mail: domondi5@yahoo.co.uk

Kindly note that this questionnaire is being distributed by the systems administrator through the intranet and it is possible that you may receive more than one copy. Should this happen, please respond to only one questionnaire.

OCCUPATIONAL SAFETY AND HEALTH HAZARD SURVEY

1. Heat / cold stress

Y	**N**	Are any staff / students routinely exposed to extremely hot work environments?
Y	**N**	Are any staff / students routinely exposed to extremely cold working environments?

2. Ergonomics / human factors

Do you have any of the following ergonomic / human factors activities in your work area?

Y	**N**	Repetitive motion?
Y	**N**	Material handling?
Y	**N**	Prolonged standing?
Y	**N**	Stress (due to work environment)?
Y	**N**	Vibration hazards? (e.g. jack hammers, grinding wheels, portable drills, etc.)

Other (please specify) ____

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3. Laser – class (I – IV)

Y	**N**	Do you have any lasers in your work area?

If yes, which of the following sources do you have and what class (I – IV) are they?

Y	**N**	**N/A**	Welding	CLASS ________________
Y	**N**	**N/A**	Cutting	CLASS ________________
Y	**N**	**N/A**	Alignment devices	CLASS ________________
Y	**N**	**N/A**	Microscopes	CLASS ________________

Y	**N**	Are safety glasses used?
Y	**N**	Do you have laser warning signs posted?

4. Noise

Y	**N**	Do you have areas where normal speech is difficult to understand?
Y	**N**	Has noise survey been done in your area?
Y	**N**	Have you identified all noise producing equipment / processes?
Y	**N**	Are ear protection signs posted on all noise producing equipment / process areas?

5. Ventilation

Y	N	
		Do you use exhaust systems in your area?

If yes, which of the following do you use?

Y	N	N/A	
Y	N	N/A	Fans
Y	N	N/A	Exhaust vent – hood
Y	N	N/A	Exhaust vent – slots
Y	N	N/A	Exhaust vent – flex duct / element trunk
Y	N	N/A	Hoods

Y	N	
Y	N	Do you have an air exhaust system?
Y	N	Is the temperature adequate in hot months in your area?
Y	N	Is humidity a problem in your area?
Y	N	Is the flow rate of ventilation system checked annually?
Y	N	Are all ventilation systems on a preventive maintenance schedule?

6. Protective clothing

Which of the following protective clothing do you use?

Y	**N**	Aprons
Y	**N**	Overalls
Y	**N**	Protective suits
Y	**N**	Shoe coveralls
Y	**N**	Leggings

Other (please specify) ____________________________________

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7. Illumination

Has light survey been performed to identify the following in your area?

Y	**N**	General lighting
Y	**N**	Supplemental lights
Y	**N**	Glare
Y	**N**	Poor lighting

8. Compressed gases

Y	**N**	**N/A**	Do you have compressed gases in your area?
Y	**N**	**N/A**	If yes, are compressed gas cylinders legibly marked to identify the gas containers?

9. Hand protection

Are any of the following gloves used in your area?

Y	**N**	Cut resistant gloves
Y	**N**	Dust gloves
Y	**N**	Heat resistant gloves
Y	**N**	General purpose gloves

10. Head protection

Are any of the following head protection items used in your area?

Y	**N**	Hard hat
Y	**N**	Welding helmets

11. Eye protection

Do you require the following eye protection in your area?

Y	**N**		Safety glasses
Y	**N**		Safety goggles
Y	**N**		Safety glasses with side shields
Y	**N**		Prescription safety glasses with side shields
Y	**N**		Face shields
Y	**N**		Do you have access to safety showers in an emergency?
Y	**N**		Do you have access to eye wash in an emergency?
Y	**N**	**N/A**	Are safety showers checked monthly?
Y	**N**	**N/A**	Are wash stations checked weekly and tagged?

12. Respirators

Y	**N**	Is respiratory protection required in your area?

If yes, which of the following respirators are used?

Y	**N**	**N/A**	Air purifying respirators (Chemical cartridge)
Y	**N**	**N/A**	Air purifying respirators - HEPA cartridge
Y	**N**	**N/A**	Powered air purifying respirators (PAPR)
Y	**N**	**N/A**	Supply air
Y	**N**	**N/A**	Self contained breathing apparatus (SCBA)

Other (please specify) ________________________________

Y	**N**	Is/are the correct type/s of respirator/s readily available for use on demand?
Y	**N**	Do you have a written respirator program?
Y	**N**	Are your staff / students trained / retrained on fire / first aid annually?
Y	**N**	Does your department provide hazard communication training for staff / students?

13. General safety

How does safety at your work environment compare with similar settings in other universities?

a) about the same
b) better than most
c) worse than most
d) no experience

14. Accident / Incident register

Y	**N**	Does the department have a formal accident / incidence register?

How many accidents / injuries were sustained at your workstation last academic year?

a) 0(none) b) 1 – 10 c) 11 - 50 d) above 50

15. Safety policies

Y	N

Do you have any safety policies currently in place at your workplace?

If yes, list down four major policies and attach copies if possible.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

16. List five major safety measures in place in your work environment.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

17. Comment on the effectiveness of existing safety measures in place in your work environment.

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18. Suggest additional measures that may help improve Occupational Safety and Health within your work environment.

Appendix 4

THE PROGRAM EVALUATION PROFILE (PEP)

FOR

ENGINEERING WORKSHOPS

PEP is a tool used in evaluating an employer's safety programs and as a source of safety and health program evaluation for the employees and the Directorate of Occupational Safety and Health.

To complete my research work on **"EVALUATION OF OCCUPATIONAL SAFETY AND HEALTH STATUS OF PUBLIC INSTITUTIONS OF HIGHER LEARNING IN KENYA: A CASE STUDY OF JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY"** I need your input in filling this evaluation form by checking **the most applicable** answer for each subheading under the major headings that best describes your safety and efforts in the department.

The **six** elements to be scored in the PEP are:

1. Management Leadership and Employee Participation.
2. Workplace Analysis.
3. Accident and Record Analysis.
4. Hazard Prevention and Control.
5. Emergency Response.
6. Safety and Health Training.

These elements [except for (6), Training] are divided into factors, which will also be scored. The score for an element will be determined by the factor scores. The factors are:

1. Management Leadership and Employee Participation.

a. Management leadership.

b. Employee participation.

c. Implementation [*tools provided by management, including budget, information, personnel, assigned responsibility, adequate expertise and authority, line accountability, and program review procedures*].

d. Contractor safety.

2. Workplace Analysis.

a. Survey and hazard analysis.

b. Inspection.

c. Reporting.

3. Accident and Record Analysis.

a. Investigation of accidents and near-miss incidents.

b. Data analysis.

4. Hazard Prevention and Control.

a. Hazard control.

b. Maintenance.

c. Medical program.

5. Emergency Response.

d. Emergency preparedness.

e. First aid.

6. Safety and Health Training (as a whole).

Each of the elements and factors of the PEP may be scored from 1 to 5

NOTE: The descriptors are intended as brief illustrations of a workplace at a particular level.

MANAGEMENT LEADERSHIP AND EMPLOYEE PARTICIPATION
Management Leadership
Visible management leadership provides the motivating force for an effective safety and health program

1	Management demonstrates no policy, goals, objectives, or interest in safety and health issues in this department
2	Management sets and communicates safety and health policy and goals, but remains detached from all other safety and health efforts
3	Management follows all safety and health rules, and gives visible support to the safety and health efforts of others
4	Management participates in significant aspects of the department's safety and health program, such as department inspections, incident

	reviews, and program reviews. Incentive programs that discourage reporting of accidents, symptoms, injuries, or hazards are absent. Other incentive programs may be present.
5	Department safety and health issues are regularly included on agendas of management operations meetings. Management clearly demonstrates – by involvement, support, and example – the primary importance of safety and health for everyone in the department. Performance is consistent and sustained or has improved over time.

MANAGEMENT LEADERSHIP AND EMPLOYEE PARTICIPATION
Employee Participation
Employee participation provides the means, through which workers identify hazards, recommend and monitor abatement, and otherwise participate in their own protection.

1	Workers participation in workplace safety and health concerns is not encouraged. Incentive programs are not present which have the effect of discouraging reporting of incidents, injuries, potential hazards or symptoms. Employees / employee representatives are not involved in the safety and health program.
2	Workers and their representatives can participate freely in safety and health activities in the department without fear of reprisal. Procedures

	are in place for communication between employer and workers on safety and health matters. Workers rights under the Occupational Safety and Health Act 2007 to refuse or stop work that they reasonably believe involves imminent danger are understood by workers and honoured by management. Workers are paid while performing safety activities.
3	Workers and their representatives are involved in the safety and health program, involved in inspection of work area, and are permitted to observe monitoring and receive results. Workers' and representatives' right of access to information is understood by workers and recognized by management. A documented procedure is in place for raising complaints of hazards or discrimination and receiving timely employer responses.
4	Workers and their representatives participate in workplace analysis, inspections and investigations, and development of control strategies throughout the department, and have necessary training and education to participate in such activities. Workers and their representatives have access to all pertinent health and safety information, including safety reports and audits. Workers are informed of their right to refuse job assignments that pose serious hazards to themselves pending management response.
5	Workers and their representatives participate fully in development of the

	safety and health program and conduct of training and education. Workers participate in audits, program reviews conducted by management or third parties, and collection of samples for monitoring purposes, and have necessary training and education to participate in such activities. Employer encourages and authorizes employees to stop activities that present potentially serious safety and health hazards.

MANAGEMENT LEADERSHIP AND EMPLOYEE PARTICIPATION
Implementation
Implementation means tools, provided by management, that include: • budget • information • personnel • assigned responsibility • adequate expertise and authority • means to hold responsible persons accountable (line accountability) • program review procedures.

1	Tools to implement a safety and health program are inadequate or missing
2	Some tools to implement a safety and health program are adequate and effectively used; others are ineffective or inadequate. Management

	assigns responsibility for implementing a department safety and health program to identified person(s). Management's designated representative has authority to direct abatement of hazards that can be corrected without major capital expenditure.
3	Tools to implement a safety and health program are adequate, but are not all effectively used. Management representative has some expertise in hazard recognition and applicable Occupational Safety and Health requirements. Management keeps or has access to applicable Occupational Safety and Health standards at the facility, and seeks appropriate guidance information for interpretation of Occupational Safety and Health Act (OSHA) standards. Management representative has authority to order / purchase safety and health equipment.
4	All tools to implement a safety and health program are more than adequate and effectively used. Written safety procedures, policies, and interpretations are updated based on reviews of the safety and health program. Safety and health expenditures, including training costs and personnel, are identified in the department's budget. Hazard abatement is an element in management performance evaluation.
5	All tools necessary to implement a good safety and health program are more than adequate and effectively used. Management safety and health representative has expertise appropriate to department size and processes, and has access to professional advice when needed.

	Safety and health budgets and funding procedures are reviewed periodically for adequacy.

MANAGEMENT LEADERSHIP AND EMPLOYEE PARTICIPATION
Contractor Safety
Contractor safety: An effective safety and health program protects all personnel on the worksite, including the employees of contractors and subcontractors. It is the responsibility of management to address contractor safety.

1	Management makes no provision to include contractors within the scope of the worksite's safety and health program.
2	Management policy requires contractor to conform to OSHA regulations and other legal requirements.
3	Management designated a representative to monitor contractor safety and health practices, and that individual has authority to stop contractor practices that expose host or contractor employees to hazards. Management informs contractor and employees of hazards present at the department.
4	Management investigates a contractor's safety and health record as one of the bidding criteria.
5	The department's safety and health program ensures protection of

	everyone employed at the worksite, i.e., regular full-time employees, contractors, temporary and part-time employees.

WORKPLACE ANALYSIS
Survey and Hazard Analysis
Survey and hazard analysis: An effective, proactive safety and health program will seek to identify and analyze all hazards. In large or complex workplaces, components of such analysis are the comprehensive survey and analysis of job hazards and changes in conditions.

1	No system or requirement exists for hazard review of planned / changed / new operations. There is no evidence of a comprehensive survey for safety or health hazards or for routine job hazard analysis.
2	Surveys for violations of standards are conducted by knowledgeable person(s), but only in response to accidents or complaints. The employer has identified principal OSHA standards which apply to the worksite.
3	Process, task, and environmental surveys are conducted by knowledgeable person(s) and updated as needed and as required by applicable standards. Current hazard analyses are written (where appropriate) for all high-hazard jobs and processes; analyses are communicated to and understood by affected employees. Hazard

	analyses are conducted for jobs / tasks / workstations where injury or illnesses have been recorded.
4	Methodological surveys are conducted periodically and drive appropriate corrective action. Initial surveys are conducted by a qualified professional. Current hazard analyses are documented for all work areas and are communicated and available to the entire workforce; knowledgeable persons review all planned / changed / new facilities, processes, materials, or equipment.
5	Regular surveys including documented comprehensive workplace hazard evaluations are conducted by certified safety and health professional or professional engineer, etc. Corrective action is documented and hazard inventories are updated. Hazard analysis is integrated into the design, development, implementation, and changing of all processes and work practices.

WORKPLACE ANALYSIS
Inspection
Inspection: To identify new or previously missed hazards and failures in hazard controls, an effective safety and health program will include regular department inspections.

Appendix 4

1	No routine physical inspection of the workplace and equipment is conducted.
2	Supervisors dedicate time to observing work practices and other safety and health conditions in work areas where they have responsibility.
3	Competent personnel conduct inspections with appropriate involvement of employees. Items in need of correction are documented. Inspections include compliance with relevant OSHA standards. Time periods for correction are set.
4	Inspections are conducted by specifically trained employees, and all items are corrected promptly and appropriately. Workplace inspections are planned, with key observations or check points defined and results documented. Persons conducting inspections have specific training in hazard identification applicable to the department. Corrections are documented through follow-up inspections. Results are available to workers.
5	Inspections are planned and overseen by certified safety and health professionals. Statistically valid random audits of compliance with all elements of the safety and health program are conducted. Observations are analyzed to evaluate progress.

Appendix 4

WORKPLACE ANALYSIS
Hazard Reporting
A reliable hazard reporting system enables employees, without fear of reprisal, to notify management of conditions that appear hazardous and to receive timely and appropriate responses.

1	No formal hazard reporting system exists, or employees are reluctant to report hazards.
2	Employees are instructed to report hazards to management. Supervisors are instructed and are aware of a procedure for evaluating and responding to such reports. Employees use the system with no risk of reprisals.
3	A formal system for hazard reporting exists. Employee reports of hazards are documented, corrective action is scheduled, and records maintained.
4	Employees are periodically instructed in hazard identification and reporting procedures. Management conducts surveys of employee observations of hazards to ensure that the system is working. Results are documented.
5	Management responds to reports of hazards in writing within specified time frame. The workforce readily identifies and self-corrects hazards; they are supported by management when they do so.

Appendix 4

ACCIDENT and RECORD ANALYSIS
Accident Investigation
Accident investigation: An effective program will provide for investigation of accidents and near “miss” incidents, so that their causes, and the means for their prevention, are identified.

1	No investigation of accidents, injuries, near misses, or other incidents is conducted.
2	Some investigation of incidents takes place, but root cause may not be identified, and correction may be inconsistent. Supervisors prepare injury reports for lost time cases.
3	The prescribed form is completed for all recordable incidents. Reports are generally prepared with cause-identification and corrective measures prescribed.
4	OSHA-recordable incidences are always investigated, and effective prevention is implemented. Reports and recommendations are available to employees. Quality and completeness of investigations are systematically reviewed by trained safety personnel.
5	All loss-producing accidents and “near-misses” are investigated for root causes by teams or individuals that include trained safety personnel and employees.

ACCIDENT and RECORD ANALYSIS
Data Analysis
Data analysis: An effective program will analyze injury and illness records for indications of sources and locations of hazards, and jobs that experience high numbers of injuries. By analyzing injury and illness trends over time, patterns with common causes can be identified and prevented.

1	Little or no analysis of injury / illness records; general registers are kept or conducted in accordance with the Occupational Safety and Health Act.
2	Data is collected and analyzed, but not widely used for prevention. A general register is completed for all recordable cases. Exposure records are analyzed and organized and are available to safety personnel.
3	Injury / illness logs and exposure records are kept correctly, are audited by department personnel, and are essentially accurate and complete. Rates are calculated so as to identify high risk areas and jobs. Workers compensation claim records are analyzed and the results used in the program. Significant analytical findings are used for prevention.
4	Employer can identify the frequent and most severe problem areas, the high risk areas and job classifications, and any other exposures responsible for OSHA recordable cases. Data are fully analyzed and

	effectively communicated to employees. Illness / injury data are audited and certified by a responsible person.
5	All levels of management and the workforce are aware of results of data analysis and resulting preventive activity. External audits of accuracy of injury and illness data, including review of all available data sources are conducted. Scientific analysis of health information, including non-occupational data bases is included where appropriate in the program.

HAZARD PREVENTION and CONTROL
Hazard Control
Hazard Control: Workforce exposure to all current and potential hazards should be prevented or controlled by using engineering controls wherever feasible and appropriate, work practices and administrative controls, and personal protective equipment (PPE).

1	Hazard control is seriously lacking or absent from the department.
2	Hazard controls are generally in place, but effectiveness and completeness vary. Serious hazards may still exist. Employer has achieved general compliance with applicable OHSA standards regarding hazards with a significant probability of causing serious physical harm. Hazards that have caused past injuries in the department have been corrected.

3	Appropriate controls (engineering, work practice, and administrative controls, and PPE) are in place for significant hazards. Some serious hazards may exist. Employer is generally in compliance with voluntary standards, industry practices, and manufacturer's and suppliers' safety recommendations. Documented reviews of needs for machine guarding, energy lockout, ergonomics, materials handling, blood borne pathogens, confined spaces, hazard communication, and other generally applicable standards have been conducted.
4	Hazard controls are fully in place, and are known and supported by the workforce. Few serious hazards exist. The employer requires strict and complete compliance with all OSHA, consensus, and industry standards and recommendations. All deviations are identified and causes determined.
5	Hazard controls are fully in place and continually improved upon based on workplace experience and general knowledge. Documented interviews of needs are conducted by certified health and safety professionals or professional engineers, etc.

HAZARD PREVENTION and CONTROL
Maintenance
Maintenance: An effective safety and health program will provide for facility and equipment maintenance, so that hazardous breakdowns are

prevented.

1	No preventive maintenance program is in place; break-down maintenance is the rule.
2	There is a preventive maintenance schedule, but it does not cover everything and may be allowed to slide or performance is not documented. Safety devices on machinery and equipment are generally checked before each production shift / student practice session.
3	A preventive maintenance schedule is implemented for areas where it is most needed; it is followed under normal circumstances. Manufacturers' and industry recommendations and consensus standards for maintenance frequency are compiled with. Breakdown repairs for safety related items are expedited. Safety device checks are documented. Ventilation system function is observed periodically.
4	The employer has effectively implemented a preventive maintenance schedule that applies to all equipment. Departmental experience is used to improve safety-related preventative maintenance scheduling.
5	There is a comprehensive safety and preventive maintenance program that minimizes equipment reliability.

HAZARD PREVENTION and CONTROL
Medical Program
An effective safety and health program will include a suitable medical program where it is appropriate for the size and nature of the workplace and its hazards.

1	Employer is unaware of, or unresponsive to medical needs. Required medical surveillance, monitoring and reporting are absent or inadequate.
2	Required medical surveillance, monitoring, removal, and reporting responsibilities for applicable standards are assigned and carried out, but results may be incomplete or inadequate.
3	Medical surveillance, removal, monitoring, and reporting comply with applicable standards. Employees report early signs / symptoms of job-related injury or illness and receive appropriate treatment.
4	Healthcare providers provide follow-up on employee treatment protocols and are involved in hazard identification and control in the workplace. Medical surveillance addresses conditions not covered by specific standards. Employee concerns about medical treatment are documented and responded to.
5	Healthcare providers are within the department for all production shifts and are involved in hazard identification and training. Health care

	providers periodically observe the work areas and activities and are fully involved ion hazard identification and training

EMERGENCY RESPONSE
Emergency Preparedness
Emergency preparedness: There should be appropriate planning, training / drills, and equipment for response to emergencies.

1	Little or no effective effort to prepare for emergencies.
2	Emergency response plans for fire, chemical, and weather emergencies as required by the OS&H Act are present. Training is conducted as required by the applicable standard. Some deficiencies may exist.
3	Emergency response plans have been prepared by persons with specific training. Appropriate alarm systems are present. Employees are trained in emergency procedures. The emergency response extends to spills and incidents in routine production. Adequate supply of spill control and PPE appropriate to hazards in the department is available.
4	Evacuation drills are conducted no less than annually. The plan is reviewed by a qualified safety and health professional.
5	Designated emergency response team with adequate training is in the department. All potential emergencies have been identified. Plan is

	reviewed by the local fire department. Plan and performance are reevaluated at least annually and after each significant incident. Procedures for terminating an emergency response condition are clearly defined.

EMERGENCY RESPONSE
First Aid
First aid / emergency case should be readily available to minimize harm if an injury or illness occurs.

1	Neither within the department nor nearby community aid (e.g., emergency room) can be ensured.
2	Either within the department or nearby community aid is available on every shift.
3	Personnel with appropriate first aid skills commensurate with likely hazards in the workplace and as required by the OSHA standards are available. Management documents and evaluates response time on a continuing basis.
4	Personnel with certified first aid skills are always available in the department or in close proximity; their level of training is appropriate to the hazards of the work being done. Adequacy of first aid is formally reviewed after significant incidents.

5	Personnel trained in advanced first aid and / or emergency medical care are always available in the department or located within close proximity.

SAFETY and HEALTH TRAINING
Safety and health training should cover the safety and health responsibilities of all personnel who work at the department or affect its operations. It is most effective when incorporated into other training about performance requirements and job practices. It should include all subjects and areas necessary to address the hazards at the department.

1	The department depends on experience and peer training to meet needs. Managers / supervisors demonstrate little or no involvement in safety and health training responsibilities.
2	Some orientation training is given to new hires. Some safety training materials (e.g., pamphlets, posters, video tapes) are available or are used periodically at safety meetings, but there is little or no documentation of training or assessment of worker knowledge in this area. Managers generally demonstrate awareness of safety and health responsibilities, but have limited training themselves or involvement in the department's training program.
3	Training includes OSHA rights and access to information. Training required by applicable standards is provided to all department

	employees. Supervisors and managers attend training in all subjects provided to employees under their direction. Employees can generally demonstrate the skills / knowledge necessary to perform their job safely. Records of training are kept and training is evaluated to ensure that it is effective.
4	Knowledgeable persons conduct safety and health training that is scheduled, assessed, and documented, and addresses all necessary technical topics. Employees are trained to recognize hazards, violations of OSHA standards, and facility practices. Employees are trained to report violations to management. All department employees – including supervisors and managers – can generally demonstrate preparedness for participation in the overall safety and health program. There are easily retrievable scheduling and record keeping systems.
5	Knowledgeable persons conduct safety and health training that is scheduled, assessed, and documented. Training covers all necessary topics and situations, and includes all persons working at the department (students, supervisors, managers, contractors, part-time, permanent and temporary employees). Employees participate in creating department-specific training methods and materials. Employees are trained to recognize inadequate responses to reported program violations. Retrievable record keeping system provides for appropriate retraining, makeup training, and modifications to training as the result of evaluations.

ASSESSMENT OF THE STATUS OF NOISE AND VIBRATION AT THE WORKPLACE

1. **Place of work** ______________________________

2. **Measuring facility to be used** ______________________________

3. **Technical parameters of measuring equipment** ______________

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4. **Certificate of previous assessment if any: (Date and number of certificate)** ______________________________

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5. **Main sources of noise (vibration) and the character of noise (vibration) produced**

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6. **Number of working persons involved:** ______________________

7. **Sketch of a place (territory, working place, hand machine) with which the source of noise (vibration) and using arrow pointing to the place of installation and orientation of microphone (Sensors) sequence number of measuring points.**

Results of Noise (Vibration) Measurement

Laboratory Works (Noise)

- **Investigation of noise and available facilities for protection against it**
- **Determination of required reduction of noise**
- **Calculation of noise damping screens and clad**
- **Determination of expected level of noise at the working place**

STUDY SITE

A6 – 1 An aerial view of part of Jomo Kenyatta University of Agriculture and Technology (Google Maps, 2009)