UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

ASSESSMENT OF OCCUPATIONAL HEALTH AND SAFETY OF WOOD MACHINING OPERATION AT A WOOD PROCESSING AND MARKETING CENTRE IN GHANA

MARK BRIGHT DONKOH

(MPhil, BEd. Cert "A")

MAY, 2021

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A Thesis in the Department of Construction and Wood Technology Education, Faculty of Technical Education, submitted to the School of Research and Graduate Studies, University of Education, Winneba, in partial fulfilment of the requirements for award of the Doctor of Philosophy (Wood Science and Technology) degree

MAY, 2021

DECLARATION

STUDENT'S DECLARATION

I, MARK BRIGHT DONKOH, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …………………………

DATE: …………………………………

SUPERVISOR'S DECLARATION

We hereby declare that the preparation and presentation of this dissertation was supervised in accordance with the guidelines and supervision of thesis as laid down by the University of Education, Winneba.

SUPERVISOR: PROF. STEPHEN JOBSON MITCHUAL

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SUPERVISOR: PROF. EMMANUEL DARTEY

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DATE: …………………………………

ACKNOWLEDGEMENTS

I would like to give my sincere appreciation and thanks to my supervisors, Prof. Stephen Jobson Mitchual and Prof. Emmanuel Dartey for their valuable guidance, enthusiastic support and continuous encouragement that steer me on the right path while undertaking this research. I wish to thank sincerely, all the lecturers and staff I worked with in the course of this programme. I cannot forget their pool of knowledge in which I swam, and their constant encouragement to me to finish up.

I also acknowledge the assistance of Dr. Humphrey Danso, Dr. Yehands Arthur all of University of Education, Winneba – Kumasi campus, Mr. Adepa Appiah of University of Education, Winneba – Mampong campus chemistry laboratory, Mr. Yaw Krah of Sokoban Wood Village, Mr. Haruna Seidu, Mr. Anthony Abotiatsi and Mr. Ahmed Saeed all of Forestry Research Institute of Ghana of Centre for Scientific and Industrial Research.

Finally, I would like to thank Mrs. Margaret Sefa Ansaa Donkoh my wife, my brothers, sisters, and children (Wilhemina Aba Takyiwaa Donkoh, Wilhelina Aba Takyiwaa Donkoh, Mercylove Ama Kumiwaa Donkoh and Nhyiraba Adepa Nana Adjoa Donkoh, Mr Senanu Zoiku and Kwame Antwi-Boasiko for their patience, prayers and unflinching support, especially in the course of my study and to all who contributed directly or indirectly towards the success of this work, I say, God bless you.

DEDICATION

To Mrs. Margaret Sefa Ansaa Donkoh, Mrs Joyce Jobson Mitchual, Miss Mary Ampong Mensah, Mr. Paul Kingsley Tachie and Mr. Isaac Kofi Adu who really encouraged and supported me throughout this work.

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ABSTRACT

The woodworking industry is considered to be a risk-prone working environment since every working item and materials used present potential danger through accidents or health risk. Workers in the woodworking industry are also faced with potential accidents that can be caused by flying wood chips and some parts of the machines that may be broken. This study assessed the occupational health and safety hazard associated with wood machining operation in a selected wood processing and marketing centre in Ghana. The study adopted mixed approach design of observation, cross-sectional survey, experimental and interventional design. Positivism and phenomenologist philosophical paradigms as well as inductive and deductive research approaches were used. The data was analyzed using Statistical Package for Social Scientist. Findings from the study indicate that none of the wood processing machines assessed had operator's manual, safety code or signs on them. Most of the safety parts were absent. However, few were improvised. The mean ratings of machine operator's adherence to practicing occupational health and safety were lower than the theoretical mean of 3.0. This implies that the machine operators do not practice occupational health and safety. The study also revealed that, there was heavy metal concentration of airborne particulate such as Arsenic, Cadmium, Copper, Iron, Lead, Manganese and Zinc in the sawdust the workers were exposed to. Metal concentration levels exposed to by the workers were above Occupational Safety and Health Administration and Environmental Protection Agency permissible exposure limits (PEL) thresholds. On workers exposure to sawdust, the result indicates that workers do experience headache, nausea, eye and skin irritation, shortness in breathing and coughing. Again, the operation and activities of the woodworkers could significantly influence their exposure to sawdust. Additionally, the study revealed that the woodworkers were not provided with personal protective equipment during their

operations. Furthermore, the study revealed that training could significantly influence the woodworkers' practice of occupational health and safety in the wood processing industry. The outcome of this study suggests that the management of the enclave studied need to do more to enforce practice of safety, especially the use of personal protective equipment, to reduce hazards and injuries associated with wood processing industry.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Keeping the workplace safe must not be the concern of only workers and companies but also national and global economies whose productivity and competitiveness play a major role on safe working environment. To improve health and safety measures at the workplace with the aim of ensuring continuous labour productivity, every business entity needs to put in place pragmatic health and safety practices that will address industrial accidents resulting in injury and death of workers (Ganson, 2014). Accidents are costly to an organization due to a variety of outcomes including; demotivation of workers, disruptions of activities, delayed progress of work, additional adverse effects of the organizations overall cost structure, productivity and reputation (Mohammed, 1999). This implies that, improved safety performance in the wood processing industry should be a primary concern for both laborers and managers at all levels.

The International Labour Organisation considers issues relating to occupational health and safety to be of much importance to the extent that it has devoted about 80% of its standards and instruments either wholly or partly to it (Alli, 2008). This notwithstanding, currently around 160 million people are estimated to suffer from occupational diseases. Additionally, two million people die every year as a result of occupational accidents and work-related diseases and injuries (ILO, 2013). These numbers may translate into an estimate of nearly 5 percent loss of the world's GDP (Alli, 2008). Furthermore, according to the World Health Organization as cited in (Amponsah-Tawiah & Dartey-Baah, 2011), poor occupational health and safety reduced working capacity of workers may cause economic loss up to 10-20% of the Gross National Product of many countries for which Ghana is not an exception.

The International Labour Organization estimates that workers suffer 270 million accidents and at least 335 000 fatal injuries annually. Avoidable occupational diseases affect 160 million people every year. Ghana has no national policy on occupational health and safety, even though article 4 of the International Labour Organization Convention 155 (Occupational Safety and Health Convention, 1981) requires every nation to give attention to the provisions of this convention. The aim of this convention is to prevent each injury to health arising out of or linked with or occurring in the course of work. The International Labour Organization Convention 155 requires each member state to formulate, implement and periodically review a coherent national policy on occupational health and safety at the work environment.

A draft on health and safety policy in Ghana, jointly developed by the ministries of Labour, Health, Mines and Energy as far back in the year 2000 is yet to be adopted. The current National Labour Act 651 does not include any comprehensive provisions on occupational health and safety. There is also no institutional facility for training of occupational health and safety professionals at the local levels. Training of occupational health and safety professionals has largely been at the mercy of donor organizations outside the country. The occupational health and safety of persons employed in work places (with the exception of agriculture, rail and road transport) in Ghana are regulated by the Department of Factories Inspectorate.

The inspectorate is responsible for the promotion and enforcement of regulatory measures to give effect to the provisions of the Factories, Offices and shops Act Atomic

Energy Commission, the Ministry of Health and Mines Department which play complementary role in the promotion, but not enforcement of occupational health and safety measures. Traumatic occupational accidents and diseases in the sector represent a significant public concern. Work-related accidents induce enormous emotional and financial costs to families and to society (Balsari et al, 2014). Unfortunately, work-related accidents and diseases continue to be serious in the world. The human and economic cost of occupational accidents and diseases remain high and call for concerted efforts to handle them (Abongomera, 2008).

1.2 Statement of the Problem

The lives and health of employees are important not only for production but for society, family and for the general economic well-being. A job riddled with accidents, diseases, and fatalities can accumulate bad repute, and can lead to defamed corporate image. A safe and healthy working environment therefore builds competitive advantage by attracting a wider employee base during recruitment, running smooth production processes, avoiding loss of working days and avoiding expensive compensations.

Studies by the U.S Bureau of Labour Statistics reported that in 1980 there were 4,400 work-related deaths, 5.6 million occupational injuries and illnesses, and over 41.8 million lost work days resulting from employment hazards (Mellow and Sider, 2009). ILO (2013) also indicated that, globally two million people die every year as a result of occupational accidents and work-related diseases and injuries.

Additionally, there were 2.33 million work-related mortalities in 2014, and in 2015 work-related deaths accounted for five percent of the global total mortality (Work Safety and Health Institute, 2016). Work-related mortality is, however, on the increase given that it is estimated to reach 2.78 million in 2017 (Work and Safety Institute, 2017). The biggest share of work-related mortality comes from work-related diseases which accounted for 2.4 million (86.3%) of the total estimated deaths. Fatal accidents accounts for the remaining 13.7% of work-related mortality.

Even though, the direct rational for prioritizing occupational health and safety are the curtailment of deaths, injuries, and loss of working hours, there are also benefits in reducing employee injury and death-related compensation. In 1980, estimates of compensation accruing to employees as a result of work-related deaths, injuries, and illnesses were in excess of 2.1 million U. S. A. dollars (ILO, 2012). In the United States, the Occupational Health and Safety Administration (2017) estimated that employers pay almost 1 billion dollars per week for direct workers' compensation costs alone.

With lives and production at risk, the quest to understand and model occupational safety measures and standards, as well as compensation schemes for workers have been endless. Studies such as Hasle and Limborg, 2018; Hasle et al., 2012; Olsen et al., 2012, have investigated models for delivering occupational health and safety to business. Smith and Carayon (2009) used the balanced model to explain how workplace accidents occur and how to reduce them.

The balanced model of job design, introduced by Smith and Carayon (2009) postulates that various components of the workplace interact to increase and decrease workplace safety and health risk, and that careful ‘balancing’ of the components can reduce risk and improved employee safety and health. The models are largely based on the accident theory, which sees an accident as a sudden and unwanted result of the interaction between people and objects, which harms the worker (ILO, 1995). The OECD (2002) indicated that occupational accident refers to an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work, which results in one or more workers incurring a personal injury, disease or death. In that sense, occupational safety is theorised as a healthy interaction between workers and objects, which prevents harm to employees and which also prevents tasks from being unreasonably difficult, but helps in yielding the possible highest level of productivity.

The accident theory encompasses an array of individual theories that seek to explain the causes and prevention schemes of workplace accidents, thus, maintaining occupational safety. Heinrich (1941) developed a pioneering accident causation theory, which proposed a five-factor accident sequence. The factors included ancestry and social environment, worker fault, unsafe act together with mechanical and physical hazard, accident, and damage. The theory stipulated that each factor would initiate the next step in a manner of toppling dominoes lined up in a row. The theory was therefore known as the domino theory. Heinrich proposed that the key domino is number three and when removed would prevent accidents and damage.

Another major theory, known as the multiple causation theory, maintains that accidents do not occur in a lined sequence, but as a result of multiple factors acting together at the same time. The theory proposes that there may be prime causes acting together with sub-causes to result in a single accident. The theory categorises contributory factors of accidents into behavioural and environmental factors. The behavioural factors pertain to the worker, and may include improper attitudes, lack of knowledge or skill, and inadequate mental or physical ability. Environmental factors on the other hand, include improper guarding of other hazardous work element, unsafe procedures, and degradation of equipment. To prevent accidents, this theory suggests simultaneously reducing the risks caused by behavioural and environmental factors. This encompasses the Human Factors in Accidents Model, and the Risk Homeostatic Accident Model. The Hale and Glendon Model as well as the Resident Pathogens and Risk Management Model introduced the concept of residual risks in accident causation and workplace safety modelling. These theories hold that some residual risks remain after risk response and these risks can cause significant accidents at the workplace. In order to maintain occupational safety, this theory proposes the training of employees to both apply appropriate risk treatment and also identify and plan for residual risks.

These studies have been predominantly based on theoretical suppositions that focus on enterprises in the formal sector. This is because these theories and underlying models of occupational safety were founded in industrialized countries that largely do not have informal sectors. In Africa and most of the developing world, informal micro enterprises dominate, therefore, making intermediary models not suitable for risk prevention. According to the ILO (2014), inadequate safety and health standards, and environmental hazards are characteristic of the informal sector. Studies in Mozambique, South Africa, Nigeria and Ghana consent that informal worker consisting mainly of artisans in woodwork, textiles, vehicle repairs, and clothing often work under poor working environment and without adequate welfare facilities and largely non-existent occupational health services.

In Ghana Labour Act (651) of 2003 applies solely to the formal sector, and thus, informal employees are not held under the same regulations. Artisans in the Sokoban Wood village are mainly employed by informal arrangements. Master craftsmen, known as 'masters' accept apprentices who are usually in their early to late teens to learn the craft. The apprentice-master relationship does not necessarily amount to an employer-employee association. The inactiveness of the Act 651 also stems from the fact that more than 80 percent of Ghana's economy has such informal employment arrangements. One area of interest, thus, relates to how workers in the informal sector manage health and safety issues on the job.

There are many studies on occupational safety in the Ghanaian context. Ametepeh et al. (2013) found that a sample of informal workers in Sekondi Takoradi, comprising of mechanics, porters, drivers, and beauticians were exposed to a myriad of physical, ergonomic, and psycho-social occupational hazards. Akazili et al. (2018) also found that informal workers, consisting of porters and hairdressers in the Kassena-Nankana East and West Districts had no health insurance. The Women in Informal Employment Globalizing and Organizing (WIEGO, 2013) concluded in their study that, informal traders in Accra face occupational hazards, predominantly fire, poor sanitation, food poising, theft, harassment, and work-related stress.

In terms of health and safety awareness among informal artisans, Okwabi et al. (2016) indicated that master craftsmen and their apprentices in informal garages in the Accra metropolis had similar level of knowledge of health and safety practices. Generally, their level of awareness was low, but the master craftsmen reported receiving safety awareness training. At Cape Coast, Nana-Otoo (2016), found that informal food processors, textile manufacturers, wood processors, and metal workers did not have the necessary awareness and technical means to implement health and safety measures. A study conducted by Adei and Kunfaa, (2007) indicated that wood processers in Ghana are exposed to physical, ergonomic, mechanical and chemical hazards. The perceived physical hazards in their study were sawdust, noise and extreme high temperature with sawdust inhalation being the major hazard.

Many earlier studies have noted that the issue of health and safety hazards of wood workers are due to inadequate occupational safety and health policy and procedures, low priority given to occupational safety and health issues by Timber and Woodworkers Unions in Ghana, non-commitment by management to implement occupational safety and health policy where it existed and their consideration of payment of insurance premium as sufficient protection for workers (Acquah-Moses, 2002). This current study seeks to assess occupational health and safety of wood machining operations at a wood processing and marketing center in Ghana. The study further laid emphasis on the health risks resulting from improper exposure to the particulate content of wood residue. Additionally, this study will assess provision of personal protective equipment and effect of training on the practice of occupational health and safety by the woodworkers. This will fill the empirical gap and also reinforce the intervention by enlightening the participants on the risk to which they are exposed.

1.3 Research Objectives

Generally, this study assessed the occupational health and safety hazard associated with wood machining at the Sokoban Wood Village (SWV) at the Ashanti Region in Ghana. Specifically, the study assessed the:

1. Availability of safety gadgets on wood processing machines at the SWV
2. Practice of occupational health and safety by machine operators at SWV.
3. Hazard posed by particulate matter resulting from wood processing on workers at SWV.
4. Health hazards associated with wood processing at the SWV.
5. Provision of personal protective equipment to machine operators at SWV.

6. Effect of training on the practice of occupational health and safety by wood machine operators.

1.4 Research Questions

This study on assessment of occupational health and safety hazards associated with wood machining in Ghana was guided by the following research questions.

1. What is the availability of safety gadgets on wood processing machines at the SWV?
2. How do machine operators rate their practice of occupational health and safety?
3. What hazards are posed by particulate matter from wood processing at the SWV?
4. What are health hazards associated with wood processing at the SWV?
5. Are personal protective equipment provided to the machine operators at the SWV?
6. What is the effect of training on the practice of occupational health and safety by wood machine operators?

1.5 Significance of the Study

Although several studies have been carried out in the area of occupational health and safety, there is still a gap which this study would fill especially providing local content to the problem. That is to say, most of the studies conducted on occupational health and safety are foreign based and as such available literature lack local context. The study therefore, is significant so far as it gathers and analyses information in Ghana based industries.

The findings of the study will make available innovative information and new ways of handling occupational safety issues at sawmills in Ghana. This will help to reduce the cost of paying for accident compensation by the sawmill operators in Ghana. Additionally, this study would be useful to policy makers with regard to work place health and safety issues. Policy makers can make use of the findings in policy formulation and implementation on health and safety practices for improved work situations. Furthermore, the findings which were based on well-crafted questionnaire and interviews would furnish organizations that are in work place health and safety advocacy such as trade unions with wealth of information to be used in designing programs to educate and sensitize workers on the issues as well as utilized the information to advance the course of workers welfare.

The management of the Sokoban Wood village would find the findings of the study particularly relevant in coming out with concrete health and safety practices for improved safety and health of workers in the wood village. This is because the analysis of data would be more directly related to what actually pertains in the wood village in terms of employees" level of awareness of their health and safety policies, their attitude and behaviour towards such policies.

Finally, the findings of this research will exposure the content of the particulate matter inhaled by the people in the area and its environs and its effect on both human and animal lives in and around the enclave.

1.6 Limitations of the Study

There was reluctance of some key informants to provide certain information which was assumed to be a result of their limited understanding of the research topic or weakness found in the study area. It is usually known that most people do not like to disclose their weak side. Some few informants did not have enough time to fill the questionnaire; in that case, the researcher was obliged to interview them and complete the questionnaire in their presence. Some respondents tried to give wrong information in order to cover their weakness for example, lack of some important facilities.

To minimize the limitation of inadequate understanding of the topic the researcher explains to the respondents what the research is all about and also to control the problem of fear of disclosing the weak points of their work, the researcher assured respondents of anonymity.

1.7 Delimitation of the Study

Although the challenges facing the sawmill industries on standard of occupational health and safety practices is country wide, the focus of the study has been limited to Sokoban Wood Village in Kumasi metropolis alone, on the assumption that it is the area where wood processing activities are more concentrated.

1.8 Organization of the Study

This research has been organized in five chapters. Chapter one deals with the background to the study, statement to the problem, objectives of the study, research questions, significance of the study, scope of the research, limitations and organization of the study. Chapter two focuses on the review of related literature while the methodology of the study is the subject of chapter three. The chapter three presents the methods and procedures employed to collect data for the study. It covers the study area, research design, the population, sample and sampling techniques, data collection instrument, validity and reliability, data collection procedures, and data analysis techniques. In chapter four, presentation, analysis and discussion of results are presented. Finally, the summary of findings, conclusions, recommendations and suggestions for further research are catered for by chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviewed a number of related literature from published and unpublished books, journals and relevant information on what others have said and done about the issues.

2.2. Historical Background

According to Hobsbawm (1969), an investigation has been undertaken into the history of health and safety legislation to establish whether this offers any understanding of the contextual implications within which employers are currently managing the risks inherent within their undertakings. The need to operate closely within the highly prescriptive confines of legislative requirements was a phenomenon of the pre-1974 legislative era. The legacy of that approach and subsequent direction legislation has taken with the Health and Safety at Work Act 1994 and that which is now European Union led is that, there is the need to be a rapidly developing sophistication in safety management techniques. Employers are now required to 'predict and prevent', rather than 'diagnose and manage'. On that basis, do any remnants of that early legislative background still exist? If they do, do they help to provide an understanding of why, when viewed in the context of workplace safety, there may exist a gap in development methodology relating to the planning and execution of development initiatives, which this review examines?

The advent of the Industrial Revolution was a developing process that became fully evident in the third quarter of the eighteenth century and continued well into the second half of the nineteenth century. It saw a major increase in industrialization, decrease in an agricultural-based economy, and a population explosion which would raise the English and Welsh populations from approximately six and half millions in 1750 to over nine million in 1801. Population was to increase to sixteen million by 1841 Hobsbawm (1969), and was a process which continued throughout the nineteenth century. The appalling working conditions endured by women and children, and men, during this early phase are well documented. In the health and safety field, from a relatively early stage of industrialization, factory owners rather than companies were recognized as being suitable targets for punishment. The 1830's saw the beginning of the recorded history of employer's liability and an effective movement to improve the position of those in employment (Reber et al., 1990).

In 1831, a social reformer was reported as having advised a parliamentary select committee "think it would be a very good thing, instead of having fines as the punishment for breach of the law we should make it imprisonment, flogging and pillory. I have no doubt that that would keep them at it" (Bowen & Ostroff, 1998).

Reflecting the views of influential society, employers' liability during the next one hundred and fifty years developed in three phases. These phases have the common major element of being highly prescriptive in nature, and demanding strict interpretative compliance. There was little scope for a questioning approach to safety based on risk, and it was not until 1974 that a fourth and very different legislative phase appeared. This has imposed significantly differing demands on the employer, requiring him to address the broad range of risk issues associated with his undertaking which were not required under earlier legalization.

2.2.1 Phase one

Dominating the early nineteenth century was the economic theory of laissez faire, in which the welfare of the community was considered to be best served by leaving the individual free to pursue his own interests. Reflecting this theory, the courts ruled that each workman should look after himself and that if he entered employment that was inherently dangerous, he accepted the risks.

The Factory Act of 1833 is considered to be the first piece of effective legislation. Although two previous acts had been passed, one in 1802 to regulate the working conditions of pauper apprentices, and the other in 1819 to limit their hours of work as a result of there being no adequate means of enforcement, neither had been effective. The 1833 Act took the important step of appointing paid factory inspectors, and in doing so set the scene for the eventual conviction of offending employers and their observance of the law, not only in respect of this, but future legislation. It applied to all textile factories except those manufacturing silk goods (which were not at the time considered to be dangerous working environments), and regulated the employment of children. Henceforth, they could only be employed from age 9 and were to be given two hours' daily schooling. Long working hours for adults were left untouched. The 1833 Factory Act was followed in 1842 by the Mines Act, which was largely the result of a Royal Commission set up to look into the employment of children. The report highlighted the conditions endured by women and children in the pits, and had the effect of causing revulsion in public opinion to their predicament. The result was that their employment below ground was entirely forbidden. Furthermore, government inspectors for the mines were also appointed under the Act (the first taking up his duties in 1843, and becoming increasingly effective from the 1850's onwards (Mines Law of 1972). From this early stage, the volume of legislation relating to the mines, as with that concerned with factories, began to grow rapidly.

The process of law making during this first phase was not characterized by a marked concern for safety, but rather an awakening realization that society had a moral duty to protect the exploitation of children at work. The maximum working hours duly imposed, and extended to the protection of women, was the most significant feature of the period. Although by later standards, working conditions were primitive and the improvements were by no means universal, they signaled the gathering pace of changes that were to come. Significantly for safety, the introduction of factory inspectors was, in itself recognition that unless the means existed of enforcing legislation it was unlikely to be effective.

2.2.2 Phase two

Towards the middle of the 19th century, the nature of legislation began to change. As well as there being recognition of the need for the protection of workers in terms of the hours they worked, it began to extend to provide for their protection against dangerous working conditions. An early example may be found in the Factory Act of 1844, which reflected an acceptance of the risk women faced through the contact of their clothing with moving machinery. For the first time, this Act contained the provision for the fencing of machines and was also synonymous with a more humane stance becoming evident in the decisions of the courts. The influence of the factory inspectors began to emerge and the Factory Act of 1853 prepared by the leading factory inspector, Leonard Homer, reduced further the working hours of children. However, the scope for the evasion of legislation was considerable and the period is characterized by each act being largely the result of a campaign centered on a particular hazard or problem (Robens, 1972).

In 1864 statutory protection was extended beyond the textile industries into six new trades, including pottery and matchmaking. In 1867, with the passing of the Workshop Regulation Act, a start was made in regulating conditions 'across the board'. A workshop was defined for the first time, and brought within its scope were great numbers of employees not previously protected. This was because they had operated in an environment that was outside the definition of a factory such as those working in domestic workshops. The 1867 Act also included those not covered by earlier legislation, such as in large places of work e.g. ironworks and glasshouses. It also abandoned the myth that the only purpose of legislation was to protect children, with adults being theoretically capable of protecting themselves (Hobsbawm, 1969). The daily working hours of women and young persons were duly limited to 12, while children less than 8 years of age were prohibited from working at all. By 1876, the difficulties of administering what were often overlapping and contradictory laws led to the setting up of a Royal Commission and to the subsequent consolidating Factory and Workshop Act of 1878. This Act ended the division between the two types of establishments and a general definition of factory premises was made which continued largely unchanged until the major alterations introduced by the Health and Safety at Work etc. Act 1974. The Employers Liability Act of 1880 was a major step forward in the civil law protection afforded to employees. Essentially, a worker might succeed in their claim if they were able to prove that an accident had resulted from a defect in 'the ways, works, machinery or plant'. Alternatively, if it could be established that it was a result of the negligence of a person managing or superintending the work Lord Watson said in Smith v Baker (1891): "The main, although not the sole, object of the Act of 1880 was to place masters who do not upon the same footing of responsibility with those who do personally superintend their works and workmen, by making them answerable for the negligence of those persons to whom they entrust the duty of superintendence, as if it were their own. In effecting that object, the Legislature has found it expedient in many instances to enact what were acknowledged principles of the common law."

Thus, the increasing pattern of reform of working conditions, largely inspired by middleclass and working-class support, began to breach the commonly accepted rule that the government should not intervene in conditions of employment. It also signified that the theory of laissez-faire was being rejected, at least in respect of the employment of women and children. This second phase is characterized by a broadening of the scope of industrial legislation. It now began to encroach into the guarding of machinery and, as such, set the scene for the pattern of industrial safety legislation that was to follow and continue through to the 1970's.

2.2.3 Phase Three

This phase, commencing from the late 1870's, saw the proliferation of detailed and often complex legislation, with safety standards being continuously improved and some attempts being made at consolidation of the earlier piecemeal legislation. The Coal and Mines Acts of (1978) an example of legislation designed to make work safer and by 1911, safety regulations were extensive. Improvements continued to be made to the working hours of women and children, although legislation regulating the hours of men was not passed until 1908, with the Eight Hours Act, which fixed the working day for miners. The right to recover damages at common law developed by statute by Employers Liability Act 1880 referred to above, and the Workman's Compensation Act of (1906), requiring the employer to pay compensation to any workman suffering injury or disease resulting from unsafe or unhealthy working conditions. It also progressed by a series of decisions in the House of Lords. In addition, the payment of National Insurance benefits in the event of various work-related incidents, and the right of the injured employee to seek damages at common law, significantly improved the previously disadvantaged financial position of the injured employee. Furthermore, towards the end of the nineteenth century, the setting up of Wages Boards in the major industries had the effect of employers and employees' jointly determining wages and working hours. This was an important development when there was no statutory control over the working hours of men. The changes that had taken place in the fifty years up to 1900 were summarized by Hopkins (1979) who stated that: "The worker in 1900 was much less likely to be forced to work excessive hours than his predecessor in 1850, simply because standards had been established as to what constituted a fair day's work; the Factory Acts, the Wages Boards, and the spread of trade unionism had seen to this. Workers might still be dismissed on the spot in a way unthinkable at the present day, but industrial relations had become much more complex, and the ordinary workman, particularly the unskilled or semi-skilled, had much greater protection than he had in 1850 when he was virtually defenseless against an employer who was determined to exploit his labour."

Legislation to protect railway workers came relatively late, the first being introduced in 1900, with agricultural workers being largely unprotected until the Agriculture Poisonous Substances Act 1952, followed shortly afterwards by the Agriculture Safety, Health and Welfare Act of 1956. Shop worker's hours of work became regulated first in 1886 and a subsequent variety of legislation was consolidated in 1950. The physical conditions in shops were almost unregulated until the Offices, Shops and Railway Premises Act of 1963. Legislation covering particular hazards and types of occupations continued to be introduced from time to time, such as that relating to offshore installations which were covered by the Mineral Workings and Offshore Installations Act 1971.

Throughout this period, the development of legislative protection for the employee and legal remedies by which compensation for the negligence of the employer could, with increasing success, be sought in the courts reflected the developing humanitarian conscience of society. Fundamentally, it also reflected the inability of employers to manage the risks inherent within their undertaking, often because they considered safety as being low on their list of management priorities. Undoubtedly, it was also due to their possessing insufficient knowledge to do so effectively. The result was a succession of legislation passed to deal with the control of a series of identified workplace hazards. If they applied to the activities of an employer, strict adherence to them was required. The legacy of this long history of industrialization spanning one hundred and fifty years was that by 1974, employers were imbued with the philosophy that the key to a safe and healthy environment lay in the strict application of the highly prescriptive legislation applicable to their undertaking. Once the legislation had been digested, it was generally a relatively straightforward exercise of putting into practice the specific requirements it contained.

This may be illustrated by a review of a major piece of consolidating legislation introduced before the Health and Safety at Work Act 1974. The Factories Act 1961 and the Offices Shops and Railway Premises Act 1963 typified the approach to workplace safety existing at that time. An examination of the text of the Factories Act reveals, less than fourteen separate parts, a succession of prescriptive requirements demanding little interpretation. The same approach is repeated throughout the Offices, Shops and Railway Premises Act. In retrospect, it is perhaps surprising that it took until the 1970's for the realization to exist that a change in legislative direction was required. This change was from one that was based on a highly prescriptive approach, to one requiring the employer to take a holistic view of the problems existing and the manner in which they needed to be addressed.

2.2.4 1971 and Beyond- Phase Four

Since 1974, the fourth phase has seen the shift to a risk assessed approach to the management of workplace safety being imposed on employers. It requires their proactive enactment of risk management and the development of the 'science' of safety, geared towards the efficient management of the risks inherent within their undertakings. For perhaps the majority of employers, it is a process that has increasingly gathered pace during the last twenty-five years.

The watershed is the process of management being required to take a proactive approach to the means or 'technique' by which effective safety management could be achieved, was the motivating force provided by the Health and Safety at Work Act 1974. In 1970 a Committee of Inquiry, appointed by the Right Honorable Barbara Castle, M.P., who was then Secretary of State for Employment and Productivity, was set up under the Chairmanship of Lord Robens. It is of interest to note that in 1966, he had been chairman of the National Coal Board when the Aberfan disaster occurred: an event that did not generate any subsequent health and safety prosecution. The terms of reference of the Robens Committee were broadly to review the provision made for the safety and health of persons in employment, doing so· against a background of a growing discontent with the legislative framework within which safety and health was required to be conducted. As has already been described, safety requirements were by 1970 contained within numerous enactments. A significant proportion of the working population had no statutory protection, while those who did were not treated consistently. Administration of legislation was diverse and enforcement powers of the inspectorate were considered inadequate. Legislation was not generally directed towards the personal involvement of the worker and some of it was obsolete.

A study of these reveal the Committee's understanding that if organizations were to assume a more active role in accident causation prevention, they would need to ensure that safety and health is "not only a function of good management but it is, or ought to be, a normal management function -just as production or marketing is a normal function. The effective exercise of this function, as any other, depends upon the application of technique. The "technique" referred to, implied the need for the adoption of a scientific and systematic approach. Within this would be incorporated the need to plan a comprehensive system of accident causation prevention including assessing the causes of accidents and using diagnostic and predictive techniques and preventive procedures. The Committee, therefore recognized that a major improvement was required in the manner in which employers were managing safety. However, the subsequent Act did not clarify the 'technique', and it has been left to the Health and Safety Commission/Executive, researchers in the safety field, and safety practitioners, to develop relevant management techniques. The findings of the Robens Committee were presented to Parliament in July 1972 and the subsequent Health and Safety at Work Act 1974 was based largely on its recommendations (Egan, 1979).

It addressed the majority of the recommendations made in the Report and brought approximately eight million workers having no previous statutory protection while at work, within the Act. It provided comprehensive protection requiring the employer to have regard for the health and safety of employees, and also to conduct his undertaking in: "such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety".

This duty extended the employers responsibility to the protection of all contractor's personnel engaged alongside his own and to any members of the public who might be endangered by his activities. The Act moved away from the highly prescriptive nature of previous legislation to a position in which the employer was required to take all 'reasonably practical' measures to ensure the health, safety and welfare of employees and other persons to whom he owed a duty under Regulations 2 and 3. Failure to provide adequate welfare facilities could result in prosecution and if the accused wished to rely on the defense that it would not have been 'reasonably practicable' to make further provision, the burden of proof would henceforth lie on him (Luxon, 1984). It added impetus to a process of increasing realization that if employers were to provide a defense against such a claim, they would need to continually review the actions taken to ensure that they met this requirement. There was, therefore. a very real need to plan how safety was being enacted.

Further the impetus to improve the management of safety as a result of the 1974 Act came with the establishment of the Health and Safety Commission and Health and Safety Executive. In addition, a variety of enforcement inspectorates created at various times by earlier laws were merged together in the new national law enforcement agency, the Health and Safety Executive, operating under the

Commission. Furthermore, approximately eight million workers out of the remaining 16 million workforces were being protected by earlier acts and regulations having no statutory protection under previous health and safety legislation were now brought under the Act. The legislation and its enforcement thereby became a new reality for many employers. However, the fact remains that twenty-five years after the passing of the Health and Safety at Work Act 1974, management has still not comprehensively addressed and achieved effective safety management, as is demonstrated in current accident statistics and employer prosecutions. Following the 1974 Act, yet another dimension was added to the nature and requirements of safety legislation with the United Kingdom's membership of the European Community in 1973, committing it to the Treaty of Rome and other Community Treaties. However, in many ways this was to have a more significant impact, and "few can be realized that years later, in the field of health and safety, legislation derived from the latter was to have a more profound impact than the legislation derived from the former" (Hendy and Ford, 1998). For health and safety, the important point was the amendment of the Treaty of Rome with the Single European Act of 1986, and the adding of Article 118A which was specifically concerned with occupational health and safety. In 1989 Article 118A was the vehicle for the adoption of a Framework Directive on the introduction of measures to encourage improvements in the safety and health of workers. This was subsequently introduced as the Management of Health and Safety at Work Regulations 1992 and was accompanied by the following 'Directives': Health

- ✓ Workplace (Health, Safety and Welfare) Regulations 1992.
- ✓ Provision and Use of Work Equipment Regulations 1992.

- ✓ Personal Protective Equipment at Work Regulations 1992.
- ✓ Manual Handling Operations Regulations 1992.
- ✓ Health and Safety (Display Screen Equipment) Regulations 1992.

The core of these (and subsequent regulations) is the duty to assess the risks to the health and safety of employees and anyone who may be affected by the work activity. The assessment to be followed by measures involving “planning, care and information" (Walter & Nichols, 1994).

The duties imposed under the Risk Assessment requirement of Regulation 3 of the Management of Health and Safety at Work Regulations, are also contained within each of the accompanying five Regulations (collectively under what are known as the "Six Pack" Regulations) and subsequent legislation. They are merely an extension of the 'reasonably practicable' requirement and impose a very clear obligation on the employer to take a proactive approach and to anticipate and manage risks. It can be identified from the above, that the period of industrialization, and legislation introduced up to the advent of the Health and Safety at Work Act 1974, placed employers within a legal framework in which safety became closely regulated. However, there existed little guidance on the practicalities of achieving compliance, and because of its fragmented nature, no uniform guidance that could be applied throughout industry. The result of this was that employers had no history of looking holistically at addressing the risks inherent within their undertakings. The 1974 Act and subsequent European Union legislation heralded a new era in the legislative approach to safety and health in the workplace. It demanded risk management based not only on those preventative and protective measures within the bounds of what are 'reasonably practicable', but also to the undertaking of risk assessments and inherently to thereby implement appropriate safety management systems. In doing so it has demanded an increasing level of sophistication in the manner in which safety is managed and developed, and is a process that continues.

2.3 Safety Management Systems and Safe Systems of Work

2.3.1 Safety Management Systems

According to Walters (1996), underpinning the safety culture are safety management systems and safe systems of work. These are the building blocks upon which the success of the safety culture and effective safety management itself will depend. But what exactly are safety management systems? As Walters (1996) has identified "Everyone seems to have their own slant on the subject". Safety management systems according to HSE (1989) describes a system as "a whole composed of parts in an orderly arrangement according to some scheme or plan". Taking this definition further, the HSE's 'Successful Health and Safety Management' (HSG65), identifies the six elements of an effective safety management system. First published in 1991 and revised in 1997, HSG65 has become the standard reference work for employers undertaking improvements to their management of safety. In doing so, it has also provided further impetus to the concept of the safety culture and to which reference is made on several occasions in its text.

In the 'Introduction' to the second edition HSE (1997), it is stated that the guidance it contains is aimed at those at all levels involved with health and safety and that it: describes the principles and management practices which provide the basis of effective health and safety management; sets out the issues which need to be addressed; and can be used for developing improvement programs, self-audit or self-assessment. The six elements or safety management systems contributing towards successful health and safety management on which it is based are:

2.3.2 Policy

Effective health and safety policies are considered to set a clear direction for the organization to follow, demonstrating a commitment to continuous improvement and in which responsibilities to personnel and the environment are met according to legislative requirements. Cost-effective strategies are used as the basis for preserving and developing physical and human resources and reduce financial losses and liabilities.

2.3.3 Organizing

An effective management structure and arrangements should be put in place to deliver the policy, with staff being motivated and empowered to work safely and protect long-term health. Such arrangements to be underpinned by effective staff involvement and participation and sustained by effective communication and the development of competence which would permit all to make a contribution to the health and safety effort.

2.3.4 Planning and Implementing

That in place is a planned and systematic approach to implementing the health and safety policy. This to be achieved through an effective health and safety management system in which the aim is to minimize risks. Risk assessment to be used to decide priorities and set objectives for eliminating hazards and reducing risks. Performance standards to be set and used for measuring performance and specific actions identified to promote a safety culture.

2.3.5 Measuring Performance

Performance to be measured against standards using self-monitoring techniques to identify when and where improvements are needed. This will look at both hardware and software controls and in the event of their failure reactive monitoring will discover the causes of such events.

2.3.6 Reviewing Performance/ Auditing

The organization learns from experiences and applies the lessons learnt by undertaking systematic reviews of performance. In this way it is in a position to improve on past performance and develop its policies, systems and techniques of risk control. The document sets out, under the above headings, a framework around which it is recommended that the management of safety should be undertaken. The word 'recommendation' is, however, an over simplification A major factor in the success of HSG65 is undoubtedly the fact that it now sets the standards against which HSE inspectors are assessing the performance of organizations against the general duties of the Health and Safety at Work Act 1974, and the Management of Health and Safety at Work Regulations 1992, and other legislation. David Eves, Deputy Director General Health and Safety Executive, stated in the 'Foreword' to the second edition (HSE, 1997) that: "Together with legal requirements, the framework described here provides the basis for the approach which HSE inspectors take when auditing an organization's arrangements for managing health and safety." For those who are aware of the existence of HSG65, there is, therefore, a direct relationship between the management of safety in accordance with the material it contains, and the need to be able to demonstrate that compliance with it has been achieved.

Furthermore, British Standard 8800, Guide to Occupational health and safety management systems BSI (1996), provides guidelines that are based on the general principles of good management. They are designed to enable the integration of occupational health and safety management to take place within an overall management system. Three possible options are considered which reflect the links between safety environment and quality to which reference has already been made:

"The first detailed approach, based on HSE guidance Successful Health and Safety Management HS (G) 65, is designed for organizations wishing to base their OH&S management system on this approach. An alternative detailed approach has been designed for those organizations wishing to base their OH&S management systems on BS EN ISO 14001, the environmental systems standard, and as such identifies the common areas in both management systems. The guidance presented in each approach is essentially the same, the only significant difference being the order of presentation and either approach may be used to integrate OH&S management within the overall management system.

2.4 Safe Systems of Work

According to Munkman (1990), the employer's duty to take reasonable care of those to whom he has a legal responsibility requires him to establish and enforce a proper system or method of work. The significance of a 'safe system' is that it emphasizes the need for the employer to plan the work in advance having regard for the safety of those involved and then to put that plan into practice by relevant safety instructions. It is the duty of an employer to give such general safety instructions as a reasonably careful employer who has considered the problem presented by the work would give to his workmen. Although Section 2. 2a, of the Health and Safety at Work

Act 1974, requires the Employer to provide safe systems of work, it does not define what these are. Earlier legal interpretations were provided such as in the above case. Also, under Regulation 3 of the Management of Health and Safety at Work Regulations 1992, which requires employers to make an assessment of the risks to which their employees are exposed and then establish systems for dealing with them? These have provided some clarification of their meaning.

They are now seen as being fundamental to accident prevention, necessitating the documentation of hazards, precautions and safe working methods, including job training requirements Bamber (1994). On the theme of training where the employer has provided safe plant and machinery and identified the procedures to be followed, Barrett and Howells (1995) summarized its importance to safe systems stating that: "Safe workplaces are unlikely to be achieved unless those who work there are informed of the need to operate safely, trained to ensure that they know how to operate safely, and monitored to ensure that safe systems are actually being operated. Safe systems depend not only on investing in plant and equipment but also on investing in people. "Safe systems are, therefore, at the very heart of the employer's provision of a safe working environment and will include the following:

- ✓ Safe premises and plant.
- ✓ Safe tools and equipment.
- ✓ Adequate, competent and effective supervision.
- ✓ Safe working environment.
- ✓ Trained and competent staff.
- ✓ Laid down safety rules and procedures, adequately enforced.

Adequate personal protective equipment provided and used subject to supervisory inspection. The employer must, therefore, ensure they are in place, having adequate monitoring arrangements for this purpose. When undertaking accident/incident investigations, perhaps the classic test for the investigator is to question whether the above was present. Where the answer is in the negative, then that is a clear indication of the potential liability position of the employer.

2.5 Culture or Systems Change

Although there is an increasing emphasis on organizational safety culture and safety management systems and safe systems of work, there is often a lack of understanding of the essential differences between them, also how they relate to each other and how they demand different approaches to reach the altered state. Culture change is required when there is a need to alter individual ideas, beliefs, values and knowledge, which govern the way in which safety is viewed and practiced within a company (ILO, 2014).

It is notoriously difficult to achieve and was described by Deal and Kennedy (1982) in the context of organizational change, as being "a difficult, time-consuming, often gut-wrenching process." System changes require improvements to, or the introduction of new, individual safety management systems and safe systems of work, and identify the manner in which activities are to be managed and undertaken. Dyer and Dyer (1986) highlighted this essential difference between culture and system when applied to organizational development, although applying equally to safety.

2.5.1 Occupational Health and Safety in Ghana

According to Annan (2010), employers in Ghana are required by the Ghana Labour Act 2003, Act 651 to ensure their employees are not exposed to conditions that would lead them to work related injuries or illnesses. Employees are also required to exhibit their duty of care in ensuring that they work as per the employers" standard operating procedures which must incorporate safety and health requirements. The Nation has different agencies under different jurisdictions which monitor different industries for workplace and employee safety, however, there is no national body, policy nor process that govern Occupational Safety and Health management in Ghana. There is a Road Safety Commission but with little standards, guidelines and impact on the safety of the transport industry and the pedestrian. The Minerals Commission has the Mining Regulations 1970, which contains some guidelines in Occupational Safety and Health but just for the Mining Industry. There currently is a draft of the reviewed Mining and Minerals Regulations which is pending approval by the Ghanaian Parliament.

Numerous injuries, illnesses, property damages and process losses take place at different workplaces but due to under reporting or misclassification due to lack or thorough standards, or unfamiliarity with the existing guidelines, people are not normally in the known of such events as well as their actual or potential consequences and effective corrective actions required Annan (2010). There are currently two major edicts that have provided guidance in the provision of occupational/ industrial safety and health services, practice and management in Ghana. These include the Factories, Offices and Shops Act 1970, Act 328 and the Mining Regulations 1970 LI 665, but these have only driven the mining and the labour sectors and are therefore very limited in scope, given the multifaceted distribution of industrial operations that we have in Ghana. There is the Workmen's Compensation Law 1987 (PNDC 187) which relates to compensation for personal injuries caused by accidents at work and hence, indirectly impacts on monitoring worker / workplace safety. The Radiation Protection Board of the Ghana Atomic Energy Commission is also proactive in monitoring companies with radiation exposure hazards for compliance, however, due to limited resources, effectiveness of their activities is compromised Annan (2010). There are other statutes which indirectly impact on Occupational Safety and Health and these include the Environmental Protection Agency Act 490 1994, the Ghana Health Service and Teaching Hospital Act 526, 1999 and the National Road Safety Commission Act 567, 1999.

Though, Ghana is among the 183 member countries of ILO, which requires, as per the ILO convention number 155 1981, that member countries formulate, implement and periodically review a coherent policy on occupational safety and health and work environment, Ghana has not yet rectified this convention and the nation has no established authority dedicated to Occupational Safety and Health to guide and facilitate the implementation of the "Action at the National Level" as indicated in the R164 Occupational Safety and Health Recommendation, 1981. However, the Labour Act 2003, Act 651, Part XV, sections 118 to 120 apparently direct employers and employees in their roles and responsibilities in managing Occupational Health, Safety and Environment in the nation, but is not specific about whom to report accidents and occupational illnesses to. It is not clear or does not specify what to consider as Occupational Illness. It does not specify who to be responsible for ensuring the industries in Ghana implement corrective actions as per recommendations. Currently, accidents that occur in factories are expected to be reported to the Department of Factory Inspectorate but companies hardly report such events to the inspectorate for investigation and correction. When these accidents get reported, it takes a long time before corrective or preventive actions get implemented, hence, there is a little or no positive effect of the action of the Department of Factory Inspectorate on the factories. The nation has seen some positive "Safety and Health practice infection" among some of our Ghanaian companies due to the influx of some multinational companies into the country, given their corporate expectations with specific requirements in Occupational Safety and Health practices. This stems from their requirements for the contractors, and subcontractors, some of whom are Ghanaian, to follow their Health and Safety standards. In as much as this is a good effort and helps the Ghanaian to know there is more to Occupational Safety and Health than we have specified in our legal framework, it tends to confuse the Ghanaian the more with regard to which standard to follow in the nation, and what is required to make employees and employers accountable. In the academia, Occupational Health is not an option for specialization in a typical Ghanaian medical school. Safety engineering has not found its way into any of our Engineering curricula in Ghana yet. A potential intervention is the proposed Safety and Environmental Engineering program which is being expected to commence at the University of Mines & Technology, but this is not approved yet. All other Safety & Health training programs are run either by international agencies or some few Ghanaian organizations but none of these matches up to even a first-degree (Annan, 2010).

2.5.2 Health Hazards in the Wood Industry

The World Health Organization (WHO) report 2000 notes that, occupational health risks are one of the leading causes of morbidity and mortality in the world in general and developing countries in particular. In India alone, research reports estimated an annual incidence of occupational disease between 924,700 and 1,902,300 cases and 121,000 deaths (Leigh et al., 1999). Numerous studies on many industries including the leather tanning industry, textiles and metal ware have found that workers in these industries workin inhuman physical conditions for very long hours (Usha, 1984; Labour Bureau Reports 2000; 1998; 1996; 1992b; 1992a; Banerjee and Nihila, 1999; Nihila 2002). A survey by Adei and Kunfaa (2005) revealed, that employees in the wood processing industry were exposed to physical, ergonomic, mechanical and chemical hazards. The perceived physical hazards in the study were sawdust, noise and extreme hot temperature.

Sawdust was a major hazard in all the Wood Processing companies surveyed which is consistent with the work place health and safety hazards survey by the Ministry of Health (1998), that showed that wood dust and shavings were major hazards among woodworkers. The percentage of workers as the study maintains who were provided with nose masks and those who claimed to use it may be an over estimation. Apart from one small company surveyed, where all workers were seen wearing their nose masks, some workers in the rest of the companies surveyed had their nose masks on their foreheads because they found them uncomfortable to use.

Amedofu (2002) as cited in Adei and Kunfaa (2005) observed that hearing impairment usually develops slowly over a long time and the impairment can reach the handicapping stage before an individual becomes aware of what has happened. The researcher had to shout when administering the questionnaire to some of the workers at their administration block, which were insulated from noise. This suggests that majority of workers were not aware of their hearing impairment. It therefore appears that where earmuffs were provided their use was not clearly understood.

Most supervisors and workers in the wood processing companies surveyed perceived noise as an inevitable part of the production process. The supervisors had no idea of the quantitative noise levels the workers were exposed to and only 6.5 percent knew that the maximum allowable noise limit for eight-hour shift should not be more than the recommended levels by Environmental Protection Agency (EPA) in Ghana. Amedofu and Asamoah-Boateng (2003) showed that workers in sawmills, and corn mills were exposed to noise levels exceeding the recommended levels by Environmental Protection Agency (EPA) in Ghana. Workers at the boiler and kiln dryer sections in the large and medium sized companies perceived their work environment to be hot. Workers at the boiler sections experienced profuse sweating although no temperature-monitoring equipment was in place. The companies with clinics (three large and one medium-sized processing companies) had a record, complaints of fatigue, discomfort and heat exhaustion as a result of the excessive heat exposure. Ezeonu (2004), reported heat exhaustion caused by exposure to high temperature among kiln workers in a Nigerian company.

All over the world, there are steady efforts to promote and sustain safety and health at workplace and even in homes. Health and safety concerns have become paramount to individuals, government agencies and businesses alike. This is more pronounced in developed countries where occupational safety and health have become rooted in the laws, culture and lifestyle of citizens, unlike developing countries. Verma (1996) attributes Canada's successful Occupational Safety and Health (OSH) regime to initiatives like awareness creation, nationwide access to information, accessible OSH education and training at various levels including universities and colleges, and increase numbers of OSH professionals. Also, the United Kingdom has a successful OSH culture and management systems in Islington through strategies like inspections and organizing awareness raising and training events, and publicizing prosecutions to increase the general public's awareness of health and safety regulations.

Mock et al. (1999) hint that safety and health cannot be ignored since injuries alone account for 14% of all disability adjusted-life year losses for the entire world's population. It is estimated from the International Labour Organization (ILO) that globally over two million people die annually as a result of occupational accidents and work-related diseases (ILO, 2005 and Machida, 2010). Indeed, there is significant economic cost to nations as high rates of work-related accidents and diseases contribute to about 4% of the world's gross domestic product loss (Machida, 2010). According to Adei & Kunfaa (2005) workplace related accidents, injuries and diseases cost Ghana about 7% of gross domestic product (GDP). Clearly health and safety has become a major global concern and should trickle down to all countries. From the ILO, the global challenge now is extending the benefits of real advances in health and safety from industrialized nations to the whole working world (ILO, 2005).

Unfortunately, Ghana like other developing countries as of now has no comprehensive national policy on Occupational Safety and Health (OSH). Meanwhile the country is geared towards industrialization as one of the fast-growing economies in the world (Solari et al., 2012), especially following the oil boom. The reality is that a lot of efforts are usually required in promoting health and safety through legislation, enforcement, promotion and training (Labour Department of Hong Kong, 2010). Ghana is no exception in this regard. The caution is that there could be steady economic development with low awareness level of Occupational Safety and Health (OSH). For instance, Hu et al (1998) claim that despite Taiwan's rapid economic development, the general awareness, knowledge and perception of the importance of OSH were relatively lacking and limited. Though Ghana has no comprehensive OSH policy, according to Bruce (2009) there exist fragmented safety and health laws used by various ministries, departments and agencies for enforcement and complementary roles. Moreover, Adei and Kunfaa (2005) assert that there are three main laws on OSH in Ghana, namely: The Factories, Offices and Shops Act 328 (FOSA), Workmen's Compensation Law 187 (1987), and Labour Act 651 (2003). There are also claims that FOSA, which is considered the main OSH statute, has several limitations (Bruce, 2009 and Asiedu, 2010). Thus, there exist institutional framework for OSH. However, this does not deny that the OSHA regime in the country has several challenges that need attention. Apart from the limitations associated with FOSA (Act 328), it is also not clear the awareness level among the populace after over four decades of its existence. Laryea and Mensah (2010) claim that there is poor state of health and safety on construction sites attributing to reasons like lack of strong institutional framework, poor enforcement of health and safety policies and procedures, and low premium on health and safety by the Ghanaian society. The authors also attribute this to lack of awareness of health and safety obligations under existing Acts. Meanwhile, one of the key conditions for addressing health and safety is the development of awareness (Fairbrother, 1996). Osagbemi et al. (2010) suggest that health and safety awareness or consciousness influence compliance of safety measures and not necessarily socio-demographic factors. Also, the understanding from India is that awareness of safety and health should be integral part of all training programs for industries, commerce, services, and educational environments targeting all including workers, supervisors, traders, management personnel, other unions, under-graduate, post-graduate, medical students, etc (GoI, 2011). It can be inferred that improvement in health and safety is realized through sensitization, awareness creation and formal training.

The extent of awareness and compliance with the Factories, Offices and Shops Act 328 (1970), was established as the main OSH legal framework in Ghana, using one of the university communities, Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi. Specifically, the following were established: level of awareness, compliance with some basic requirements and the perception about the effectiveness of the Act.

2.5.3 Institutional Framework for Occupational Safety and Health in Ghana

Ghana like other countries also has a bit of history concerning Occupational Safety and Health (OSH) tracing back to the colonial era. According to Asiedu (2010), the development of OSH began in the 1930's without any designated body for labour administration, and OSH was limited to the processing and payment of compensations to workers who were accidentally injured. Around 1938, the British established a Labour Department and legally empowered it to deal with general labour administration. By September 25th, 1951, a fully qualified and experienced factory inspector to oversee the safety, health and welfare of workers assumed duty. The Factories Inspectorate Unit operated as a unit of the Labour Department, until May 1 1985 when it was separated from the latter and became an autonomous Department (Factories Inspectorate Department) Asiedu, 2010). The Department of Factories Inspectorate (DoFI) under the Ministry of Employment and Labour Relations (formerly Ministry of Employment and Social Welfare, MoESW) promotes health and safety of persons within the purview of the Factories, Offices and Shops Act, 1970 (Act 328) (MoESW, 2011). It is the recognized body in Ghana by the International Labour Organization, ILO on OSH (Bruce, 2009). Among the core functions of DoFI from MoESW (2011), the key ones are: inspections of workplaces to ensure maintenance of reasonable standards of safety and health, prosecutions of offences under the Factories, Offices and Shops (Act 328), and investigation of reportable occupational accidents and dangerous occurrences.

Moreover, there are other easily identifiable key stakeholders from other government ministries, departments and agencies that play complementary role in the promotion, but not enforcement of OSH measures (Bruce, 2009). These key ministries include Mines, Environment, Health, Road & Transport, and Science & Technology, while the key departments and agencies are National Labour Commission and its Departments; Environmental Protection Agency; Metropolitan, Municipal and District Sanitary Inspectorate; Chamber of Mines; Ghana Standards Board (now an authority), and Ghana Foods and Drugs Board (now an authority) (Bruce, 2009; Asiedu, 2010).

Currently, there is no comprehensive national policy on OSH in Ghana. Paradoxically, a policy document titled "Development of Legislation and Policy on OSH for all Sectors of the Ghanaian Economy" was drafted in June 2000 as a bill (Asiedu, 2010) but has not been pushed further for adoption and passage by parliament into law. Notwithstanding, there are several laws and regulations (though with diverse limitations) used by the several government ministries and agencies in the country in discharge of their responsibilities. The lead agency DoFI operates under the Factories, Offices and Shops Act, 1970 (Act 328), FOSA as the main statute. According to (WIEGO, 2010), the Act 328 (FOSA) and the Mining Regulations 1970 (LI 665 & 666) are the two main statutes that have charted the course of OSH over the years. Other statutes that have bearing on OHS include the Workmen's Compensation Law 1987 (PNDCL 1987), Environmental Protection Agency Act 490 (1994), Ghana Health Service and Teaching Hospitals Act 526

(1999), Labour Act 651 (2003) sections 118 – 120, Children's Act 560 (1998), Small Scale Gold Mining Law 1989, PNDC Law 218, Ghana Road Traffic Offences Regulations 1974 (LI 952) and Radiation Protection Regulations 1993 (LI 1553) (Adei & Kunfaa, 2005; Hodges and Baah, 2006; Asiedu, 2010; WIEGO, 2010).

According to the DIAGLGUE ILO (2006), Ghana has been a long-standing member of the International Labour Organization (ILO) since May 1957 soon after independence. It means the country should have by now have a strong institutional framework to champion the course of OSH for industrialization. On the contrarily, the framework is not clear, limited in scope for the entire economy (given the emergent oil and allied sectors), fragmented with unnecessary overlaps (Bruce, 2009) and other challenges. Adei & Kunfaa (2005) and WIEGO (2010) claim some of the OSH challenges include lack of commitment by managements and government, restrictive inspections, lack of education and enforcement by under resourced DoFI, and poor knowledge or awareness levels of laws and regulations. For instance, claims exist that the proportion of workers who receive OSH service in the informal sector alone (which dominates Ghana's workforce by 70% - 90%) is not more than 1 – 2% (WIEGO, 2010). This is a worrying picture and it cannot support productive workforce in a fast-growing economy towards industrialization. A smart approach to improving the situation will be to learn from other successful countries. The starting point is to have a comprehensive policy on OSH capable of ensuring OSH service delivery to all sectors of the economy. This seems to have worked well for others; Ghana can do it and now is the time!

2.6 The Factories, Offices and Shops Act, ACT 328, 1970

FOSA has limitations, already enumerated although it has been amended about three times under: (1) the Provisional National Defense Council (PNDC) Law 66 (1983) (2) PNDC Law 275 (1991) and (3) Ghana National Fire Service Act, 1997 (Act 537) (Ghana, Factories Offices & Shop Act 328, 1970), all to widen the scope. However, there are parts and sections of the document that explicitly seek to promote OSH, which can be listed here. These are Parts 4 through to Part 7, and then Part 9 covering the following: notification of accidents, health & welfare, safety, dangerous conditions & practices, and offenses & legal proceedings. Some basic and critical requirements of FOSA that can be seen as supported by WorkSafe (2008) are workplace amenities needed to promote health, safety, welfare and personal hygiene. These include toilets, shelter, seating, dining rooms, change rooms, drinking water, personal storage, washing facilities, workspace, temperature, air quality, lighting and flooring, firefighting, emergency exits etc.

2.7 Practices of Safety by Wood Workers

2.7.1 Factors Driving the Need for Health and Safety Development Planning

At the end of the 20th Century, what then are the forces driving the need for health and safety change and the development planning which must accompany it if such change is to be successful? The greater emphasis on management responsibilities has certainly been accompanied by a plethora of guidance identifying how the duties of the employer are to be met. It is principally the Health and Safety Commission/Executive and other specialists who have, during the last twenty-five years, undertaken the process of providing material on the manner in which legislative compliance is best achieved.

'Safety culture' and 'safety management systems', as well as the application of total quality management to health and safety, are just three recent developments in the science of the management of safety. They are now firmly established objectives of any effective management approach to the subject. However, the question remains, at the very core of their existence, is it clear what the planning processes are that are required for their successful introduction into an organization, and for their development and maintenance? As has been seen, the risk of civil litigation and potentially extremely high legal costs as well as the possibility of prosecution by the enforcing authorities are two of the more dramatic penalties facing the employer who fails to keep pace with legislative requirements.

The need to keep in step with safety requirements and thereby mitigate such possibilities having grown consistently since 1974, has meant that from that date for the majority of employers their activities have become increasingly regulated through health and safety legislation, and supporting codes of practice and guidance notes. This is in spite of government deregulation initiatives. The significance to the employer of Regulation 3, 'Risk assessment', of the Management of Health and Safety at Work Regulations 1992 cannot be over emphasized. Being based on the principle of identifying, assessing and controlling risks, before their manifestation in an accident or incident, risk assessment has now become enshrined as the cornerstone of the effective management of risk. It is a process requiring the on-going review of an organization's activities and the taking of appropriate action. For many, this has demanded a shift in corporate and individual attitudes to loss prevention. It is a move from one based on a reaction to events, to a proactive approach and the recognition that change, and the need to work and adapt to it, are ever present. Added to this trend are the demands imposed in meeting non-regulatory health and safety developments such as the concept of the 'safety culture' and safety management systems, as well as financial and quality requirements, each of which are considered below HSC (1993).

2.7.2 Organizational Safety Culture

The Institution of Occupational Safety and Health in its policy statement on health and safety culture (1994) stated that it: "seeks to describe the characteristic shared attitudes, values, beliefs and practices of people at work concerning not only the magnitude of the risks that they may encounter but also the necessity, practicality, effectiveness and preventative measures. Measures which have been taken to improve safety performance can be seen in the way in which safety is practiced by an organization's personnel being evident in an identifiable, positive and progressive organizational' safety culture'. As Davies (1988) put it succinctly: "Culture provides the framework whereby members may meaningfully interpret actions as being "correct" or "incorrect" in relation to their understanding of the organization. In this way it is a social interpretation rather than an individualistically psychological one. The phrase "We don't do it that way here" is a strong indicator of organizational culture in action (Davies, 1988).

For those employers who are aware of it, it is the component parts of such a culture to which the definition applies that many now aspire to see in operation within their organization. Drawn from the results of 216 questionnaires completed by CBI members, the significance of 'Developing a safety culture' (1990), was that it brought together eleven elements considered to constitute an identifiable safety culture. The importance of each element was already known in its own right at the time of publication. However, when combined under the banner of the ingredients of a safety culture, they assumed a corporate entity with a relevance that could be recognized as generally applicable to and achievable within, most organizations.

The eleven elements were:

- Leadership and commitment from the top which is genuine and visible.
- Acceptance that is a long-term strategy which requires sustained effort and interest.
- A policy statement of high expectations and conveying a sense of optimism about what is possible which is supported by adequate codes of practice and safety standards.
- Health and safety should be treated as seriously as other corporate aims and properly resourced.
- It must be a line management responsibility.
- 'Ownership' of health and safety must permeate all levels of the workforce.
- This requires employee involvement, training and communication.
- Realistic and achievable targets should be set and performance measured against them.
- Incidents should be thoroughly investigated.
- Consistency of behaviour against agreed standards should be achieved by auditing and good safety behaviour should be a condition of employment;
- Deficiencies revealed by an investigation or audit should be remedied promptly.
- Management must receive adequate up-to-date information to be able to assess performance.

The above represent significant, but achievable, basic performance criterion. In 1993, the Advisory Committee on the Safety of Nuclear Installations, Human Factors Study Group, in its Third report: 'Organizing for safety', endorsed the above by identifying essentially the same set of characteristics.

Safety is a positive value; it prevents injuries, saves lives, and improves productivity and outcomes. When safety is actively practiced and is regarded as a critical core value by organizational leaders, it bestows a sense of confidence and caring in all of the people who work there. A strong safety culture is required to protect employees but is especially important in protecting students and in developing students' skills and awareness of safety. It also protects academic institutional reputations. This culture emanates from ethical, moral, and practical considerations, rather than regulatory requirements. Managers/ Administrators, faculties, and staff members have ethical responsibilities to care for their employees' safety and to instill awareness about safety.

They need to teach employees the safety skills required to work in the sawmill and other organizations in the workplace. In a strong safety culture, employees will acquire the skills to recognize hazards, to assess the risk of exposures to those hazards, to minimize the risk of exposures to hazards, and to be prepared to respond to emergencies.

2.7.4 The Elements of a Strong Safety Culture

The safety culture of an institution plays a critical role in setting the tone for the importance placed upon safety by its members. Leaders are the key to building a strong culture of safety. Leaders inspire others to value safety, seek open and transparent communications to build trust, led by example, accept responsibility for safety, and hold others accountable for safety. The direction for and strength of the safety culture is determined by its leaders.

Solid safety awareness and attitudes are important and building safety awareness requires a long-term effort-safety to be highlighted repeatedly. Teaching safety and providing periodic safety awareness training continuously over the entire employee's experience can build positive attitudes and strong safety ethics among employees. Managers/Administrators and staff members have an ethical obligation to teach existing and new employee about the need for a positive, proactive attitude about safety. The proper attitude for safety is reflected in the "Safety Ethic", value safety, work safety, prevent at-risk behaviour, promote safety, and accept responsibility for safety.

2.7.5 Learning from Incidents

Much of what is known about safety has been learned from mistakes or incidents. Using these incidents and the lessons learned as case studies throughout the employees learning experience provides an opportunity to capture the interest and imagination of employees while forcing them to think about how safety measures could have prevented or minimized these incidents. An important element of a strong safety culture is establishing a system for reporting and investigating incidents, identifying direct and root causes, and implementing corrective actions.

2.7.6 Collaborative Interactions That Help Build Strong Safety Culture

For a sustainable safety program, the institution must establish an active safety committee system that includes members representing a cross-section of the employees. The committee membership should include safety professionals, faculty and staff members, administrators, and senior and junior staff, who will all be covered and affected by the program. Committees need to be active and productive, and publish informative documents regularly. A critical part of every safety program is to establish collaborative and trusting interactions among members of the institution, especially among faculty, staff, and environmental health and safety professionals. The company should establish a close working relationship with local emergency responders, especially fire departments and their hazard materials teams.

2.7.7 Promoting and Communicating Safety

According to Albert Schweitzer (2008), probably the best way to promote safety is through personal example. Promoting safety at your company is dependent upon a continuous effort to advocate for a strong safety program to faculty, staff, and employees. Advertising and promoting safety could take many forms. Today, many faculties, staff, and especially employees, tend to do everything online and through their cell phones. One way to promote a safety program might be a safety newsletter or weekly bulletin that is distributed via social networks and e-mails. Departments may consider having open seminars to discuss topical safety issues or incidents. Recognition of individuals for doing an outstanding job in safety is an important part of a vibrant safety program. Establish a procedure for soliciting suggestions for improving safety and identifying safety concerns.

2.7.8 Encouraging Institutional Support of Safety by Funding Safety Programs and Supplies

Many of the suggestions discussed can be implemented at little or no additional cost. Nevertheless, new and innovative approaches for building a strong safety culture may require funding. The first step in establishing a continuing budget for a safety program is determining institutional needs. Identifying responsibilities for safety and the corresponding staff who will accomplish this is critical in determining budgetary needs. The administration may require Department of Environment, Health, and Safety (EHS) support for a safety program.

Printing, office and safety supplies, and training materials are recurring expenses that often come from departmental budgets. Report regularly to the administration the progress and accomplishment of the safety program and explain the benefits in terms of how funding your request will benefit the organization, and how funding the program can make the company a leader and a resource to your community.

2.8 Machines Safety in the Sawmilling Production

Sawmill is a process of mechanically breaking down logs, timber or boards into commercial use. This involves activities such as sawing, planning, edging, trimming moulding etc. Machines that have moving parts and workers who operate them have an uneasy relationship. Machines make workers more productive and enable them to form and shape material in ways that would be impossible with hand tools. Technology can make machines safer, but as long as workers need machines to help them process material – to cut, shear, punch, bend, or drill – they will be exposed to moving parts that could harm them. Much of the danger occurs at the point of operation, where the work is performed and where the machine cuts, shears, punches, bends, or drills.

2.8.1 Basic Safety Rules for Woodworking Machines

- Use mechanical feeding basic safety rules for woodworking machines where ever possible.
- Enclose all cutters and saw blades as far as practicable.
- Ensure all machines are well maintained.
- Ensure adequate lighting at every machine.

2.8.2 Basic Safety Rules for People Who Work at or Operate Woodworking Machines

- Only authorized people who have been properly trained and assessed as competent, should operate or work at woodworking machines.
- Safe operating procedures must be provided and used in respect of each machine.
- Appropriate hearing protection, eye shields and dust masks should be worn when required.
- Machines must be switched OFF when not in use and ISOLATED before any repair, cleaning or maintenance is done.
- The machinist’s attention must not be distracted while work is in progress.
- Don’t operate machinery if fatigued or otherwise unfit for the task at hand.
- If mechanical feeding is not available, use push sticks or avoid the need for hands to be near cutters or saw blades.

2.8.3 Major Wood Processing Machines in Sawmills and Their Safety Parts

Wood processing industry make use of machines in order to process the wood to its required use. This type of machines to be used depends on the type of operation. Below are some major wood processing machines which are been used in the sawmills.

2.8.3.1 Mortising Machine

The mortising machine is a specialized woodworking machine used for cutting square, rectangular and circular holes in a piece of wood. They are generally electrically powered and operate by lowering the cutting mechanisms onto a workpiece secured to a work surface. These safety devices and protocols must be observed before operating the machine.

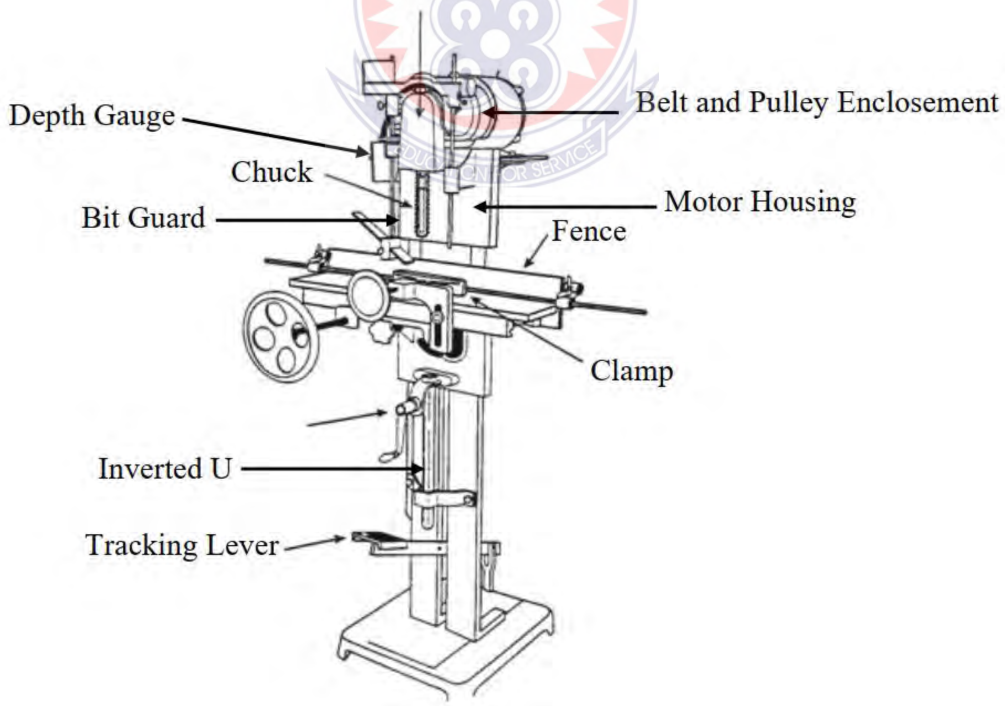


Figure: 2.1 **Wood Mortiser Machine with safety parts**

Source: ISO 19085-7.2019. Accessed on 21st January 2020

Guard: It encloses the chuck and the bit from accidental contact by the operator.

Stock Clamp: Is a fastening device used to hold or secure objects tightly together to prevent movement or separation through the application of inward pressure.

Back Fence: The fence helps to place the stock on the table against it therefore guaranteeing that the distance from the edge to the mortise is the same on every joint.

Inverted-U Shape Guard: This guard provide a barrier between the operator and the operating treadles.

Feed Lever: The drill bit is plunged into a workpiece by pulling down on the feed lever mounted on one side of the machine. Since it is spring-loaded, the lever returns automatically – but the mechanism can be locked with a clamp lever to run the drill in a lowered position, leaving both hands free for working.

Depth Gauge: Drilling depth is controlled by setting a gauge. Mark the required depth on the side of the workpiece. Lower the chuck until the tip of the drill bit aligns with the mark, then set the depth-gauge stop to limit the vertical travel of the chuck.

Safety Guard: Safety guard is (usually of transparent plastic) that drops down or swings across to shield the drill-press chuck. The guard prevents hair or loose clothing becoming caught in the rotating chuck.

2.8.3.2 Spindle Moulder

As one of the full handy woodworking equipment, the spindle moulder can be used for multipurpose. As the name suggests, it is intended for simple moulding work, but this machine can also be used for making trenches, links, and even box combings. The spindle moulder can cut out shapes, construct raised panels, and flat, curved surfaces. It works swiftly, forms naturally, and delivers first-class wood texture.

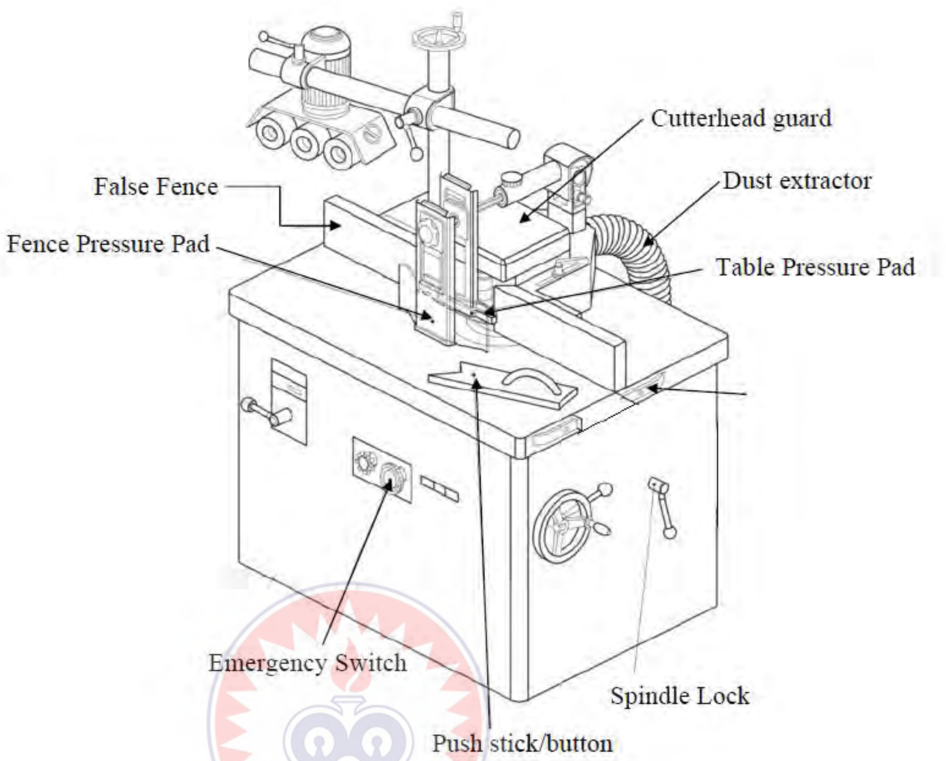


Figure 2.2 Spindle moulder with the safety parts

Source: ISO 19085-6:2019. Accessed on 21st January 2020

Push Stick: The push sticks or blocks are used to move the timber through the machine. **Safety Shield**: This prevent access by the operator to the cutter when the workpiece is removed. It must be long enough to prevent the operator's hand from reaching the cutter.

False Fence: It is an attachment that closes the gap between the outfeed and the infeed fence. This provides good a good workpiece support and prevent the workpiece from dipping and reduces the exposure of dangerous parts

Spindle Guard: This guard covers the spindle cutter and prevents the operator from contact of the cutter.

Dust Extractor: This collects the saw dust and send its outside the working environment**.**

Spindle Block Guard: This protects the operator from accidentally contact of the spindle block.

Cutterhead guard: This covers the cutter head of the spindle moulder.

Pulley and Belt Enclosement: This house the driving mechanisms of the spindle moulder.

Cutterhead guard: This house the spindle block and protects the operator from getting in contact with the spindle cutter head.

2.8.3.3 Surface Planer Machine

A planning machine is used to finish a piece of wood to the desired thickness, on one or both sides of the wood. This checklist provides information to assist all workers in the safe operation of these machines, and to ensure a safer workplace environment'

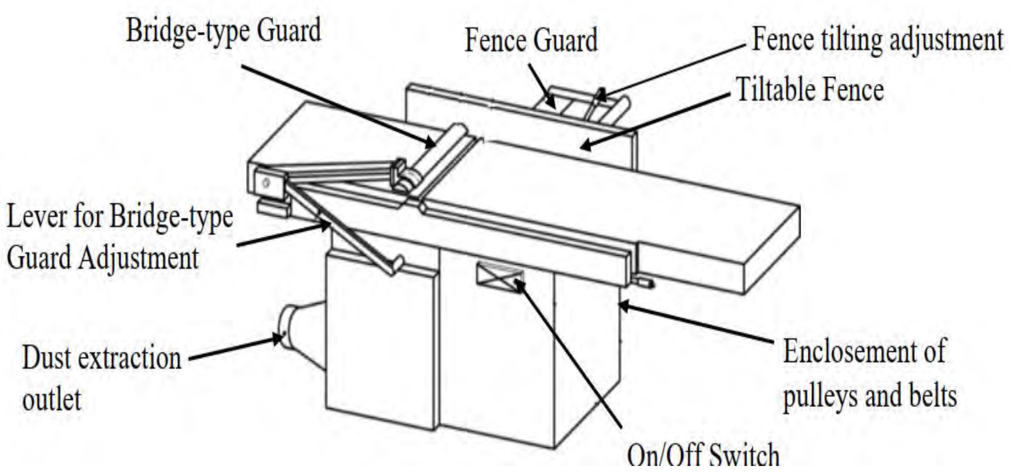


Figure 2.3: Surface planner with safety parts

Source: Source: ISO 19085-4:2019. Accessed on 21st January 2020

Cutter-head Guard: A planer's revolving cutters are capable of severing a finger-tip in a fraction of a second – so never operate the machine without the appropriate guard.

A bridge guard that is adjustable in height and which can be slid across the entire width of the cutter block is the ideal form of protection. Some planners are made with spring-loaded bridge guards which are lifted or pushed aside by the work as it is passed over the cutter block. This type of guard is superior to the simpler version that merely swings aside to expose the cutters.

In addition, there should be a guard behind the fence that is automatically drawn across the cutter block as the fence is adjusted sideways.

You should never attempt to rebate a workpiece without a vertical/horizontal hold-down guard, so your hands need not approach the cutters.

Isolated Switch: Isolated switch should be accessible from either end of the machine so you can turn it off quickly in an emergency, no matter whether you happen to be surface-planning or thicknessing.

Fence: The fence helps to place the stock on the table against it therefore guaranteeing that the distance from the edge can easily be moved against it. This provides good a good workpiece support and prevent the workpiece from dipping and reduces the exposure of dangerous parts.

Enclosement of Pulleys and Belts: This is a sheet metal that encloses the pulleys and other driving mechanisms of the surface planner. This prevents the operator from getting in contact with the moving parts of the machine.

Push Button: This is a wooden stick use for emergency stopping of the machine.

Feed rollers: A planner is equipped with two motor-driven spring-loaded feed rollers that pass the workpiece under the revolving cutter block and out the other end of the machine. The infeed roller, usually a horizontally ribbed steel roller, is situated in front of the cutter block and provides the main driving force. The outfeed roller, which is situated behind the cutter block, is smooth – so as not to mark the planed surface – and exerts less pressure on the work. When taking a very shallow cut, the parallel bruising left by a ribbed roller is sometimes detectable on the planed surface. For this reason, some planners are made with rubber-covered drive rollers.

Anti-kickback Device: If some reason the drive rollers lose their grip on a workpiece, it may be thrown out of the machine by the cutter block and a serious accident can occur if you are feeding the work at the time. To prevent this, row of pointed metal teeth or 'pawls' hang in front of the infeed roller. As the work travels under them, the pawls lift to allow free passage. Should the work begin to travel backwards, the pointed pawls catch in the wood surface and restrict its movement.

Dust Extractor: Without an extractor, shavings are dumped onto the tables above and below the cutter block where they impair the efficiency and accuracy of the machine. Consequently, you have to stop the planer regularly to clear the accumulated debris. A hose attachment leading to a portable extractor solves the problem.

2.8.3.4 The Circular Saw

Circular saw machines are versatile and are used for crosscutting, ripping, bevel cut and to do other operations using accessories. In using it for sawing the operator adjusts the saw to the proper cutting depth and pushes the wood through the saw.

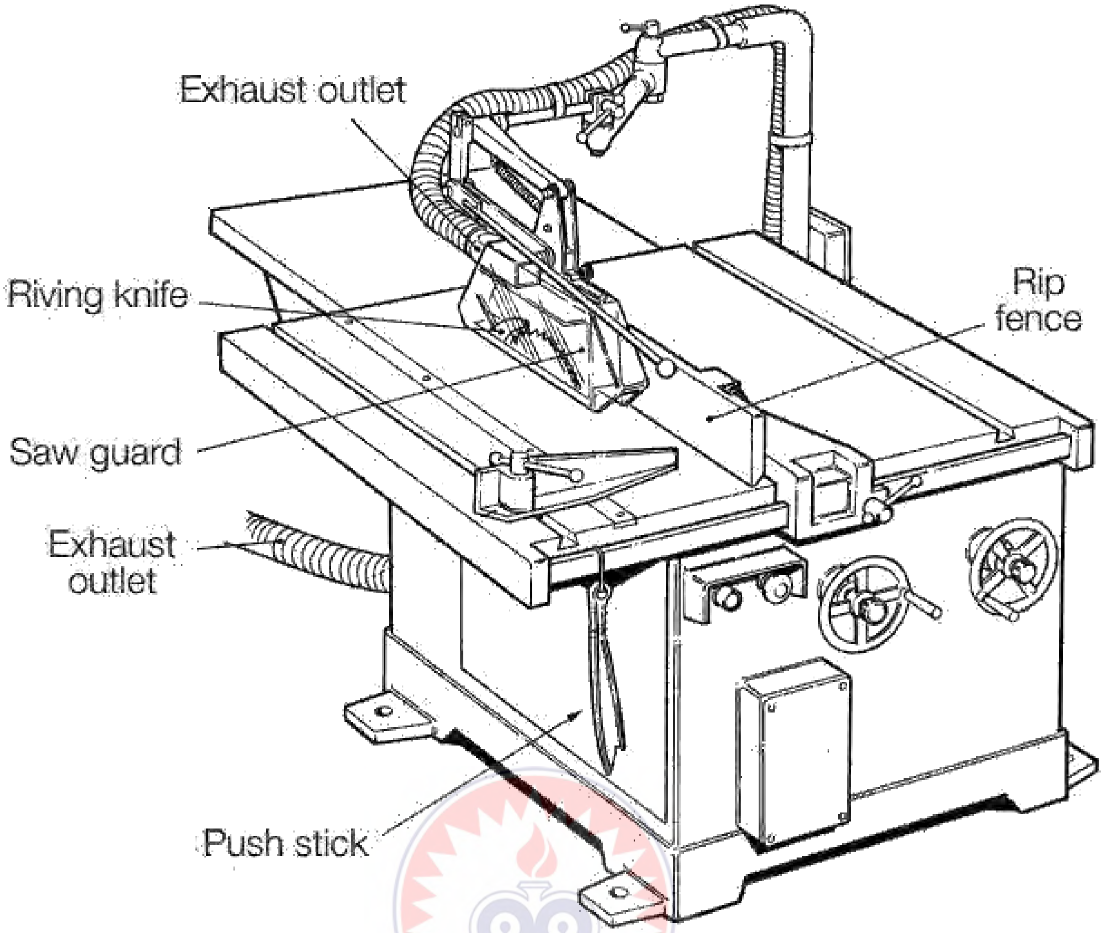


Figure 2.4 Circular saw with parts

Source: ISO 19085-3:2019. Accessed on 21st January 2020

Saw Guard: The blade guard is suspended over the blade to prevent inadvertent blade contact from the above, sides and the rear. This device protects the operator's hand from accidental contact of the saw blade during the operation of the machine. A Sturdy metal is suspended directly and is also to restrain the workpiece if it is lifted from the table by the motion of the saw. The guard is bolted onto the riving knife or suspended from an adjusted arm.

Riving Knife: Is a thin piece of steel metal located behind the blade with a purpose of keeping the saw kerf of the cut open or split to prevent the workpiece from pinching the blade in contacting the rear. The riving knife is adjustable to suit blades of different diameters. When adjusted correctly it should be approximately 3mm ($^{1}{}_{8}$ in) from the saw teeth at its lowest point, no more than 8 or 9 mm ($^{3}{}_{8}$in) from the teeth at its tip and a maximum of 2 to 3 mm ($^{1}{}_{8}$ in) below the highest point of the saw blade.

Kick-back: This prevent the board been sawn from throwing the workpiece back at the operator at high speed.

Anti-Kickback: These are small plates such that when the workpiece moves backward towards the operator, the teeth dig into its upper surface and restrain such motion. **Exhaust/Hood**: This is a device connected to the machine which helps to get rid of the sawdust of saw chippings, from the machine

Push Stick: The push stick is use to protect the operator's hand while allowing good hand control of the stock as it is pushed through the cutter head or blade.

Mitre Fence

An adjustable mitre fence slides on a path parallel to the blade in a slot machined in the table. It is used when crosscutting timber from 90 to 45 degrees. The fence must run smoothly without being slack and it should be marked with a clear scale to indicate its angle.

On/Off Switches

Choose a saw with easily accessible on/off switches. This will help to easily on/off the machine in case of emergency.

Rip Fence

A workpiece is run against a rip fence to guide it on a straight path as it is sawn from end to end. It is essential that the fence is study and inflexible. To this end some fences are held at both the front and back of the saw table, but this is not essential provided that the fence is constructed with a well-designed single mounting. The fence is should be capable of very fine adjustment from side to side, with a clear graduated scale.

2.8.3.5 Sanding Machine

The sander is a general-purpose finishing tool. The abrasive is looped around the disc and the circular motion makes it effective for sanding with the grain of wood. Abrasive of various grades also make the sander useful for shaping.

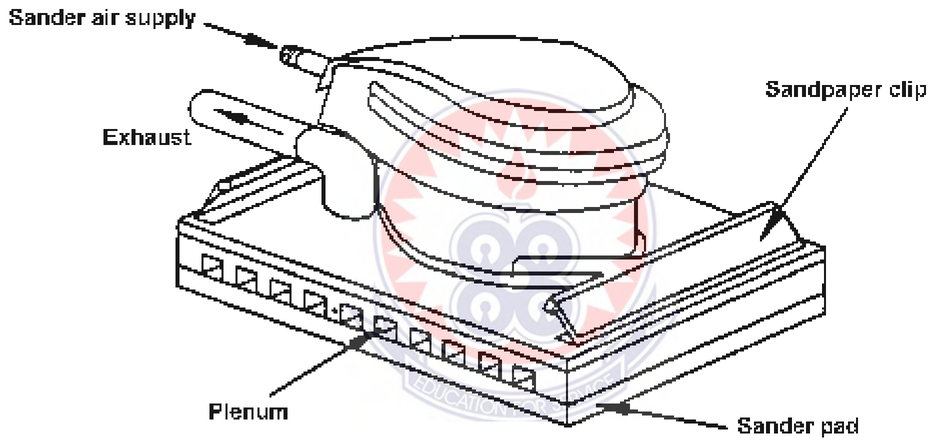


Figure 2.5 Sanding machine

Source: ISO 19085-2:2019. Accessed on 21st January 2020

Enclosement of power transmission: This protects the wires connected to the machine and prevents it from being exposed directly to the operator.

Dust extractor: This is a device that accumulates all the dust that will be generated during sanding. This prevents the dust from polluting the working environment.

Guard feed rollers: They are motor-driven rollers that revolve around the sander disc and provides the main driven force during the sanding.

Guard on unused runs: This protects the unused parts of the disc which is not directly in contact with the sanding operation and prevents accidental contacts of the disc by the machine operator.

Guard to close drum: This protects the running drum during the sanding operation. This helps to avoid contact of the operator during operation of the machine.

2.8.3.6 Bandsaw Machine

A vertical band saw machine uses a thin, flexible, continuous metal band saw with cutting teeth on one edge. The saw runs on two pulleys. In order to make a cut, the operator keep the stock flat on the work table, hand-feed and manipulate the stock against the blade by exerting the proper amount of force. Serious cuts or amputations can occur if the operator contacts the blade.

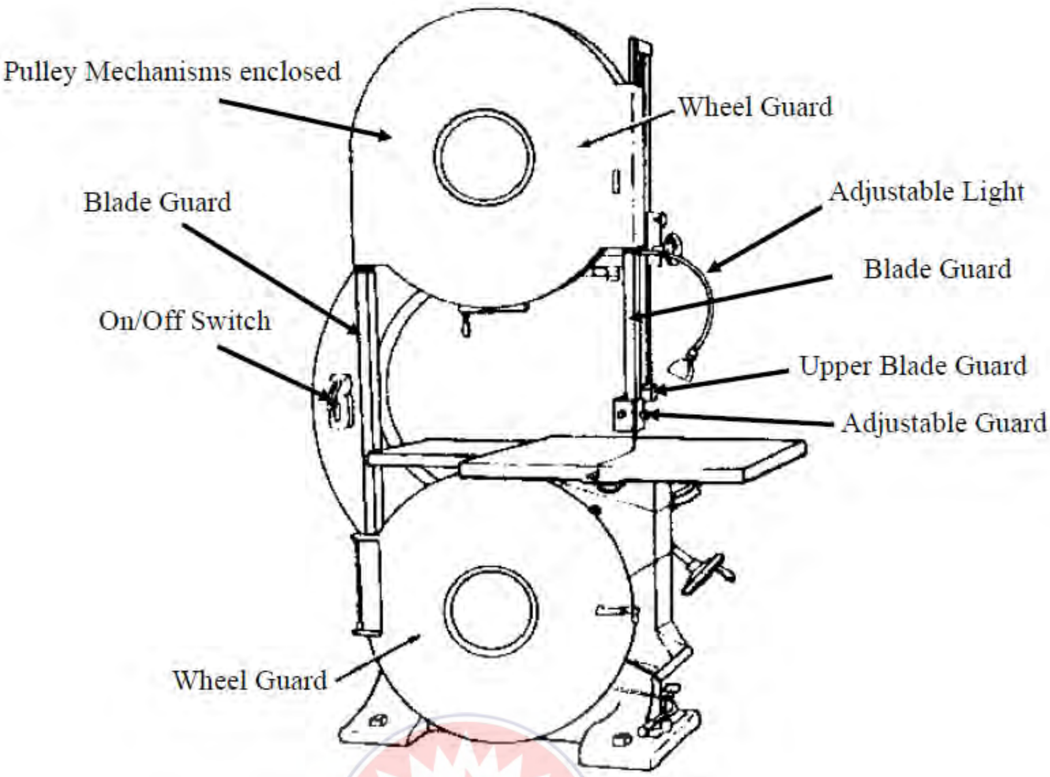


Figure 2.6 The vertical bandsaw machine

Source: ISO 19085-1:2019. Accessed on 21st January 2020

Wheel Guard: This covers the pulley systems and the blade above and below the working table.

Top Blade Guard: Except for the part exposed to work, the entire bandsaw blade is enclosed by the machine's casing. The exposed section is shielded by a vertically adjustable guard. Protect the blade during operation of machine.

Blade Guides: Bearings or guide blocks support the blade on both sides and from behind so as to resist the tendency for it to be twisted and pushed off the band wheels by the action of cutting a workpiece. One set of bearings, mounted above the saw table, moved up and down to accommodate the thickness of the work; and a fixed set of bearings is usually mounted below the table. Blade guides must be capable of adjustment to very fine tolerances.

Tracking Device: The tracking is adjustable to ensure that the blade runs centrally on and around the pulleys of the band wheels.

Saw Frame: The best band saws are constructed with rigid heavy gauge steel frame to resist the considerable tension applied to the blade. A saw cannot run true if the frame is flexible.

Adjustable Guard: This helps the operator to adjust the blade during cutting of curved potion of the workpiece.

Rip fence: Straight rip cuts are made against a short adjustable fence. Very deep or long workpieces may prove unstable when using the rip fence as supplied – in which case, extend the fence by screwing a higher wooden fence onto it. You will find it advantageous if the rip fence can be mounted on either side of the blade, particularly for bevel ripping when the gravity will help hold the work against the fence on the titled table. Some saws are made with a depth stop mounted ahead of the rip fence for cutting tenons and other joints to length.

Mitre Fence: A mitre fence slides along a groove machined or cast int the saw table. By adjusting the angle of the fence, it is possible to make square or mitred crosscuts. Mitre fences are often too short, and should be extended with a wooden facing to support long workpieces.

Emergency Switch: As a safety feature, on/off switches are sometimes made with a removable key. On some models opening the blade-access doors automatically immobilizes the machine to ensure that the saw cannot be switched on accidentally when the blade and wheels are exposed.

Foot Brake: Floor standing band saws are sometimes fitted with a brake to bring the blade to stop after switching the machine off.

Dust Extraction: A sawdust exhaust port below the table can be attached to the hose of a portable extractor to throw off dust out of the working area.

Tension Control Device: The blade's tension is adjusted by moving the top band wheel up or down. Some saws are made with a scale that indicates the tension for each blade, but usually the correct blade tension has to be ascertained by experimentation and experience. This helps to prevent the bandsaw blade from breaking**.**

2.8.4 Machinery (Guarding)

Machine Guard provides important information for the safety and health of those who operate, clean, repair or maintain woodworking machinery. It applies to employers, contractors, supervisors, self-employed persons, employees and safety and health representatives. Failure to provide, attach or replace guarding on moving parts, or follow safe locking-out and tagging procedures are common causes of injury in woodworking industries. Safe Use of Woodworking Machinery (Guarding) is one of three publications dealing with woodworking hazards - wood dust, chemicals and woodworking machinery. Woodworking machinery includes: spindle moulders, circular, crosscut and rip saws, radial arm saws, band saws, jointers, planers**,** shapers, lathes, sanding machines, boring and mortising machines, routers, and tenoning machines.

2.8.5 What are the Risks?

Risk factors associated with woodworking machinery include: sharp unguarded parts that can cut or amputate, pierce, or graze. Rotating unguarded parts turning at high revolutions that can severely cut or amputate body parts, trap, nip or catch clothing, jewelry or body parts, cause a friction burn or abrasion; the force exerted on a piece of wood by a rotating part causing the machinist to be injured or knocked off balance. Unguarded moving parts “nipping” (or coming together), or moving without warning, or moving unpredictably, with the potential to amputate fingers, or crush body parts; hand feeding without using a jig or push stick. The parts most likely to cause injury or harm are: nip points rotating blades; rotating wheels; moving parts; movable (reciprocating) blades; pressing parts. The employer must carry out risk assessments of these parts to determine their likelihood of causing injury or illness. Risk assessments should include any automated machinery at the workplace as well as other woodworking hazards such as wood dusts, chemicals, fire and manual handling. Procedures for controlling the risk of injury or illness should be developed by the employer in consultation with employees and any others likely to have access to the machine, such as for maintenance or repairs. Instruction and training should be provided at induction of new employees, on introduction of new machines, and as refresher training, on an ongoing basis.

2.8.6 Controlling Risks

This Guidance Note focuses on guarding machines or the parts of machines most likely to cause injury or harm. Guarding is the most effective means of reducing the risk of injury or harm from dangerous parts of a machine. In its simplest form, guarding is a physical barrier preventing access to any part of a machine that has the potential to cut, pierce, graze or crush a person or a body part. Guarding can be designed and manufactured as part of a machine or it can be designed and manufactured as a separate part. Many types of guarding systems are available to protect workers from dangerous machinery. If guarding is used as a control measure, it should, as far as practicable, prevent access to the danger points or dangerous areas of the machine. Effective guards protect workers from preventable injuries.

The guards should not be removed or disabled unless it is necessary for cleaning, repair or maintenance, and only then in accordance with agreed (and preferably written) safe procedures that prevent operation or unintentional start-up. The operators of the machines and other employees should be involved in developing these procedures, and be trained to carry them out. Locking-out and tagging is an essential safe procedure when machinery guarding must be removed for cleaning, maintenance and repairs. This requires a machine to be stopped and its energy source isolated and locked off while work is being done.

Only the person deactivating and working on the machine can hold the key to restore power and restart the machinery. Personal protective equipment is not considered to be guarding, but safety signs should be placed on machinery advising of the PPE required by operators. All new or inexperienced workers should be supervised at all times.

2.8.7 Guidelines for Purchasing Machinery

The law requires designers of machinery and those who manufacture and supply it to carry out a risk assessment of the likelihood of the machinery causing injury or harm when properly used at a workplace. When a new or used item of machinery is purchased for a workplace, information on the purpose for which the machine was designed and the knowledge, training or skill necessary for its safe use must be provided to the purchaser.

Designers, manufacturers, importers and suppliers are obliged to ensure this information is available. Information should also be available to enable an employer to take the risk of injury of employees into account when considering the purchase of new or used machinery. Guarding should be a key consideration when purchasing machinery. Choosing machinery with appropriate guarding will reduce the potential cost for maintenance, adjustment or repairs.

Choosing machinery with appropriate guarding will reduce the potential for injury and be less costly if a risk assessment at the workplace identifies the need for additional guarding. Employers are entitled to expect adequate guarding is in place before machinery is offered for sale. However, employers must still undertake their own risk assessments to ensure guarding on newly purchased machinery in order to reduce the risk of injury or harm. Well located emergency stop buttons should be considered when purchasing machinery. A buyer of used machinery should also have access to related safety information before making a commitment to purchase.

2.8.8 How Should Hazardous Machines be Guarded

In order of importance, guarding should be: a permanently fixed physical barrier that ensures no person has either complete or partial access to dangerous areas during normal operation, adjustment, maintenance or cleaning; an interlocking physical barrier that ensures no person has either complete or partial access to dangerous areas during normal operation, adjustment, maintenance or cleaning; or a physical barrier securely fixed in position by fasteners to ensure that the guard cannot be altered or removed without the aid of a tool or key, in cases where neither permanently fixed nor an interlocking physical barrier is practicable. If none of these types of guards are practicable, installing a presence sensing system should be considered. Stationary guards have no moving parts. They offer protection only when the guard is in the correct position. Stationary guards may be:

Fixed guards preventing access to moving parts by enclosing or providing a physical barrier;

Distance guards not completely enclosing the hazard but reducing the access to the danger point by their location in respect to the hazard;

Fence guards completely surrounding a machine, isolating the worker from the machine; adjustable guards provided with an opening to the machine through which material can be fed, the whole guard or part of it being adjustable to suit the size of the material being used. The space between an adjustable guard and the material should be minimal;

Riving knives attached to circular saws to prevent cut timber jamming or catching on the rear of the saw blade and being thrown back at the operator.

2.8.9 Guard Construction

Where guarding is not an integral part of the machine and has to be constructed and installed at the workplace, consideration should be given to how the guard should function, e.g. by preventing access, containing the hazard, or a combination of both these safeguards. Where a risk assessment shows an existing guard to be inappropriate or inadequate, any modifications or redesign should ensure the guard itself will not create a hazard, e.g. with trapping or shear points, and rough or sharp edges likely to cause injury.

Moving, non-interlocking guards are connected to the machine so that when the machine moves or the material is moved, the guard moves with it and takes a safe position by covering the dangerous parts. Moving, non-interlocking guards may be:

- **automated guards** moved automatically by the machine;
- **Self-adjusting**, moveable guards which adjust to accommodate the material. These guards are opened at the beginning of the operation by the passage of the material and return to the safe position when the last of the material passes through the guard.
- **Interlocking guards** provide a physical barrier connected to the power or control system of the machine, preventing the machine from operating until the guards are in place. Interlocking guards may be: interlocking distance moving interlocking guards that contain movable parts and whose movement is interconnected with the power or control system of the machine; guards that don't completely enclose a hazard, but prevent access by their distance from the hazard.

Guards can be made from durable material suitable for the purpose and may be: solid sheet metal, metal rod, perforated or mesh material (small enough to ensure that body parts cannot enter the danger zone), acrylic or polycarbonate, stainless steel, rubber, or timber.

When selecting a material for guarding or assessing its adequacy, the following should be considered: weight (if it's too heavy it is unlikely to be replaced, e.g. after maintenance), strength and durability of the material, effects on the machine's performance and reliability, e.g. does it cause the machine to overheat, does it affect the visibility of the operator, and control of other hazards, e.g. does it affect the control of wood dust and noise?

2.8.10 Removal of Guarding

An employer may provide guarding that allows the convenient repair, servicing, adjustment and maintenance of the machine when not in normal operation. However, by-passing or disabling guarding, whether deliberately or by accident, should be made as difficult as possible. If removing guarding is the most practicable means of providing access to the machine for servicing or maintenance, the guarding must be replaced and secured before normal operations re-commence. The machine must be isolated and locked-out whenever guarding is not in place. If a machine is designed with guarding that does not allow a particular task to be carried out, the reason could be that the machine is being used incorrectly or inappropriately for the task.

Agreed (and preferably) written locking-out and tagging procedures must be followed each time machinery guarding is removed for cleaning, repair or maintenance. The procedures should be drafted to ensure:

- only one person holds the key to locking off the machine's power supply;
- all persons likely to be involved with the machine are notified of intended work;
- normal shut-down procedure for the machinery is followed;
- the machine's power is isolated from its main source by an isolating switch;
- no other stored or other energy source remains that may activate machinery thought to be shut-down;
- the isolating switch is locked "off" with a locking-out device until work is finished and guarding replaced;
- a danger tag is attached to the isolating switch;
- danger signs are placed strategically to warn people entering the area;
- only the person doing the work and holding the key can turn the power back on;

- there is an emergency procedure to isolate or restore power if the person holding the key is unavailable or cannot do so.

2.8.11 Other Forms of Safety Devices

Safety devices can be designed to sense the presence of a person or body part and shut the machine down before access to the dangerous area occurs. Safety devices may be:

- **Trip devices** - physical devices that stop the operation of a machine or make it assume a safe position when a person approaches beyond a safe limit, thereby preventing an injury.
- **Electro-sensitive safety systems** - also called photoelectric safety systems, light curtains or electronic beams. These systems detect an object when the beam of light is broken, and shut the machine or parts of it down so that a person cannot come in contact with the dangerous parts.
- **Pressure sensitive systems -** systems based on sensors that detect pressure applied by a person or object. Once a predetermined pressure has been detected, the machine, or parts of it, is shut down, so that a person cannot reach the dangerous parts.

Sharp, well maintained cutting tools are essential to safety and productivity. Satisfactory arrangements must be made for the carriage of these valuable items to and from the machines so that the tools are protected from damage and their handlers from injury. Cutting tools should normally be carried in a purpose made box or other form of protection to ensure the tools are not handled directly. A trolley should be used for heavy or awkward loads. Every person involved in carrying or handling cutting tools should be trained in the approved methods for each type of tool.

2.8.12 What the Law Says

The Occupational Safety and Health Act 1984 says as far as is practicable, employers must provide and maintain a work environment in which employees are not exposed to hazards. This includes providing a safe system of work, information, training, supervision and, where appropriate, personal protective equipment. The Act says employees must take reasonable care of their own safety and health and avoid adversely affecting the safety and health of others. They must comply, as far as possible, with safety instructions, use personal protective equipment provided and report hazards and injuries.

The Act says any person who designs, manufactures, imports or supplies any machinery for use at a workplace shall, as far as practicable, ensure the design and construction of the machinery does not expose people who properly install, maintain or use the machinery to hazards. The Act says any person who designs, manufactures, imports or supplies any machine must provide information on hazards that are likely to result from the use of the machine, and should provide information on its safe operation and maintenance. Machinery guarding is covered in Part 4 of the Occupational Safety and Health Regulations 1996. These regulations should be explained to woodworking employees and others involved in machinery maintenance as part of their induction and ongoing information and training. Where guarding does not eliminate the risk of injury, or it is not practicable to guard a moving part, workers should not operate or be close to the moving part unless a safe system of work is in place to reduce the risk. Do not use safety devices such as the emergency stop button or lanyard to routinely shut off the machine.

2.9 Effect of Wood Processing on the Health of Wood Workers Occupational Exposure to Wood Dust

2.9.1 Definitions and Concepts of Dust

Airborne contaminants occur in the gaseous form (gases and vapours) or as aerosols. In scientific terminology, an aerosol is defined as a system of particles suspended in a gaseous medium, usually air in the context of occupational hygiene, is usually air. Aerosols may exist in the form of airborne dusts, sprays, mists, smokes and fumes. In the occupational setting, all these forms may be important because they relate to a wide range of occupational diseases. Airborne dusts are of particular concern because they are well known to be associated with classical widespread occupational lung diseases such as the pneumoconiosis, as well as with systemic intoxications such as lead poisoning, especially at higher levels of exposure. But, in the modern era, there is also increasing interest in other dust-related diseases, such as cancer, asthma, allergic alveolitis, and irritation, as well as a whole range of non-respiratory illnesses, which may occur at much lower exposure levels. This document aims to help reduce the risk of these diseases by aiding better control of dust in the work environment.

2.9.2 Dust as an Occupational Hazard

According to the International Standardization Organization (ISO 4225 - ISO, 1994), "Dust: small solid particles, conventionally taken as those particles below 75 µm in diameter, which settle out under their own weight but which may remain suspended for some time". According to the "Glossary of Atmospheric Chemistry Terms" (IUPAC, 1990), "Dust: Small, dry, solid particles projected into the air by natural forces, such as wind, volcanic eruption, and by mechanical or man-made processes such as crushing, grinding, milling, drilling, demolition, shoveling, conveying, screening, bagging, and sweeping. Dust particles are usually in the size range from about 1 to 100µm in diameter, and they settle slowly under the influence of gravity."

However, in referring to particle size of airborne dust, the term "particle diameter" alone is an over simplification, since the geometric size of a particle does not fully explain how it behaves in its airborne state. Therefore, the most appropriate measure of particle size, for most occupational hygiene situations, is particle aerodynamic diameter, defined as "the diameter of a hypothetical sphere of density 1 g/cm^3 having the same terminal settling velocity in calm air as the particle in question, regardless of its geometric size, shape and true density." The aerodynamic diameter expressed in this way is appropriate because it relates closely to the ability of the particle to penetrate and deposit at different sites of the respiratory tract, as well as to particle transport in aerosol sampling and filtration devices.

In aerosol science, it is generally accepted that particles with aerodynamic diameter > 50 µm do not usually remain airborne very long: they have a terminal velocity >7cm/sec. Dust found in the work environment include:

- **mineral dusts,** such as those containing free crystalline silica (e.g., as quartz), coal and cement dusts;
- **metallic dusts,** such as lead, cadmium, nickel, and beryllium dusts;
- **other chemical dusts,** e.g., many bulk chemicals and pesticides:
- **organic and vegetable dusts,** such as flour, wood, cotton and tea dusts, pollens;
- **biohazards,** such as viable particles, moulds and spores

Dusts are generated not only by work processes, but may also occur naturally, e.g., pollens, volcanic ashes, and sandstorms. Although in occupational hygiene, the term "airborne dust" is used, in the related field of environmental hygiene, concerned with pollution of the general atmospheric environment, the term "suspended particulate matter" is often preferred.

2.9.3 Penetration and Deposition of Particles in the Human Respiratory Tract

A schematic representation of the respiratory system is presented in **Figure 2.1** and **2.2** to indicating the different regions, namely, nasopharyngeal (or extra thoracic region), tracheobronchial region and alveolar region.

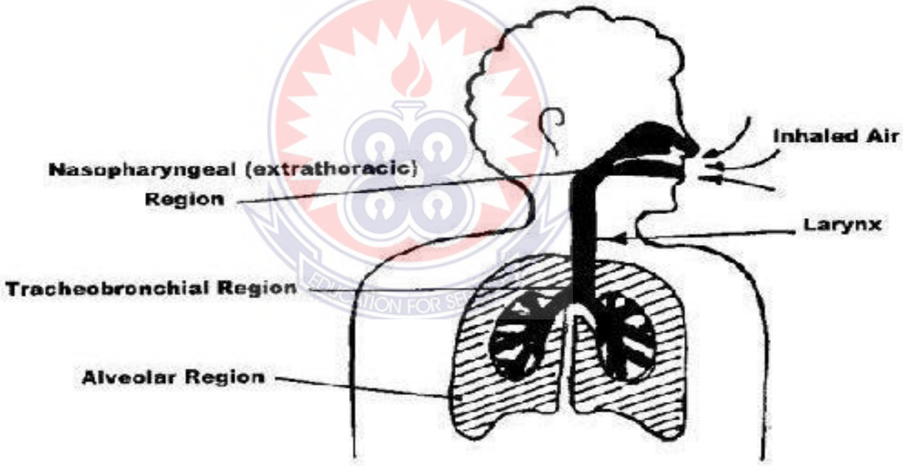


Figure 2.7: Schematic representation of the human respiratory track

Source: Lippmann, 1977

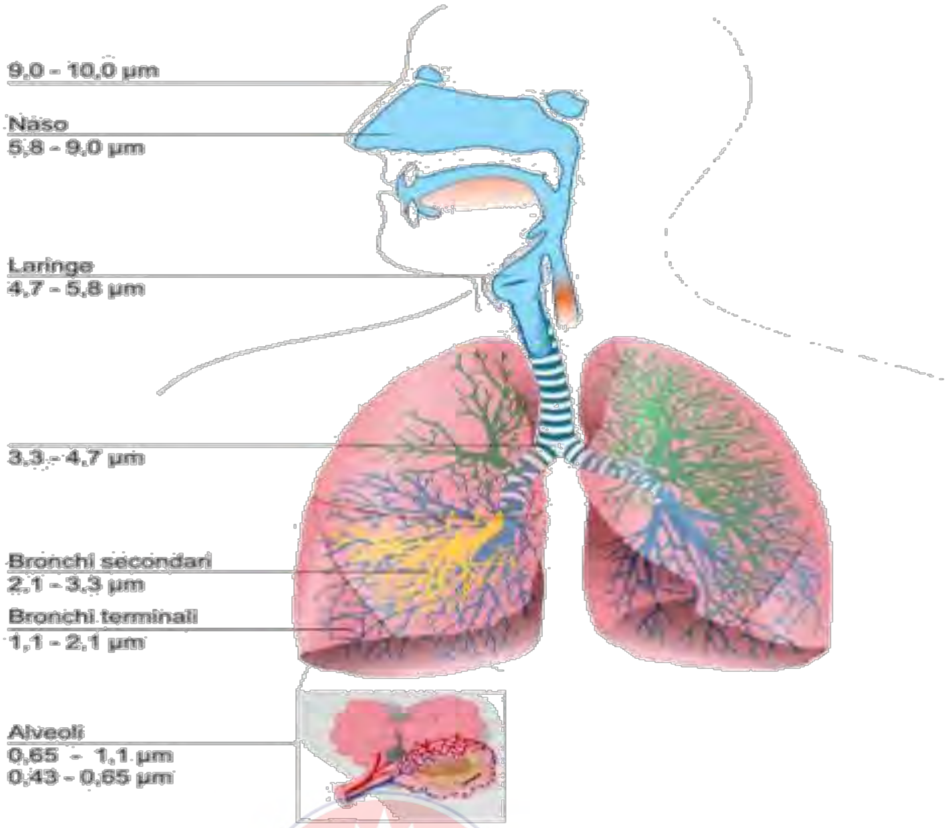


Figure 2.8 Particulate size with associated depth of lung deposition

Source: Lippmann, 1977

Particles small enough to stay airborne may be inhaled through the nose (nasal route) or the mouth (oral route). The probability of inhalation depends on particle aerodynamic diameter, air movement round the body, and breathing rate. The inhaled particles may then either be deposited or exhaled again, depending on a whole range of physiological and particle-related factors. The five deposition mechanisms are sedimentation, inertial impaction, diffusion (significant only for very small particles < 0.5 µm), interception, and electrostatic deposition. Sedimentation and impaction are the most important mechanisms in relation to inhaled airborne dust, and these processes are governed by particle aerodynamic diameter. There are big differences between individuals in the amount deposited in different regions (Lippmann, 1977).

The largest inhaled particles, with aerodynamic diameter greater than about 30 µm, are deposited in the airways of the head, which is the air passages between the point of entry at the lips or nares and the larynx. During nasal breathing, particles are deposited in the nose by filtration by the nasal hairs and impaction where the airflow changes direction. Retention after deposition is helped by mucus, which lines the nose. In most cases, the nasal route is a more efficient particle filter than the oral, especially at low and moderate flow rates. Thus, people who normally breathe part or all of the time through the mouth may be expected to have more particles reaching the lung and depositing there than those who breathe entirely through the nose. During exertion, the flow resistance of the nasal passages causes a shift to mouth breathing in almost all people. Other factors influencing the deposition and retention of particles include cigarette smoking and lung disease.

The particles which fail to deposit in the head, the larger ones will deposit in the tracheobronchial airway region and may later be eliminated by muscularly clearance. The smaller particles may penetrate to the alveolar region, the region where inhaled gases can be absorbed by the blood. In aerodynamic diameter terms, only about 1% of 10-µm particles gets as far as the alveolar region, so 10µm is usually considered the practical upper size limit for penetration to this region. Maximum deposition in the alveolar region occurs for particles of approximately 2 µm aerodynamic diameter. Most particles larger than this have deposited further up the lung. For smaller particles, most deposition mechanisms become less efficient, so deposition is less for particles smaller than 2 µm until it is only about 10-15% at about 0.5 µm. Most of these particles are exhaled again without being deposited. For still smaller particles, diffusion becomes an effective mechanism and deposition probability is higher. Deposition is therefore a minimum at about 0.5 µm.

After deposition, the subsequent fate of insoluble particles depends on a number of factors. (Soluble particles depositing anywhere may dissolve, releasing potentially harmful material to the body). The trachea and bronchi, down to the terminal bronchioles, are lined with cells with hair like cilia (the ciliated epithelium) covered by a mucous layer. The cilia are in continuous and synchronized motion, which causes the mucous layer to have a continuous upward movement, reaching a speed in the trachea of 5-10 mm per minute. Insoluble particles deposited on the ciliated epithelium are moved towards the epiglottis, and then swallowed or spat out within a relatively short time. Intermittent peristaltic movements of the bronchioles, and coughing and sneezing, can propel particles in the mucous lining towards the larynx and beyond.

The epithelium of the alveolar region is not ciliated; however, insoluble particles deposited in this area are engulfed by macrophage cells (phagocytes), which can then (1) travel to the ciliated epithelium and then be transported upwards and out of the respiratory system; or (2) remain in the pulmonary space; or (3) enter the lymphatic system. Certain particles, such as silica-containing dusts, are cytotoxic; and that. they kill the macrophage cells.

Wherever the particles are deposited, either in the head or in the lung, they have the potential to cause harm either locally or subsequently elsewhere in the body. Particles that remain for a long time have increased potential to cause disease. This is why inhaled particles are important in relation to environmental evaluation and control.

2.9.4 Particle Size Fractions: Conventions for Dust Sampling

As described above, the fractions of the airborne particles inhaled and deposited in the various regions depend on many factors. However, for sampling purposes conventions have been agreed in terms of aerodynamic diameter, which say what should be collected, depending on which region is of interest for the substance and hazard concerned. The American Conference of Governmental Industrial Hygienists (ACGIH), the International Organization for Standardization (ISO), and the European Standards Organization (CEN) have reached agreement on definitions of the **inhalable, thoracic** and **respirable** fractions (ACGIH, 1999; ISO, 1995; CEN, 1993; ICRP, 1994). Depending on the health effects, one or another region will be of interest.

Inhalable particulate fraction is that fraction of a dust cloud that can be breathed into the nose or mouth. Examples of dusts for which any inhalable particle is of concern include certain hardwood dusts (which may cause nasal cancer), and dusts from grinding lead-containing alloys (which can be absorbed and cause systemic poisoning).

Thoracic particulate fraction is that fraction that can penetrate the head airways and enter the airways of the lung. Examples of dusts for which this fraction is of particular concern include cotton and other dusts causing airway disease.

Respirable particulate fraction is that fraction of inhaled airborne particles that can penetrate beyond the terminal bronchioles into the gas-exchange region of the lungs. Examples of dusts for which the respirable fraction offers greatest hazard include quartz and other dusts containing free crystalline silica; cobalt-containing and other hard metal dust produced by grinding masonry drill bits; and many others

2.9.5 Mechanisms of Dust Generation and Release

In order to ensure efficient and safe process design or to effectively modify a certain process or operation to decrease dust exposure, many factors must be considered; inputs from aerosol sciences and engineering (Vincent, 1995; Faye and Otten, 1984) are essential. Success can only be achieved through teamwork involving occupational hygienists, production personnel, engineers, aerosol technology specialists and other professionals.

Dusts usually originate from larger masses of the same material, through a mechanical breakdown process such as grinding, cutting, drilling, crushing, explosion, or strong friction between certain materials (rocks and wood). Dust generated from these materials are often called "primary airborne dust", for example wood dust produced in sawing and sanding, cotton dust in ginning, carding and spinning operations, and wool dust in shearing sheep. The rate of dust generation increases with the energy associated with the process in question. For example, a sander will produce more dust when it operates at higher speeds. Although friability, that is ability to be broken down, is another important characteristic, more friable does not necessarily mean more hazardous.

2.9.6 Dust Exposures

Many work processes involve operations which, if not properly planned, controlled and managed, may cause appreciable dust exposure and pose serious health risk. The visual appearance of a dust cloud will be strongly dependent on the wavelength of the light and the angle of viewing with respect to the light source, as well as particle size, shape, refractive index and, of course, dust concentration. With this in mind, and depending on the conditions, it is usually fair to assume that a dust cloud that is visible to the naked eye may represent a hazard. However, it should not be assumed that the lack of a visible cloud represents “safe” conditions.

A respirable particle is too small to be seen with the unaided eye A dust release can be localized and only affect the immediate worker, or it may spread throughout the workplace and affect everybody else. This happens if the release is large enough and uncontrolled, particularly if the dust particles are very fine, thus able to stay airborne for a long time. Airborne dust poses an inhalation hazard; however, after it has settled, it can create a problem through contact with the skin and ingestion. For instance, even if dust is controlled by means of a local exhaust ventilation system, there may be leaks that allow fine, possibly invisible, respirable dust back into the workroom. Or side drafts may disturb the capture efficiency of the system. Therefore, even if there is the impression that the situation is under control because there are ventilation systems, these should still be periodically checked to make sure they are actually adequate and efficient

2.9.7 Dusty Processes

Dust releases in the workplace may result from any form of mechanical breakdown, such as occurs in mining and quarrying, machining and other process operations, or from the movement of dusty materials. Specific dust-producing operations include sandblasting, rock drilling, jack hammering, stone cutting, sawing, chipping, grinding, polishing, breaking of sand moulds, “shake-out”, cleaning foundry castings, use of abrasives, plus all the powder and granule handling operations such as weighing and mixing (common to most batch processes) and transferring dusty raw materials and products (e.g., bag filling, conveyor belts, transfer from one container to the other). One type of emission source, often overlooked, is the transportation of bags, or any containers with dusty materials; this may constitute an important and moving dust source, particularly if bags have holes, or containers are not properly closed. Disposal of empty bags can also be an important source, especially if the bags are manually compressed to save space. These will probably not be listed as specific operations in the plant, being consequently disregarded as potential emission sources which require control.

Transportation paths should be followed and carefully observed. Other areas where appreciable hazards may be overlooked are storage rooms.

Machining operations, using tools such as lathes, grinders, turning and milling machines, can produce large amounts of dusts, as well as cutting oil mists. The dimensional cutting of metals and other materials is usually a high energy process that produces dust in a wide range of particle sizes which are then carried in the flow of air. The hazard often comes from the part being worked, for example, carbide steel alloys contain metals which include nickel, cobalt, chromium, vanadium and tungsten. Many hard metals are used in the manufacture of special tools and parts, and it may happen that workers machining or sharpening them have no idea of the original composition, often believing that the dust produced is quite harmless.

However, health hazards cannot be linked solely to occupations, but must be linked to the working environment. It often happens that dust-producing occupations are carried out alongside others which offer practically no risk, particularly in small industries.

Woodworking can produce large amounts of dust, particularly at sawing and sanding operations; these need to be controlled both for health reasons (nasal cancer, allergies, and irritation) and for safety reasons (as large amounts of fine wood dust may create a risk of fire or explosion. The uninformed worker will often continue to work in such conditions, although if the dust is hazardous, disabling or fatal diseases can rapidly develop, as described in the next section. However, implementation of control measures can reduce such exposures to satisfactory levels of problems caused by dust (Swuste et al., 1993; Swuste, 1996; Fang, 1996).

2.9.8 Routes of Exposure

Most attention is given to dust exposure by inhalation, and the problems by this route are dealt within however, other routes are often important. Skin absorption (or percutaneous absorption) can occur, for example, if water-soluble materials dissolve in sweat and pass through the skin into the bloodstream, causing systemic intoxication. Although this report does not deal with liquid aerosols, it must be noted that spraying will often lead to skin exposure and absorption, even when protective clothing is worn. This can lead to substantial risk when pesticides are sprayed (Vreede et al., 1998; Garrod et al., 1998).

Ingestion is likely when poor hygiene allows eating, drinking or smoking in contaminated or dirty workplaces. Particles do not need to be airborne. For example, many cases of lead poisoning have occurred in poorly kept small potteries, in which ingestion of lead salts has been an important route. Obviously, entry by this route can be significantly reduced by good housekeeping, personal hygiene and adequate work practices. Many inhaled particles are swallowed and ingested, but for control and measurement purposes these are usually considered with the inhalation route.

In addition to the risk of absorption through the skin, many dusts may affect the skin directly, causing various types of dermatoses, which are a widespread and often serious problem, or even skin cancer. Dust of any size has health significance, even if it never becomes airborne. This is important for the woodworking industry.

2.9.9 Potential Health Effects by Inhalation

If dust is released into the atmosphere, there is a good chance that someone will be exposed to it and inhale it. If the dust is harmful, there is a chance that someone will suffer from an adverse health effect, which may range from some minor impairment to irreversible disease and even life-threatening conditions. The health risk associated with a dusty job depends on the type of dust (physical, chemical and mineralogical characteristics), which will determine its toxicological properties, and hence the resulting health effect; and the exposure, which determines the dose. Exposure depends on the air (usually mass) concentration and particle aerodynamic diameter of the dust in question, and exposure time (duration). The dose actually received is further influenced by conditions that affect the uptake, for example, breathing rate and volume. Particle aerodynamic diameters will determine if and for how long dusts remain airborne, their likelihood of being inhaled, and their site of deposition in the respiratory system. Dust concentration in the air and the aerodynamic diameter of the particles will determine the amount of material deposited, hence the dose received at the critical site.

As already mentioned, very soluble substances can be absorbed from all parts of the respiratory tract, so for soluble particles the site of deposition (and hence aerodynamic diameter) is of less importance. For insoluble particles, the site of deposition in the respiratory system is of fundamental importance, which means that the aerodynamic properties of the particle, shape (fibers), dimensions of the airways and breathing patterns are relevant.

Health effects resulting from exposure to dust may become obvious only after long-term exposure; this is often the case with pneumoconiosis. It may happen that effects appear even after exposure has ceased, thus being more easily overlooked or mistakenly attributed to non-occupational conditions. For example, mesothelioma resulting from exposure to crocidolite has appeared after latency periods of 40 years or more after beginning of exposure. Therefore, the fact that workers do not have any symptoms, or that symptoms appear after a long time, should be no excuse for inactivity concerning avoidance of exposure to known hazards.

However, many dusts have effects that result from shorter exposures to higher concentrations. Even when dealing with pneumoconiosis-producing dusts, there are cases of acute effects. Health effects, which may result from exposure to different types of dust, include pneumoconiosis, cancer, systemic poisoning, hard metal disease, irritation and inflammatory lung injuries, allergic responses (including asthma and extrinsic allergic alveolitis), infection, and effects on the skin. The same agent can cause a variety of adverse health effects, for example, certain wood dusts have been known to cause such impairment as eye and skin irritation, allergy, reduced lung function, asthma, and nasal cancer.

2.9.10 Pneumoconiosis

One of the definitions of pneumoconiosis by ILO is: “pneumoconiosis is the accumulation of dust in the lungs and the tissue reaction to its presence”. The lung changes in pneumoconiosis range from simple deposition of dust, as in the case of siderosis (deposition of iron dust in lungs, clearly observed by X-ray examination but with no clinical manifestations), to conditions with impairment of lung function, such as byssinosis.

2.9.11 Cancer

Many dusts are confirmed carcinogens, for example: asbestos (particularly crocidolite), which may cause lung cancer and mesothelioma, free crystalline silica (IARC, 1997), hexavalent chromium and certain chromates, arsenic (elemental and inorganic compounds), particles containing polycyclic aromatic hydrocarbons, and certain nickel-bearing dusts. Certain wood dusts have been recognized as causing nasal cancer (IARC, 1995).

Deposited wood dust particles in to human body expose the lungs to significant doses, which may cause carcinoma of the lung tissue, or they may be transported from the lungs and damage other parts of the body (Liou et al., 1996). Soluble carcinogens may pose a risk to both lungs and other organs (Li et al., 1990). It should be mentioned that, in the case of lung cancer, wood dust constitutes a confirmed non-occupational causal agent. Moreover, there is a strong synergistic effect on certain airborne dusts, for example in wood dust by which the potential risk is enormously increased (Pope et al., 1995). For this reason, any meaningful control strategy to avoid occupational exposure should be linked to some cessation campaign.

2.9.12 Skin Irritation and Skin Sensitization

Skin irritation can be caused by contact with the wood itself, dust, bark, sap or lichens growing on the bark. Some species of wood can cause nettle rashes or irritant dermatitis on the forearm, back of the hands, the face, neck, scalp and the genitals (Enarson and Chan-Yeung, 1990). Sensitization dermatitis is usually caused by exposure to the fine dust from certain wood species. This exposure produces symptoms similar to skin irritation. Once sensitized, the body sets up an allergic reaction, and will react severely when exposed even to a small amount of wood dust

(Nylander and Dement, 1993). Inhalation of fine wood dust causes a number of effects on the respiratory tract. The nasal symptoms are rhinitis (runny nose), continuous sneezing, blocked nose, and nose bleeds. Eye symptoms are soreness, watering and conjunctivitis.

2.9.13 Allergic Respiratory Effects

The most commonly reported allergic respiratory effect due to wood dust is asthma ("woodworker's asthma"). It may occur alone or in conjunction with dermatitis. The hypersensitivity reaction may be immediate or delayed or dual. The presence of alkaloids, acids and other natural constituents, which give colour and grain to the timber, produces the pulmonary sensitivity (Goldsmith and Shy, 1988). Occupational asthma and rhinitis due to exposure to western red cedar has been studied extensively. It is one of the most common types of occupational asthma prevailing in British Colombia. In cedar sawmill workers, the prevalence of asthma is reported to be more than twice than that of the un-exposed population (Enarson and Chan-Yeung, 1990). Occupational asthma occurs in 5% of exposed workers in British Colombia (Chan-Yeung,1982).

According to research conducted by Vedal et al. (1986) revealed that prevalence of cough, dyspnea, persistent wheeze, and asthma increased with increase in dust exposure level. Levels of FVC and FEV1 were lower with dust concentrations greater than 2 mg/m^3. An eight hours' time-weighted-average dust level below 3.5 mg/m^3 of western red cedar is necessary in order to reduce the incidence of occupationally related asthma (Brooks et al., 1981). In the US, OSHA established an exposure limit of 2.5 mg/m^3 for western red cedar based on allergenic properties of the dust Federal Register.

2.9.14 Non-allergic Respiratory Effects

According to Carosso et al. (1987), exposure to wood dust can cause chronic obstructive lung diseases, even in the absence of reported asthma (Enarson and Chan-Yeung, 1990). Many of the epidemiological studies of wood dust associated health hazards are focused on the furniture industry. A number of studies have demonstrated a reduction in pulmonary function due to wood dust exposure (Al Zuhair et al., 1981; Whitehead et al., 1981a; Holness et al., 1985; Carosso et al., 1987; Goldsmith and Shy, 1988b; Rastogi et al., 1989; Shamssain, 1992; Liou et al., 1996). Dose-response relationships were reported among percentage predicted lung function values and cumulative dust index given by mean area dust level multiplied by number of years of exposure (Holness et al., 1985), and reduction in lung function indices with wood dust exposure, classified by job titles (Goldsmith and Shy, 1988b; Liou et al., 1996). Exposure to saw fumes containing terpenes also causes a chronic obstructive impairment in lung function (Hedenstierna et al., 1983; Dalqvist et al., 1994; 1996). Saw fumes are generated when lumber is sawn in band saws or frame saws, and when the battens are edged. Airborne terpene levels in Swedish sawmill have been reported to be in the range of 80-550 mg/m^3. It has been reported that workers exposed to an average of 250 mg/m^{3}of pinene and carene had decreased lung function (Hedenstierna et al., 1983). In Sweden there are no specific exposure limits for individual terpenes, but the exposure limit for turpentine (450 mg/m^3) is used when assessing exposure to saw fumes (Eriksson and Levin, 1990). Terpenes also cause irritation of skin and mucous membrane, and also allergic and non-allergic contact dermatitis. The verbenols (metabolites from penne) in urine (Eriksson and Levin 1990) can be used as a biological exposure index of saw fumes (Eriksson et al., 1996).

2.9.15 Respiratory, Nasal, eye and Other Symptoms

According to the research conducted by Holness et al. (1985); Li et al. (1990); Pisanello et al. (1991); Shamssain (1992); Liou et al. (1996), Respiratory, nasal and eye symptoms are the most common symptoms reported by woodworkers. Chronic bronchitis is prevalent among workers of which woodworkers are not excretion (Li et al., 1990; Liou et al, 1996). A study on wood mill workers making joss sticks reported that the prevalence of chronic bronchitis was 15% among smokers and 8% among non-smokers (Liou et al., 1996). Another similar woodworking study reported chronic bronchitis among 33% of the wood workers studied (Li et al., 1990).

A South Australian study conducted by Pisanello et al. (1991) reported that the prevalence of regular blocked nose was 51%, sneezing 41%, regular runny nose and excess nasal secretion 45% and eye irritation 35% among furniture workers. Hardwood users reported more nasal symptoms than users of reconstituted wood. This latter study also reported that the woodworkers with the least experience were more likely to report symptoms than more experienced workers. A South African study reported that the prevalence of nasal symptoms was 49%, cough 43%, and phlegm 15% among furniture workers Shamssain (1992). In contrast to the previous South Australian study, the South African study reported that the prevalence of cough and nasal symptoms increased with increase in the number of years of employment.

A Canadian study reported high prevalence of cough (38%), sputum (30%), wheeze (18%), rhinitis (32%) and eye irritation (20%) among woodworkers compared with the controls (Holness et al., 1985). Significant correlations have also been reported between frequent sneezing and eye irritation with wood dust exposed jobs (Goldsmith and Shy, 1988).

2.9.16 Sino Nasal Effects Other Than Cancer

According to the research conducted by Black et al. (1974), chronic exposure to wood dust can cause impaired mucociliary clearance among woodworkers. A British furniture industry study reported that nasal mucociliary function is significantly impaired in workers who have been exposed to wood dust in the furniture industry for more than 10 years (Black et al., 1974). A Swedish furniture industry study reported that 20% of workers had nasal hypersecretion, nasal obstruction (40%), and impaired nasal clearance (54%) compared to controls (Wilhelmsson and Drettner, 1984). Work-related impairment of nasal mucociliary clearance among woodwork teachers exposed to dust concentrations below the TLV of 2 mg/ ^{3} has been reported from Sweden (Ahman et al., 1996). Among them 55% had work-related nasal obstruction, runny nose (27%), sneezing (39%), nose bleed, and impaired smell (22%), the prevalence being significantly higher than in the controls.

2.9.17 Nasal Mucostasis

According to the research conducted by Andersen et al. (1977), it has been reported that the mucostatic factor in wood dust is of importance in the development of nasal adenocarcinoma because of the prolonged retention of dust in the nasal cavity (Andersen et al., 1977). The study found that the number of workers with nasal mucostasis was directly proportional to the wood dust concentration. This study also reported that at a wood dust concentration of 25.5 mg/m^3, 63% of workers had mucositis and at 2.2 mg/m^{3}only 11% showed mucositis.

A number of studies showed that cuboidal metaplasia with dysplasia were a possible precursor to nasal adenocarcinoma among workers exposed to wood dust (Boysen and Solberg, 1982; Wilhelmsen et al., 1985; Boysen et al., 1986). The histological examination of biopsies for nasal dysplasia can be used as an appropriate tool in identifying occupational groups with an increased incidence of Sino nasal carcinoma (Boysen et al., 1986).

2.9.18 Nasal and Other Types of Cancer

The association between nasal cancer and occupational exposure to wood dust, especially in the furniture industry, was first noted in the late 1960's in the UK (Macbeth, 1965; Acheson, 1976), where the annual incidence of nasal adenocarcinoma was 0.7 cases per 1000 and is estimated as 500 times the level found in the general population (Acheson et al., 1968). Nasal cancer is a significant hazard of woodworking, particularly associated with furniture making and hardwoods (Acheson et al., 1981; Rang and Acheson, 1981). Australian studies have confirmed that not only furniture workers but also saw millers and carpenters are at risk (Matthews, 1975; Franklin, 1982). Hardwood dust exposure has been shown to be associated with nasal adenocarcinoma (Acheson et al., 1981) while softwood dust exposure has been shown to increase the risk of both sin nasal and nasopharyngeal squamous cell cancers (Voss et al., 1985; Vaughan and Davis, 1991). The etiological factors for nasal adenocarcinoma are still unknown. A review has stated that it is possible that the health hazards of hardwoods are related more to physical properties than to any chemical constituents (Walker, 1988). The period of latency on average for nasal cancer is about 41years (Andersen et al., 1977). The International Agency of Research on Cancer (IARC) in their monograph on the "Evaluation of Carcinogenic

Risks to Humans" has concluded that wood dust is carcinogenic to humans (group 1) IARC (1995).

The carcinogenic aspects of exposure to wood dust have been reviewed by Wills (1982), HSE (1986), Walker (1988), Nylander and Dement (1993), and in more detail in an IARC monograph, 1995. The association between nasal cancer and wood dust exposure has been confirmed to varying degrees in France (Luce et al., 1993; Leclerc et al., 1994); the Netherlands (Hayes et al., 1986); a pooled case-control study of seven countries - France, China, Germany, Italy, the Netherlands, Sweden, the US (Demers et al., 1995); Australia (Iron side and Matthews, 1975; Franklin, 1982), the United Kingdom (Macbeth, 1965; Acheson et al., 1981); Denmark, Finland and Sweden (Hernberg et al., 1983a; 1983b), British Colombia Elwood (1981), Japan (Fukuda and Shibata, 1988), and Norway (Voss et al., 1985). The studies reported from the US are less convincing (Imbus and Dyson, 1987; Viren and Imbus, 1989).

Larger wood dust particles are not retained in the nose, since the deposited larger particles are removed by muscularly clearance. Only the finer particles are trapped in nasal passages, causing mucositis's, which may in turn lead to nasal cancer. It has been reported that the much lower risk observed in British Colombia compared with English furniture makers is most probably due to the use of softwood rather than hardwood, or the use of course and unseasoned timber rather than kiln dried timber, or the use of rough sawing rather than fine finishing, or outdoor or large indoor workplaces rather than small shops or a combination of these factors. The study also reported that in British Colombia, forestry and sawmills employ a large proportion of the population while furniture manufacturing is very limited. Workers performing sanding operations may have an especially high risk of development of cancers within the Sino nasal area because the mean airborne wood dust concentration in the breathing zone of workers engaged in hand or machine sanding has been found to be nearly three times the concentration found in the breathing zone of persons employed in sawing, planning and drilling (Anderson et al., 1977; Wills, 1982). Excess risk of nasal cancer is associated with high levels of exposure to airborne wood dust. One review has suggested that nasal adenocarcinoma can be eliminated in Europe and its occurrence can be prevented in the US if wood dust exposures do not exceed an 8-hour time-weighted-average (TWA) of 5 mg/ ^{3} (Blot et al., 1997).

2.9.19 Lung Fibrosis

According to Michaels (1967), inhaled wood dust can cause lung fibrosis. Results of an animal study also have suggested that wood dust has a very weak fibro genetic effect on lungs (Yuan et al., 1990). A British study Hubbard et al. (1996) has given evidence of cryptogenic fibro sing alveolitis (CFA) among workers associated with exposure to metal or wood dust. CFA is characterized by progressive dyspnea, dry cough, inspiratory crackles on auscultation of the chest, and restrictive lung function.

2.9.20 Systemic Poisoning

Some chemical dusts can enter the organism and pass to the bloodstream, thus being carried through the organism and exerting toxic action on one or more organs or systems, e.g., kidneys, liver, blood. Systemic intoxication can be acute (i.e., of rapid onset and short duration), or chronic (of long duration and usually slow onset), depending on the type of chemical and degree of exposure. Toxic metal dusts - such as lead, cadmium, beryllium and manganese - may cause systemic intoxications, affecting blood, kidneys or the central nervous system. Although less usual, certain toxic dusts may also enter the organism by absorption through the skin, e. g. pentachlorophenol crystals may dissolve in sweat and easily penetrate through intact skin.

There are some wood dusts which can also be toxic if inhaled or ingested, for example, East Indian Satinwood, South African boxwood. Wood toxins are usually alkaloids. Overexposure to certain hard metal dusts (e.g., arsenic and cadmium) may lead to a diffuse pulmonary fibrosis, with increasing dyspnea. Severe cases may progress even after cessation of exposure. This disease is often complicated with occupational asthma.

2.10 Metals in Particulate Matter

Exposure to metals in the air is capable of causing a myriad of human health effects, ranging from cardiovascular and pulmonary inflammation to cancer and damage of vital organs (Utsunomiya et al., 2004). Contemporary research into air pollution is revealing that the metals components of particulate matter (PM) are contributing significantly to adverse health effects, even at the low levels found in ambient air (Pope et al., 1995). The Environmental Protection Agency has set-out health-based standards for fine particulates in 1997, but the standards do not take into account new research on the composition of the particulate matter or the toxicity of its components (Konkel, 2009). The toxicity of particulate matter, in particular the fine and ultrafine particles (those particles smaller than 2.5 µm, has been proven to cause severe mortality and morbidity in humans over the past 25 years; however, in the past decade, emerging research is providing evidence that the metallic particles may be more dangerous than other PM components (Konkel, 2009). In addition, current evidence is showing that mass concentration of PM alone may not be the best indices for associating health effects with exposure to PM (Costa & Dreher, 1997).

The most recently published U.S. Census presents that approximately 80% of the U.S. population lives in urban areas (U.S. Bureau of the Census, 2000). Accordingly, a majority of the U.S. population is exposed to typical ambient metals concentrations found in urban environments. Furthermore, a significant segment of this population also lives in the vicinity of metals sources, such as waste incinerators, metal processors, metal fabrication, welding, etc., where they may be exposed to airborne metals greatly in excess of the typical ambient concentrations. Recent monitoring data in East St. Louis, Illinois depicts levels of metal HAPs in the general community and near schools that not only exceed residential regulatory limits, but reach levels above guidelines set for exposure in an occupational setting (arsenic, measured at approximately 2,340 mg/m^3; occupational short-term exposure limit is 2,000 mg/m^3 (Pettersen, 2010). Levels such as these would prompt be wearing respiratory personal protective equipment in an industrial setting, yet these levels were found near not only unprotected members of the general public, but children, who are more sensitive to elevated airborne metals.

As mentioned, trace metals are released to the atmosphere by the combustion of fossil fuels such as wood, high temperature industrial activities and waste incinerations. Natural emissions are mainly from volcanism, wind erosion, as well as from forests fires and the oceans (Nordberg, 2007). Specifically, the combustion of fossil fuels constitutes the principal anthropogenic source for beryllium, cobalt, mercury, molybdenum, nickel, antimony, selenium, tin and vanadium. Fossil fuel combustion also contributes to anthropogenic release of arsenic, chromium, copper, manganese and zinc. In addition, a large percentage of arsenic, cadmium, copper, nickel and zinc are emitted from industrial metallurgical processes. Exhaust emissions from gasoline formerly contained variable quantities of Lead, Copper, Zinc, Nickel and Cadmium. Zinc emission is also associated with tire rubber abrasion (Councell, 2004). Several independent groups of investigators have shown that the sizes of the airborne particles determine the potential to elicit inflammatory injury, oxidative damage, and other biological effects (Costa & Dreher, 1997; Lippmann, 2006; Ghio et al. 2002; Sangani et al, 2010; Utsonomiya et al., 2004). The particle size distribution of an aerosol will also determine the deposited fraction of inhaled particles in the various regions of the respiratory tract (Oller, 2010). PM is a complex mixture of extremely 8 small particles and liquid droplets and is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. The EPA is concerned about particles that are 10 µm in diameter or smaller, because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs, travel throughout the body, deposit in organs, penetrate cell membranes, and cause serious health effects (Adachi and Buseck, 2010). EPA groups particle pollution into two categories:

- "Inhalable coarse particles," such as those found near roadways and dusty industries, are larger than 2.5 µm and smaller than 10 µm in diameter.
- "Fine particles," such as those found in smoke and haze, are 2.5 µm in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

These particles can be further defined with reference to relevant health effects for various regions, as described by Nieboer et al. (2005):

- The Inhalable aerosol fraction" is the fraction of total airborne particles that enters the body through the nose and/or mouth during breathing. This fraction corresponding to particles with aerodynamic diameter (d) > 100 µm is relevant to health effects throughout the respiratory tract such as rhinitis, nasal, bronchial effects, and lung cancer. This fraction is also relevant for systemic effects.
- The ''thoracic aerosol fraction" is a subfraction of the inhalable fraction (d_a < 30 µm) composed of particles that can penetrate into the tracheo-alveolar region of the lung and is important for asthma, bronchitis, and lung cancer.
- The ''respirable aerosol fraction" (or alveolar fraction) is the subfraction of the inhaled particles (d_a < 10 µm) that penetrates into the alveolar region of the lung (i.e., includes the respiratory bronchioles, the alveolar ducts and sacs) and is pertinent to the development of such chronic diseases as pneumoconiosis and emphysema.

2.10.1 Characteristics of Fine Particulate Matter

The World Health Organization states that 2.4 million people die each year from causes directly attributable to air pollution (WHO, 2002), particularly to fine particles (Ravindra, 2001). According to current human health research, we now know that free radicals similar to those in cigarettes are also found in airborne fine particles and potentially can cause many of the same life-threatening conditions (Dollemore, 2008).

In a study of trace metals in PM performed in the Detroit urban atmosphere, Utsonomiya et al. (2004), postulates that if toxic trace elements are homogenously dispersed as impurities in insoluble larger-size particles, risks to human health and the environment are less than if they occur as major constituents in individual, trace-metal and nano scale particles. Generally, the evaluation of most studies shows that the smaller the size and solubility of the PM, the higher the toxicity through mechanisms of oxidative stress and inflammation (Valavandis, 2008). A study of $PM_{2.5}$ in 2010 showed that metals were the important source for cellular oxidant generation and subsequent health effects (Maciejczyk, 2010). Health effects are stronger for fine (1 to 2.5µm) and ultrafine (0.1 to 1µm) particles. For an explosion to occur in a dust-air mixture, the dust concentration must be above the lower limits.

2.10.2 Air Exposure Pathways

The major pathways for human intakes of metals in which air serves as the primary medium of contact are inhalation and dermal. Exposure assessment depends on ambient and anthropogenic concentrations and multiple routes of exposure. People are exposed to toxic air pollutants in many ways that can pose health risks, such as by:

- Breathing contaminated air.
- Eating contaminated food products, such as fish from contaminated waters; meat, milk, or eggs from animals that fed on contaminated plants; and fruits and vegetables grown in contaminated soil on which air toxics have been deposited.
- Drinking water contaminated by toxic air pollutants.

- Ingesting contaminated soil. Young children are especially vulnerable because they often ingest soil from their hands or from objects they place in their mouths.
- Touching (making skin contact with) contaminated soil, dust, or water (for
- example, during recreational use of contaminated water bodies).

Other indirect pathways in which air serves as a medium include:

- Deposition of metals to surface dusts and intake from ingestion, inhalation, or dermal contact;
- Deposition to surface water and sediment and intake from ingestion and dermal contact; and

- Uptake of deposited metals into aquatic and/or terrestrial biota, entrance into the human food chain, and intake from ingestion.

Although, in most instances in which airborne metals have resulted in environmental contamination, ingestion of surface dust tends to be the dominant contributor to human health risk, this may not always be the case. Bioavailability of inhaled metals can be much higher than for other routes of intake. This can result in relatively high internal doses from inhalation even when inhalation intakes are similar to intakes from other routes. An example of this is the large contribution made by woodworkers to the body burden of cadmium (Newman, 2004).

Infants and children can be particularly vulnerable to airborne metal particulates because differences in airway geometry and airstream velocities tend to result in higher deposition fractions of inhaled particulates in infants and children than in adults at similar exposure levels. In addition, research shows that particle pollution may significantly reduce lung function growth in both adult and children (EPA, report 2004).

2.10.3 Metal Concentration in an Inhaled Dust

Wood dust inhaled as mentioned earlier showed that, wood dust contains metallic elementals in the particulate matter inhaled such as arsenic, lead, manganese and many others. Theses elementals in the particulate matter inhaled may or not cause harm to the worker. Below shows a list of elements present in the saw dust inhaled and its possible effects associated with wood processing.

2.10.4 Arsenic (As)

Aside from occurring naturally in the environment, arsenic can be released in larger quantities through volcanic activity, erosion of rocks, forest fires, and human activity. The wood preserving industry uses about 90% of the industrial arsenic in the U.S. Arsenic is also found in paints, dyes, metals, drugs, soaps and semi-conductors. The most common exposure pathway for inorganic arsenic is through food ingestion with lower amounts coming from drinking water and air. Inhalation may occur near metal smelters and by burning wood treated with an arsenic wood preservative. Exposure to arsine occurs through inhalation. The average concentration of arsenic compounds in the air that humans can inhaled should not exceed the threshold or the recommended 0.5 mg/m^3 permissible exposure limit (PEL) (ISO, OSHA, EU, CEN, NIOSH, EPA and ACGIH Standards).

Short-term Health Effects: Arsenic is odorless and tasteless. Gastrointestinal effects (nausea, diarrhea, abdominal pain) and central and peripheral nervous system disorders can occur from acute inorganic arsenic inhalation and ingestion. Acute oral exposure to inorganic arsenic can result in death. Arsine is extremely toxic and can result in headaches, vomiting, and abdominal pains occurring within a few hours of exposure. Acute exposure to high levels of arsine can also result in death. Lower levels exposure can cause decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet.

Long-term Health Effects: Inhalation of inorganic arsenic can result in skin and mucous membrane irritation. Gastrointestinal effects, anemia, peripheral neuropathy, skin lesions, hyperpigmentation, and liver or kidney damage can occur with long-term oral exposure. Long-term low-level exposure can cause darkening of the skin and the appearance of small corns or warts on the palms, soles, and torso. Inhalation of inorganic arsenic is strongly associated with lung cancer and oral exposure has been linked to a form of skin cancer and also to bladder, liver, and lung cancer. Women who work in, or live near, metal smelters may have higher than normal spontaneous abortion rates and their children may exhibit lower than normal birth weights. Human inhalation studies have reported inorganic arsenic exposure to be strongly associated with lung cancer. Inorganic arsenic is classified by the EPA as a Group A human carcinogen and can cause cancer of the skin, lungs, liver, and bladder.

2.10.5 Cadmium (Cd)

Cadmium is a soft silver-white metal that is usually found in combination with other elements. Cadmium is most commonly a byproduct from the smelting of zinc, lead, or copper ores. Cadmium is also used in manufacturing (pigments and batteries), metal-plating, and in the plastics industry. Inhalation and ingestion of contaminated food are the two major exposure pathways. Cadmium is emitted into the air from burning fossil fuels, from incineration of municipal waste materials, and from zinc, lead, and copper smelters. Smoking cigarettes is another source of airborne cadmium; smokers have about twice the amount of cadmium in their bodies as do nonsmokers. Ambient air cadmium concentrations in any environment should not exceed 0.2 mg/m^2 (ISO, OSHA, NIOSH, CEN, EU, EPA and ACGIH), permissible exposure limits standards (PEL).

Short-term Health Effects: The short-term effects of cadmium inhalation include lung effects such as bronchial and pulmonary irritation. A single acute exposure to high levels of cadmium can result in long-lasting impairment of lung.

Long-term Health Effects: Long-term effects of cadmium inhalation and ingestion can result in cadmium build-up in the kidneys and can have effects on the liver, lung, bone, immune system, blood, and nervous system. The cadmium poisoning caused softening of the bones (brittle bones) and kidney failure. Cadmium exposure has been tentatively linked to an increased risk of lung cancer. Cadmium is classified by the EPA as a group B1, probable human carcinogen.

2.10.6 Lead (Pb)

Lead is a naturally occurring, bluish-gray metal that is found in small quantities in the earth's crust. Pure lead is insoluble in water; however, the lead compounds vary in solubility. The primary use of lead is in manufacturing batteries. Lead is also used in the production of metal products, including sheet lead, solder, and pipes, and in ceramic glazes, paint, ammunition, cable covering, and other products.

Exposure: The largest source of lead in the atmosphere has been from leaded gasoline combustion; however, air lead levels have decreased considerably with the phase-down of lead in gasoline. Exposure to lead can occur by inhalation of airborne lead from combustion of solid waste, coal, oils, emissions from iron and steel production and lead smelters, and tobacco smoke. Ingestion of lead in food and soil are also common pathways. The recommended exposure limit for exposure to lead (Pb) is 0.05 mg/m^3 (OSHA, EPA, NIOSH, EU, CEN and ACGIH).

Short-term Health Effects: Lead is very toxic in low doses and can cause death in children with high lead blood levels. Short-term exposure to lead can also lead to brain damage, kidney damage, and gastrointestinal distress.

Long-term Health Effects: Long-term effects of lead exposure can lead to problems with the blood, CNS, blood pressure, kidneys, and Vitamin D metabolism. Neurological symptoms have been reported in workers, and slowed nerve conduction in peripheral nerves in adults. Chronic lead exposure can cause loss of IQ, slowed cognitive development, reduced growth, hearing loss, and other developmental effects in children. Additional effects of lead exposure can include reproductive effects e. g., decreased sperm count, spontaneous abortions, low birth weight, slowed postnatal neurobehavioral development. EPA considers lead to be a Group B2, probable human carcinogen.

2.10.7 Manganese (Mn)

Manganese is a silver-colored metal that forms compounds in the environment with chemicals such as oxygen, sulfur, and chlorine. Manganese chloride is used in the chlorination of organic compounds, in animal feed, and in dry-cell batteries. Manganese is use to glazes and varnishes in ceramics. Manganese is an essential nutritional element in humans.

Exposure: Manganese is a naturally occurring element found in low levels in water air, soil, and food. Elevated levels of manganese can occur in the air near iron and steel production plants, power plants, and coke ovens. The most common route of exposure to high doses of manganese is through inhalation of contaminated air. Ambient Air Concentration of Manganese within air inhaled should not be more than 5 mg/m^3.

Short-term Health Effects: No short-term effects for acute manganese exposure have been reported in humans; however, contemporary researchers are evaluating manganese health effects. Some tests in animals have shown effects on the lungs via inhalation. Manganese is considered to have moderate acute toxicity based on the short-term tests in rats.

Long-term Health Effects: Long-term exposure to manganese leads primarily to effects on the CNS, including slowed visual reaction time, hand steadiness, and eye-hand coordination. Inhalation exposure specifically can cause respiratory effects. Chronic exposure to high levels can also result in a syndrome called manganese, which typically begins with feelings of weakness and lethargy, tremors, a mask-like face, psychological disturbances, and can involve impotence and loss of libido. EPA has classified manganese as a Group D, not classifiable as to carcinogenicity in humans.

2.10.8 Copper (Cu)

Copper is used to make wire, plumbing pipes, and sheet metal. U.S. pennies made before 1982 are made of copper, while those made after 1982 are only coated with copper. Copper is also combined with other metals to make brass and bronze pipes and faucets. Copper compounds are commonly used in agriculture to treat plant diseases like mildew, for water treatment and, as preservatives for wood, leather, and fabrics. Copper is also used in contraception as intrauterine devices.

Exposure: Copper is a metal that occurs naturally throughout the environment, in rocks, soil, water, and air. Copper is an essential element in plants and animals (including humans). Plants and animals absorb some copper from eating, drinking, and breathing. In general, the soluble ionized salts of copper are much more toxic than the insoluble or slightly dissociated compounds. Sources of exposure are from fume, from copper ore smelting and related metallurgic operations, from welding, and from dusts of copper metal and salt.

Short-term Health Effects: Inhalation of dust, fumes, and mists of copper salts can result in irritation of nasal mucous membranes, eye irritation, upper respiratory tract irritation; metallic taste, nausea, and metal fume fever. Acute copper poisoning can cause liver injury, methemoglobinemia, and hemolytic anemia. Effects of single exposure following suicidal or accidental oral exposure have been reported as metallic taste, epigastric pain, headache, nausea, dizziness, vomiting and diarrhea, tachycardia, respiratory difficulty, hemolytic anemia, massive gastrointestinal bleeding, liver and kidney failure, and death.

Long-term Health Effects: Mammals have efficient mechanisms to regulate copper stores such that they are generally protected from excess dietary copper levels; however, at high enough levels, chronic overexposure to copper can damage the liver and kidneys. Chronic exposure may also result in an anemia. Vineyard sprayer's lung disease, a lung and liver disease, occurs in individuals exposed to copper sulfate spray for 2 to 15 years. Wilson's disease is inherited, genetic disorders in which copper builds

up in the liver; symptoms include liver toxicity (jaundice, swelling, pain) usually do not appear until adolescence.

Although some studies of workers exposed to copper have shown increased cancer risks, they were also exposed to other potentially carcinogenic chemicals. Copper is currently categorized as Group D, not classifiable as to carcinogenicity in humans.

2.10.9 Iron (Fe)

Iron is the second most abundant metal and the fourth most abundant element in the earth's crust, comprising 5.1% (by weight) of the earth's crust. Hydrous iron (II) oxides are generally red-brown gels and are the major constituents of soil. Iron is an essential element that is required by all forms of life. Iron is a natural constituent of all foods of plant or animal origin, and occurs in foods as iron oxides, inorganic and organic salts, and organic complexes, such as hemoglobin.

Iron is the most widely used of all the metals, accounting for 95% of worldwide metal production. Its low cost and high strength make it indispensable in engineering applications such as the construction of machinery and machine tools, automobiles, the hulls of large ships, and structural components for buildings. Since pure iron is quite soft, it is most commonly used in the form of steel. The production and use of iron compounds as catalysts, pigments, drugs, as well as their use in agriculture, nutrition, metallurgy, and leather tanning may result in their release to the environment through various waste streams. The mining and processing of iron ores also may result in the release of iron compounds to the environment. The iron and steel industries are also likely sources of emissions of iron compounds to the environment. Occupational exposure to iron compounds may occur through inhalation and dermal contact with these compounds at workplaces where iron compounds are produced or used.

Short-term Health Effects: Toxicity occurring with acute iron overdose results from a combination of the corrosive effects on the gastrointestinal mucosa and the metabolic and hemodynamic effects caused by the presence of excessive elemental iron. Inhalation of ferric salts as dusts & mists is irritating to the respiratory tract. Ferric salts are regarded as skin irritants. Early symptoms of acute iron toxicity include diarrhea, sometimes containing blood; fever; nausea, severe; stomach pain or cramping, sharp; vomiting, severe, sometimes containing blood. Late symptoms of acute iron toxicity include bluish-colored lips, fingernails, palms of hands; drowsiness; pale, clammy skin; seizures; unusual tiredness or weakness; weak and fast heartbeat.

Long-term Health Effects: The corrosive effect of iron results in stomach and intestinal erosions and ulceration (i.e., hemorrhagic gastritis and enteritis with blood loss); however, there is a lack of correlation between the severity of intestinal damage and death. Large chronic doses of iron may so interfere with assimilation of phosphorus as to cause severe rickets in infants. Free iron is a pro-oxidant and can induce oxidative stress and DNA damage. The carcinogenicity of iron has been demonstrated in animal models, and epidemiologic studies have shown associations with several human cancers.

2.10.10 Zinc (Zn)

Zinc is one of the most common elements in the earth's crust. It is found in air, soil, and water, and is present in all foods. Pure zinc is a bluish-white shiny metal. Zinc has many commercial uses, such as coatings to prevent rust, in dry cell batteries, and mixed with other metals to make alloys like brass, and bronze. Common zinc compounds found at hazardous waste sites include zinc chloride, zinc oxide, zinc sulfate, and zinc sulfide. Zinc compounds are widely used in industry to make paint, rubber, dyes, wood preservatives, and ointments.

Exposure: Zinc is an essential trace element, necessary for plants, animals, and microorganisms. Some zinc is released into the environment by natural processes, but most comes from human activities like mining, steel production, coal burning, and burning of waste. It attaches to soil, sediments, and dust particles in the air. Rain and snow remove zinc dust particles from the air. Humans are exposed to zinc through drinking contaminated water or a beverage that has been stored in metal containers or flows through pipes that have been coated with zinc to resist rust; eating too many dietary supplements that contain zinc; and working in any of the following jobs: construction, painting, automobile mechanics, mining, smelting, and welding; manufacture of brass, bronze, or other zinc-containing alloys; manufacture of galvanized metals; and manufacture of machine parts, rubber, paint, linoleum, oilcloths, batteries, some kind of glass, ceramics, and dyes.

Short-term Health Effects: Zinc is an essential element in our diet. Too little zinc can cause problems, but too much zinc is also harmful. Harmful effects generally begin at levels 10-15 times higher than the amount needed for good health. Large doses taken by mouth even for a short time can cause stomach cramps, nausea, and vomiting. Inhaling large amounts of zinc (as dusts or fumes) can cause a specific short-term disease called metal fume fever. Acute exposure to zinc oxide can result in coughing, sub sternal pain, upper respiratory tract irritation, rales, chills, fever, nausea, and vomiting. Zinc chloride fume is an irritant of the eyes, skin, mucous membranes, and lungs in humans. The signs and symptoms of acute exposure to zinc chloride fume include conjunctivitis, irritation of the nose and throat, hoarseness, cough, dyspnea, wheezing, rales, rhonchi, chest tightness and/or pain, nausea, vomiting, epigastric pain, listlessness, lightheadedness, and a metallic taste in the mouth.

Long-term Health Effects: Excessive concentrations of zinc taken on a long-term basis can cause anemia and decrease the levels of good cholesterol. Chronic exposure to zinc oxide by skin contact may result in popular-pustular skin eruptions in the axilla, inner thigh, inner arm, scrotum and pubic areas. Excessive absorption of zinc suppresses copper and iron absorption. The U.S. Food and Drug Administration (FDA) has stated that zinc damages nerve receptors in the nose, which can cause anosmia (loss of sense of smell). Epidemiologic studies of zinc refinery workers found no correlation between industrial zinc exposures and lung or other types of cancer. Based on incomplete information from human and animal studies, the EPA has determined that zinc is not classifiable as to its human carcinogenicity.

2.11. Occupational Exposure Limits

Occupational Exposure Limits (OELs) are a key element in risk management and are often incorporated in legal standards (Vincent, 1998). Although obvious exposure to known harmful agents should be controlled regardless of any existing regulation, establishment of a control limit often draws attention to a substance. Occupational exposure limits are usually expressed in one of the following forms:

- Time-weighted average concentration (TWA), which is the average concentration over a full shift, usually 8 hours.
- Ceiling concentration, which is an instantaneous concentration (in so far as this can be measured) not to be exceeded at any time.
- Short-term exposure limit (STEL), which is the average concentration over a specified time, e. g. 15 minutes.

For dusts whose effects depend on long-term average exposure, such as the pneumoconiosis-producing dusts, OELs are given as time-weighted average concentrations, whereas for substances which are fast acting, OELs are given as short term or ceiling limits.

Occupational exposure limits are initially based on dose-response, or exposure-effect assessments. The establishment of the "health-based occupational exposure limits" (WHO, 1980) requires consideration of the questions: "How much exposure causes what effect?" or "What exposure level causes no harm?" A health-based limit can then be established at a lower level. For example, health-based occupational exposure limits for mineral dusts were the subject of a WHO publication (WHO, 1986).

However, in some cases it is not possible to establish such a level, or the level may be impossible to achieve in practice. Authorities may then promulgate "operational exposure limits" (WHO, 1980), which involve yet another question: "how much effect is acceptable, if any". This involves a decision-making process, which requires consideration of technical and socio-economic issues (Ogden and Topping, 1997).

It should be kept in mind that OELs, even when established on sound scientific bases, are not necessarily adequate in all situations. Exposures below the OELs do not mean that all workers are protected, for reasons that include concomitant exposures to other substances and individual sensitivities; it is accepted that occupational exposure limits do not usually protect the hyper-susceptible workers. Moreover, values established for one country will not necessarily protect workers in another country where a number of factors, including duration of working week, climate and work schedules, may differ. Also, risk assessment is a dynamic process and a substance, once thought to be relatively harmless, may suddenly be proven to be the etiologic agent of a serious disease.

In any case, occupational exposure limits cannot be used as “fine lines between safe and dangerous”; professional judgement must be exercised at all times, accounting for the degree of uncertainty that exists not only in the establishment of these limits, but also in the assessment of the exposures which actually occur in the workplace. Nevertheless, occupational exposure limits provide occupational health professionals with a useful tool for assessing health risks and deciding whether a certain exposure situation is acceptable or not, and whether existing controls are adequate. Exposure in excess of these limits requires immediate remedial action, through the improvement of existing controls or implementation of new ones. Many authorities have established action levels at ½ or 1/5 of the OEL, at which preventive action should begin.

National or local regulations and standards concerning dust exposure should be followed. However, in the absence of exposure values acceptable by law in the jurisdiction in question, values adopted internationally (e.g., by the European Union), or in other countries (ACGIH, 1999a) are often used. Although “imported” values may serve as initial guidance, prompt action should be taken to establish relevant national regulations. In any case, lack or inadequacy of regulatory instruments should never be an obstacle to the recommendation and implementation of necessary preventive measures.

It should be kept in mind that simplistic approaches of just measuring concentrations and comparing results with values in a table may be misleading, as many factors influence the consequences of exposure to a certain hazardous agent. The interpretation of exposure assessment results has to be made by adequately trained professionals. Moreover, there are not yet (and there will probably never be) established occupational exposure limits for all of the currently utilized substances. Therefore, occupational hygienists should be well acquainted with and have access to sources of information concerning risk assessment and toxicology (including publications and data bases) in different countries, as well as in international agencies (IARC, ILO-CIS, IPCS, IRPTC-UNEP, WHO). If hazard information is available, then the control-banding approach may give useful guidance on controls.

2.12 Sampling Strategy

In any work environment there are spatial and temporal variations in the concentration of airborne contaminants, so that exposure may differ with workers' movement as well as with time of the day, week, or even month. There are also sampling and analytical errors: some can be avoided by careful procedures, while others are inherent to a certain methodology and have to be accounted for when deciding on the degree of reliability required for the estimation of the true value of the exposure parameter.

Therefore, a sampling strategy, accounting for all factors that may lead to any variation in the results, must be designed and followed, so that the data obtained is representative of the workers' exposure, thus ensuring a reliable exposure assessment. Important factors include:

- the day, week, or month sampling is performed,
- production rate,
- raw materials,
- work shift,
- task performed,
- individual performing task,
- dust control measures,
- technology used,
- number of workers,
- climate,
- other nearby processes,
- distance of worker from source, and
- errors in sampling and analytical procedures

If the national authority responsible for the adopted OELs has laid down an accompanying assessment strategy, this should be followed. If not, the responsible professional should design and follow a suitable strategy. CEN has produced a European Standard (EN 689) which gives practical guidance for the assessment of exposure to chemical agents and measurement strategies (CEN, 1994). In any case, professional judgement during an assessment is indispensable.

The classic questions when designing a sampling strategy are: Where to sample? For how long to sample? When to sample? and How many samples to collect? (BOHS, 1993). However, although specific methodological principles have been well established, there are nuances in their application. Obviously, any sample must be representative of the worker's exposure, which usually determines where and when to sample. Also, for the same type of agent and the same type of collecting medium, the recommended duration of sampling will be of the same order. However, specific situations may dictate differences in the number of samples required for an evaluation, because this, together with the quality of the measuring system, will determine the accuracy and precision of the obtained results, and the degree of reliability required will depend on the objective of the hazard evaluation. For the assessment of inhalation exposure, it is necessary to characterize the air that workers are actually inhaling; therefore, the samples should be collected in the "breathing zone," which is usually defined as a hemispherical zone with a radius of approximately 30 cm in front of the head.

Some design considerations should include "worst case" exposure sampling or sampling a representative number of workers indicative of all job categories. Sampling should be of full-shift duration or for the complete length of a process cycle, if the objective is to determine a time-weighted average concentration. Due to the variability in results and the probable lognormal distribution of dust exposures, sampling needs to be conducted over several shifts and during several days to best characterize the workplace exposures.

When assessing exposure to fast-acting substances (seldom the case with dusts) that can cause irreversible damage even on brief high exposures, sampling of very short duration (at the right time) is required, in order to detect concentration peaks, particularly if there are appreciable concentration fluctuations. High concentrations occurring for short periods can remain hidden, and undetected, if a sample is collected over a longer period of time during which very low concentrations also occur. Infrequently performed tasks also need to be characterized so that potential short duration but high concentration or peak exposures can be documented.

For the same exposure situation (including the expected environmental fluctuations), if the coefficient of variation of the measuring procedure is known and constant, it is possible, through the application of inductive statistical methods, to determine how reliable an estimate is, or what degree of uncertainty can be expected from a certain number of samples or measurements. This will guide the decision on how many samples to collect or how many measurements to make. The better the sensitivity, accuracy and precision of the measuring system and the greater the number of samples, the closer the estimate will be of the true concentration. It is usually accepted that, if measurements are needed, they should be as accurate and precise, that is as “reliable”, as possible. However, there is the issue of the associated cost and, in practice, an acceptable and feasible degree of reliability must be established, according to the purpose of the investigation and in view of the available resources. One approach is to look at the purpose of the results. For example, in determining control measures the results should be reliable enough to decide what control action is necessary. A different accuracy may be required if the measurements are part of an epidemiological investigation.

If it seems too costly and difficult to establish compliance (or non-compliance) with a standard, it may be better just to reduce the exposure. Considering that new knowledge on risk assessment often leads to a decrease in acceptable exposure limits, good practice should aim at controlling exposures to the lowest possible level. The required reliability depends largely on the consequences of making a wrong decision on the basis of the collected data.

2.12.1 Measuring Equipment

As previously mentioned, measurements can be made by:

- the use of direct-reading instrumentation, to obtain results in (near) real time, and,
- collection of samples, for weighing or subsequent laboratory analysis.

Sampling for airborne particles requires instruments that extract them from a measured volume of air and collect them in a manner that permits subsequent weighing and/or chemical analysis, or particle counting under a microscope. These instruments comprise a sampling head, an air mover (with a power source) and a flow meter. The sampling head must be designed to collect the fraction of airborne particles to which the OEL applies. The head will therefore consist of a collecting device (e.g., a filter in a filter holder), and a pre-collector such as a cyclone for the respirable dust fraction or a specially designed entry if the inhalable dust fraction applies (ACGIH, 1995, 1999b; Courbon et al., 1988; Kenny et al., 1997; Mark and Vincent, 1986; Vincent, 1995).

It is essential that the air mover (sampling pump) functions at a measurable and practically constant flow rate and that the flow is always checked before and after sampling with a properly calibrated flow meter. Analysis of air samples should be performed by a qualified laboratory which has an established quality assurance/quality control program.

For exposure assessment, the best practice is to utilize personal samplers, which are portable sampling units carried by the workers as they move around. A common procedure is to attach the air mover to the belt, and the sampling head (which should be in the breathing zone) to the lapel of the worker's clothing. Care must be taken, however, when evaluating exposures to airborne particles, because it may happen that particles collected in the clothing are re-entrained into the sampling unit thus introducing a bias in the sampling, as demonstrated Cohen et al. (1984).

2.12.2 Elutriators

The dusty air is sucked along a vertical or horizontal channel, and the particles separated according to their settling velocities. Elutriators must be used in their design orientation, so they cannot be used for personal sampling.

2.12.3 Cyclones

Cyclones use centrifugal force to remove dust. A particle in a rotating air stream is subjected to a centrifugal force that accelerates it towards a surface where it will impact and lose momentum, thus being removed from the air stream. These cyclones are usually of small sizes, from 10 mm to no more than 50 mm in diameter. They have been widely used since the 1960s to collect the respirable fraction. In a typical cyclone pre-collector, the air enters tangentially at its side and swirls around inside. Particles above a certain size are thrown to the cyclone walls and collected at its base ("grit-pot"). The air containing the respirable dust leaves through the central exit in the top of the cyclone, and the air is filtered to collect the dust.

Because of the complexity of fluid behavior in cyclones, it is difficult to predict mathematically their collection characteristics and they are based on empirical design. To achieve the proper size selection, however, the air sampling pump must be calibrated to provide the appropriate flow throughout the cyclone opening, within a specified variability, and the flow must be smooth. If the pump is not calibrated correctly, the selection will be shifted, either to larger (for low flow) or smaller (for high flow) aerodynamic diameters. Once calibrated, cyclones can be used for all particles, but are not generally used for fibers. The cyclones available on the market to be used as pre-collectors in two-stage samplers are usually made of nylon or aluminum. Different cyclone designs and manufacturers each have their own specific operational flow rates and filter cassette configuration (2-piece or 3-piece).

2.12.4 Impactors

When a dust-laden airstream is forced to make a sudden change in direction, as when it flows directly and at high velocity against a flat surface, the momentum of the larger dust particles causes them to hit the surface. The particles may be collected on a liquid or gel surface for further analysis. The collection efficiency of an impactor, which relies on this principle, depends on the aerodynamic diameter of the particles and the velocity of the air stream. The multistage jet impactor, e. g., the Andersen sampler for viable particles, is used to separate fractions of different particle sizes.

2.12.6 Filters

Filtration is in fact a combination of principles as it involves direct interception, inertial collection, diffusion, electrical forces, adhesion and re-entrainment. Filtration efficiencies vary depending on parameters which include particle shape, density, surface characteristics, amount, humidity and collection velocity, but the filters used with dust samplers are close to 100% efficient. A great variety of filters are commercially available, for example: silver membrane, nucleopore, cellulose ester membrane, glass fibre, plastic fibre, etc., and the choice is usually determined by the analytical method to be used.

If the filter is to be weighed, it is necessary to ensure that it is not significantly affected by changes in relative humidity. Polyvinyl chloride (PVC) or Teflon (PTFE) filters are most commonly used to reduce mass gain or loss from humidity. Information provided by filter and sampling equipment manufacturers will usually aid filter selection.

2.12.7 Re-evaluation

Exposure measurements should be repeated after controls have been put in place, to check that controls are effective. It will be necessary to repeat the process described periodically, to check that substances used and processes have not been changed, and that controls have been properly maintained and are still effective. If the original assessment showed that exposures were well below OELs, and effectiveness of controls is obvious, then the re-evaluation may not require measurement. If this is not the case, then a fairly frequent re-evaluation should take place. This should consider newly available possible methods of control, for example, new possible substitutes.

If a repeat measurement survey is necessary, methods should permit comparison with the original results. In comparing the results, the random variability of concentrations should be considered, as well as any possible changes related to the day of the week and the season of the year (for example, related to heating and ventilation), and the different work practices of individual workers.

Table 2.1 Occupational/Industrial Limits for Metals of Concern (μg/m3)

Metal	Carcinogen?	IDLH	NIOSH REL (10-hr TWA)	OSHA PEL (8-hr TWA)
Antimony [a]	No	50,000	500	500
Arsenic [a,b]	Yes	500	2b	10
Beryllium [a,c]	Yes	400	0.5	2
Bismuth [d]	No	N.D.	5	5
Cadmium [a]	Yes	900	N.E.	0.005
Chromium [a]	No	250,000	0.5	1
Chromium III [a]	No	2,500	0.5	0.5
Chromium VI [a]	Yes		0.001	0.005
Cobalt [a]	No	20,000	0.05	0.1
Copper [e]	No	100,000	1	1
Lead [a,f]	No	100,000	50	50
Manganese [a,g]	No	500,000	1000	5,000
Mercury [a,h]	No	10,000	0.1	100
Nickel [a,i]	Yes	10,000	15	1000
Selenium [a,j]	No	100	200	200
Silver	No	10,000	10	10
Vanadium [k]	No	35,000	50	50

Source: OSHA Annotated Table Z-1,2 and 3 (2019)

IDLH = Immediately Detrimental to life and Health

NIOSH = National Institute of Occupational Safety and Health

REL = Recommended Exposure Limit

OSHA = Occupational Safety and Health Administration

PEL = Permissible Exposure Limit

[a] Metals designated as Hazardous Air Pollutants by the EPA.

B NIOSH REL for arsenic is a 15-minute ceiling

C OSHA PEL for beryllium has a 30-minute ceiling of 5 $\mu g/m^3$

D REL and PEL for bismuth is a respiratory limit, the total REL is 10 $\mu g/m^3$ and total PEL

E Additional REL of 0.1 and PEL of 0.1 for copper fume

F NIOSH REL for lead is an 8-hour TWA standard

G NIOSH short term exposure limit (STEL) for manganese is 3,000 $\mu g/m^3$ and the PEL

H NIOSH REL for mercury for skin is 50 $\mu g/m^3$ and the REL is a ceiling

I Nickel as Ni $(CO)_4$ has an IDLH of 14,000 $\mu g/m^3$ and an REL and PEL of 7 $\mu g/m^3$

J Selenium as SeF_6 has an IDLH of 2000 $\mu g/m^3$ and an REL and PEL of 400 $\mu g/m^3$

K NIOSH REL for vanadium is a 15-minute limit

2.13 Dust Control and Good Management

Program implementation requires the involvement and cooperation of management, production personnel, workers and occupational health professionals, including occupational hygienists, occupational physicians, occupational nurses, and ergonomists, among others. Management must provide the required resources and administrative support, but will have the benefit of a healthier and happier work force and increased productivity. Workers whose health is preserved will enjoy better quality of life and greater productivity. In protecting the health of workers, government satisfies a fundamental obligation and promotes the economic well-being of the country. Specific control measures should not be applied in an ad-hoc manner, but integrated into comprehensive and well-managed hazard prevention and control program, which require:

- political will and decision-making;
- commitment from top management;
- adequate human and financial resources;
- technical knowledge and experience; and
- competent management of program.

Decision-making is based on political will and motivation, both of which require awareness of the problems and knowledge of their possible solutions, as well as understanding of the resulting impact in terms of human health, environment and economics. Decision-makers must be aware of the ill effects of uncontrolled hazards in the workplace, as well as of the possibilities for their prevention, and the resulting social and economic benefits. As long as risk management is not included in the priorities of the top management and is not considered as important as productivity and quality, there is very little chance that efficient prevention and control program can be implemented in a workplace. Good management is built up from the following elements:

- a clear and well circulated official policy;
- elaboration of management tools;
- implementation and use of these tools;
- monitoring of the system performance; an
- continuous improvement of the system.

The importance of a multidisciplinary approach to the design, implementation, and maintenance of control strategies cannot be overemphasized. Only through joint efforts involving all stakeholders and drawing from the relevant environmental and medical sciences, is it possible to achieve good protection of workers' health and of the environment. An initial step should be the institution of multidisciplinary teams and the elaboration of mechanisms for efficient teamwork. In many countries (e. g., Canada), the establishment of joint labour-management occupational health and safety committees is mandatory. At this point, a clear assignment of responsibilities and resources to teams and individuals, as well as the establishment of lines of communication, within and outside the service, are essential.

2.13.1 Required Resources

Even when the need for control measures has been established and the decision to implement them has been taken, practical difficulties may arise, one usual "stumbling block" being the shortage of adequately trained personnel. Hazard prevention and control require specialized "know-how", involving both technical (engineering) and managerial competence. The former would include, for example, the selection of alternative technologies or the design of industrial ventilation systems, and the latter, the integration of specific measures into efficient program. As in other areas of science and technology, the design and implementation of hazard prevention and control strategies and measures require a combination of knowledge and experience. Academic training without experience is likely to lead to deficiencies in the design and use of hazard controls. On the other hand, experience without sound knowledge can be unreliable and costly. The use of adequately trained and certified professionals can provide greater confidence in the delivery of the required services.

Appropriate knowledge is gained by long term formal education, by attending short courses and similar training activities, by the use of educational materials, and by obtaining advice from experts. Information on possibilities for training in control technology can be obtained from relevant international and national organizations. Experience is obtained, for example, by internships and practical work under the supervision of well-qualified professionals. The World Health Organization has published a review of the requirements for professional occupational hygienists (WHO, 1992).

Resources must be allocated within a framework of priorities, always keeping the required balance among the different components, namely facilities, human resources, field equipment and information systems, never overlooking operational costs, including update of information systems and maintenance of staff competence. Many programs failed because operational costs were not correctly and realistically foreseen.

2.14 Effect of Training on the Attitude of the Woodworkers Towards Occupational Health and Safety Issues

Various operations in wood processing industries could be improved if workers adopt the correct procedure to guard against occupational hazards. The improvement on the management of occupational hazards in wood processing industries could be done through some activities in various occupations. Any occupation is based on information (facts, concepts and ideas) which individuals must know as well as the skills (operations, procedures and techniques) they must be able to perform with an acceptable level of proficiency (Ede, 2001). Proficiency in industries refers to the process of performing various operations in a skilled or an expert way as a result of training and practice. Workers could be proficient in all the activities in wood processing industries if proper training is acquired and practiced. Training can be considered as the creation of learning opportunities.

Adequate training of employees and the use of appropriate strategies could improve on the management of hazards. Training is a process that develops and improves skills related to performance. Training of workers could be done to improve on productivity. It could start from factory workers to executive and inexperienced workers but also to experienced workers. Employers who provide all new employees with training on safe an proper job procedures experience fewer accidents (Juergen,2005). Training is needed by employees who wear personal protective equipment and workers in high-risk areas. Managers and supervisors should also be included in the training program. Supervisors should receive training in company policies and procedures as well as hazards detection and control accidents investigation, handling of emergency and how to train and reinforce training.

Training for managers should emphasize their role in supporting the safety and health program, Managers should pay a particular attention to new employees and to employees who are moving to new jobs, train the employees on the hazards they could be exposed to and how to protect themselves and undertake management and health responsibilities for the staff.

According to Onah (2003), training program should also include those who are promoted to higher – level jobs and the periodic re-training of present employees by means of "refresher" courses. The newly appointed workers should start their training as soon as they are employed in wood processing industries. Training is needed for all the workers in the major wood product categories such as sawn timber, wood – based panels, wood chips, paper and paper products and miscellaneous, others including poles and railway sleepers. Some types of safety and health training needed include orientation training for site workers, process safety management standard, training for emergency response people, accident investigation training and emergency drills (OSHA, 1996). Training programs are very important in assisting workers in wood processing industries to wipe out the hazards in various occupational areas. According to Nwachukwu (1988), indications that employees in any organization requires training are the following factors: lack of interest in one's job., negative attitude to work, low productivity, excessive absenteeism rate, excessive complaints, high rejects or low-quality output, high and incidence of accidents. Training is needed in wood processing industries to improve on workers' competencies in order to avoid low productivity, high cost, poor material control, poor quality and excessive violation of rules of conduct and poor discipline, excessive absenteeism and delayed production. Training needs are basically any shortfall in employee performance or potential performance, which can be remedied by appropriate training (Cole, 2002).

Training programs are very important in assisting workers in wood processing industries to wipe out the hazards in various occupational areas. Nwachukwu (1988), indicated that there are several factors that hinder employees in any organization towards their training are: lack of interest in one's job, negative attitude to work, low productivity, excessive absenteeism rate, excessive complaints, high rejects or low-quality output, high and incidence of accidents. Training is needed in wood processing industries to improve on workers' competencies in order to avoid low productivity, high cost, poor material control, poor quality and excessive violation of rules of conduct and poor discipline, excessive absenteeism and delayed production.

2.14.1 Sawmill Workers' Practice of Occupational Safety and Health Training (Pre-Intervention)

The level of education is important especially during hazard awareness creation through training and following of safe work and safety procedures. Olaoye (2013) on management of occupational hazards in wood processing industry in south-west Nigeria asserted that only an average of 25.7.0% of the saw mill key workers were trained professionally on safety. However, on the level of training of the respondents on safety and technology in the sawmill industry, the study concludes that majority of the employees did not have any professional education or occupational safety and health training at all. In fact, there was a clear indication of low training levels, low competence and professional skills at the sawmilling industries studied. This is also an answer to various production constraints, injuries experienced and difficulties in the production of timber and other products. ILO management guidelines of 2001 include the employer as part of management and responsible for the safety and health of the workers. The Seoul declaration (2008), state that a safe and health working environment should be considered as a fundamental human right and it encourages government to consider ratification of the ILO Promotional Framework for Safety and Health Convention, 2006 (no 187) as a priority, (Hope 2009). Safety and health are basic human rights to be enjoyed by all employees throughout the world. Bello (2010), on his study indicated that, most of the wood workers entered the timber industry not as trained wood industry workers with a requisite professional knowledge. This had exposed most of the workers to some untold level of hazards.

2.14.2. Use of Personal Protective Equipment (PPEs):

In a study carried out in Zimbabwe (Jerie, 2011), shown that the use of personal protective equipment was poor and inappropriate in the wood processing industries. OSHA (2007) requires the use of personal protective equipment to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective in reducing these exposures to acceptable levels.

2.14.3. Safety Signs in the Woodworking Industry

Geneva (2011), stated that signs such as don't do it, no bodies allowed, do not enter, do not use hands and no smoking could be placed on the walls of industries. Warning signs guide the workers in industries while carrying out various activities.

Table 2.2: The various safety signs and their implications

Colour	Sign	Meaning
Blue		Mandatory, Wear protective gear
Green		No danger, (safe condition), First aid
Red		Fire (fire equipment)
Red		Prohibition
Yellow		Warning, Emergency, Hazard, Danger

Source: Barrett (2020)

2.14.4. Safety of Woodworking Machines and Maintenance

Oyo and Osun (2013), in their study in wood processing industries in Nigeria, indicated that major risk factor noticeable in the factory were age factor of machines and equipment in use. Colman et al., (2007) noted that rotating devices, cutting or shearing blades, in running nip points and meshing gears are typical examples of potential sources of workplace injuries while crushed hands, severed fingers, amputations and partial blindness are typical wood working accidents.

2.14.5. The Working Environment

Addai (2002) stated that environmental problems such as pollution must be addressed in order to protect and maintain a sustainable environment to save it from imparable damage. This is the fact that wood processing industries contain many hazards which need to be addressed to make life comfortable for workers. When a worker is exposed to wood dust, he/she is prone to suffer from an allergy reaction after repeated exposures. Sawdust also causes eye irritation, nasal dryness, irritation to eyes and the nose and frequent dryness. To manage sawdust effectively, the researcher advised that sawdust extractors should be put in place to minimize wood dust at their source of production. This has consequently exposed sawmill workers to hazards which have a negative impact to their health. According to OSHA (2003), dust exposure should be controlled through the adoption and maintenance of effective extraction and filtration systems which are supplemented by use of personal protective equipment such masks and respirators.

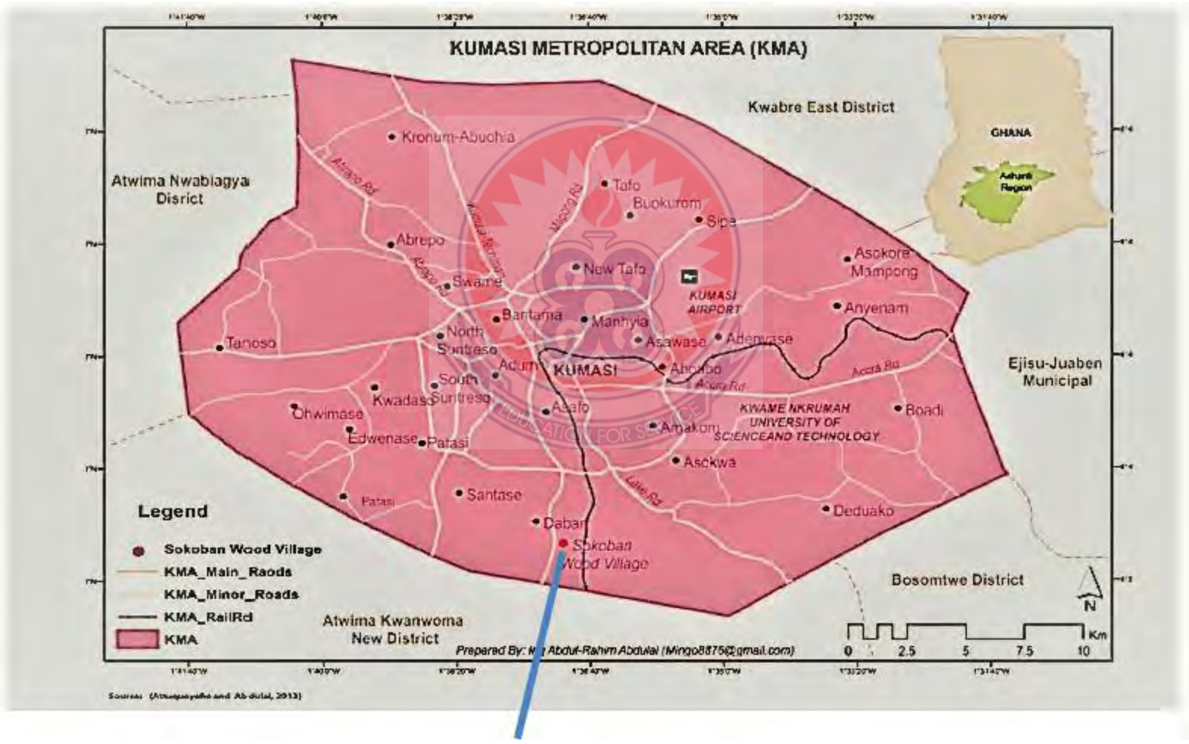
CHAPTER THREE

METHODOLOGY

3.1 Introduction

The methodology for this research work considered the study site, research philosophy, research design, research approach, population, sampling technique, research instrument for the study, data collection procedure, method of data analysis as well as ethical issues.

3.2 Study Site



Sokoban Wood Village

Figure 3.1: Map of Kumasi Metropolitan area showing Sokoban Wood Village

Source: Ghana Statistical Service

The Sokoban Wood Village (SWV) of KMA enclave as shown in Figure 3.1is a purpose-built industrial hub accommodating wood workers displaced as a result of the Agency Francaise De Development (AFD) Kumasi Roads and Urban Development Project at Anloga along the Anloga-Asokwa Road.

The displaced wood workers included carpenters, plywood and hardware sellers, saw millers, lumber and firewood sellers. The area was selected due to its high concentration of wood-based industries and its recognizable services to Ghana and across some ECOWAS countries. This stretch also has many of the large-scale timber and plywood manufacturing companies which supply wood to the Sokoban Wood Village. The Sokoban Wood Village currently has an estimated worker population of 8000. This comprises of artisans, suppliers, commercial workers like bankers and petty traders (Attuquayefio & Abdulai, 2013). Therefore, SWV is a community which houses lumber sellers, carpenters and other woodworkers with economic activities ranging from the sale of food, wood and wood products, wood processing machine parts, banking and other commercial activities that aid easy access to banking and credit facilities (Attuquayefio & Abdulai, 2013). It could also be seen as conglomerated wood industry made up of micro, small, and medium-scale firms owned by private individuals who operate various businesses and produce all kinds of wood products ranging from household furniture to office furniture. As a result, the 'village' has become an industrial cluster of importance to Kumasi city and Ghana as a country. As result of the above SWV was considered as the best place for the research work.

3.3 Research Philosophy

The study adopted both positivist and phenomenologist philosophical paradigms of research. Positivism is the central philosophy to scientific research, and underlies quantitative research approach in social sciences. It represents logical and mathematical analyses of data and sensory experience (Macionis & Gerber, 2003). Positivism philosophical paradigms of research adheres to the view that only “factual” knowledge gained through observation (the senses), including measurement, is trustworthy. In positivism studies the researcher is limited to data collection and interpretation in an objective way since the findings are usually observable and quantifiable. Positivism depends on quantifiable observations that lead to statistical analyses. One key feature of positivism philosophical approaches according to Klauer and Phye (2008) is that it is research progresses through hypothesis and deduction.

3.4 Research Design

The research adopted mixed approach design of observation, cross-sectional survey, experimental and interventional design for the study. Objective one was conducted using observation -check list. Observation checklists consist of a list of things that an observer look for when observing a group or equipment (Onwuegbuzie & Leech, 2007). Onwuegbuzie e*t al*. (2009) opined that, observation checklists not only give the observer a structure and framework for an observation but also serve as a contract of understanding, which may as a result be more comfortable, and will get specific feedback.

The research design used for objective two, four and five was a cross-sectional survey design. According to Neumann (2000) cross-sectional surveys are appropriate for situations where the data to be collected are based on self-reported beliefs. Besides, it enables the researcher to collect data and compare many different variables at the same time without manipulating the study environment.

Onwuegbuzie e*t al*. (2009) opined that, observation checklists not only give the observer a structure and framework for an observation but also serve as a contract of understanding, which may as a result be more comfortable, and will get specific feedback. The research design used for objective two, four and five was a cross-sectional survey design. According to Neumann (2000) cross-sectional surveys are appropriate for situations where the data to be collected are based on self-reported beliefs. Besides, it enables the researcher to collect data and compare many different variables at the same time without manipulating the study environment.

Objective three was conducted using experimental design. Chenail (2007) indicated that, experimental research designs are the primary approach used to investigate causal (cause/effect) relationships and to study the relationship between one variable and another. Finally, objective six of the study used interventional design approach. Bacallao (2004) asserted that, intervention research is the systematic study of purposive change of strategies which is characterized by development of intervention. This involves specification of an intervention and it is defined by explicit practical principles, goals and activities.

3.5 Research Approach

The research adopted deductive and inductive research approaches in this study. Deductive research approach **is** a logical procedure in which the conclusion is dependent on the concordance of multiple premises which are considered to be as true. Wilson (2010) indicated that deductive approach in research is concern with "developing a hypothesis (or hypotheses) based on existing theory, and then designing a research strategy to test the hypothesis. This design according to Gulati (2009), might be tested to see if there is a relationship or link will be obtained on more general circumstances. Deductive approach can be explained by the means of hypotheses, which can be derived from the propositions of the theory. In other words, deductive approach is concerned with deducting conclusions from premises or propositions.

In inductive research approach, the researcher perform investigation on research topic on which there is little or no existing literature that exists. In such type of investigation, the researcher begins the research by observing things and design theory after completion of the study. This helps in producing meaning from the information which the researcher has to accumulate from different sources. The researcher basically uses an inductive approach in research to analyzing the pattern and develop an understanding of the relationship between different variables of the study. Gaining knowledge about the interrelationship between different variables of the study is very much important for designing a hypothesis. The main benefit of using inductive approach in a study is that anytime the researcher can easily change the direction of your research.

3.6 Population for the Study

The population for the study involved wood processors, food vendors, furniture makers and wood sellers at the Sokoban Wood Village. According to the Kumasi Metropolitan Assembly (KMA), the Sokoban Wood Village, covers 12.35 hectares of land space and accommodates about 5,000 workers which includes 410 machine operators, 520 are wood sellers, 452 are furniture makers and 84 food vendors. The population for objective one of the studies which assesses the availability of safety gadgets on the wood processing machines within the Sokoban Wood Village comprised of 410 wood processing machines that were in use at the time of the study. The breakdown of the machines is as follows: Bandsaws = 50, Circular saws = 156, Surface planners = 71, Sanding machines = 30, Spindle moulders = 64 and Mortisers = 39.

The population for objective two which aimed at assessing the wood workers practice of occupational health and safety within the Sokoban Wood Village comprised of all the 410 wood processing operators. These includes: 50 bandsaw operators, 156 circular saw operators, 71 surface planner operators, 30 sanders, 64 spindle moulder operators and 39 mortiser operators.

The population used for objective three which assessed the risk posed by particulate matter resulting from wood processing activities comprised of machine operators and other wood workers (Wood sellers, food vendors and furniture makers). The machine operators were 410, food vendors were 84, wood sellers were 520 and finally the furniture makers were 452.

Objective four, assessed the injuries and diseases workers at the SWV and its enclave do experience as a result of wood processing. The population comprised of 410 machine operators, 84 food vendors, 520 wood sellers and 452 furniture makers. The population for objective five which assessed the provision of personal protective equipment (PPE) to the wood processor comprised of 410 wood work machine operators. Finally, the population for objective six comprised of the 410 machine operators. This also comprise of the follow: Bandsaws = 50, Circular saws = 156, Surface planners = 71, Sanders = 30, Spindle moulders = 64 and Mortisers = 39.

3.7 Sampling Technique and Sample Size

This part of the study describes the sampling technique and sampling size used for the study. For objective one which assessed the wood working machines used at the SWV the entire 410 machines currently being used at the Sokoban Wood Village were used for the study. This comprise of the follow: Bandsaws = 50, Circular saws = 156, Surface planners = 71, Sanders = 30, Spindle moulders = 64 and Mortisers = 39. The respondents used for objective two comprised of all the operators of the 410 woodwork machines. This is made up of 50 bandsaw operators, 156 circular saw operators, 71 surface planner operators, 30 sanders, 64 spindle moulder operators and 39 mortiser operators.

To achieve objective three an experimental work was conducted. Five persons were randomly sampled from each machine type operators. Thus, 5 bandsaw operators, 5 circular saw operators, 5 surface planner operators, 5 sanders, 5 spindle moulder operators and 5 mortiser operators. Additionally, five persons were sampled each from the following wood worker - Wood sellers, food vendors and furniture makers – at different distances from processing machines (1 – 20 m; 21 – 40 m; 41 – 60 m; 61 – 80 m and 81 – 100 m). In all, thirty (30) samples were taken from the various machine operators, twenty-five (25) each from furniture makers, food vendors and wood sellers which totaled one hundred and five (105).

Considering objective four stratified random sampling technique was used to obtain the sample size from a population of 1466 comprising of: Machine operators = 410; wood sellers = 520; furniture producer = 452 and food vendors = 84. A total sample size of 315 was obtained in accordance with the mathematical formula: $n = N/[1+N(\alpha)^2]$ where n = sample size; N = sampling frame; α = confidence level (0.05) (Adei & Kunfa, 2007). The sample size of each group of respondents was then obtained proportionally. The breakdown of the 315 participants is as follows: Machine operators = 88; food vendors = 18; wood sellers = 112 and furniture makers = 97.

The entire population of machine operators numbering 410 comprising of 50 bandsaws operators; 156 circular saw operators; 71 surface planners; 30 sanding machine operators; 64 spindle moulder operators and 39 mortise machine operators were used for objectives five and six.

3.8 Instruments for Data Collection

The instrument used for data collection included an observation check-list and questionnaire. The observational checklist was used to access the availability of safety gadgets on the 410 wood processing machines at the Sokoban Wood Village. Check-lists were used to access the availability of safety gadgets on boring and mortising machines, moulding machines, sanding machines, surface planners, bandsaw machines and circular saw machines. In the observation process the researcher was interested in whether safety gadgets of the machines existed, never existed or were improvised.

Each of the machines had its own observation check-list since they had different safety requirements. Items observed for bandsaw machines included; operator's manual to guide operation of the machine, machine guard to provide barrier for the blade, emergency power switch, tension control device and pulley mechanisms enclosed. With the mortise safety parts looked for where - operator's manual, enclosement of chains and driving mechanisms, wheel for movement of the table and emergency stop switch. Furthermore, the following were observed on the spindle moulder - the operator's manual, cutter head covered with metal guard or cage, safety shield, and belt and pulleys completely enclosed. The researcher also assessed the following safety parts on the sander machine: operator's manual, guards to enclose drum and disc, fixed guards enclosing power transmission and dust bag. Safety parts observed on the surface planner were operator's manual, cutter head enclosed with an automatic guard or cage, stick to push workpiece, fence to enable timber being edge to be processed and power transmission systems enclosed. Lastly, safety gargets inspected on the circular saw machines were: operator's manual, guard for belts and pulleys, an anti-kickback device and blade guard.

The instrument employed by the researcher to collect data for objective two was a questionnaire. The questionnaire was adapted from safety management perception questionnaire (Lapidu & Waite 2001). This questionnaire was for machine operators only and it consists of two parts. The first part dealt with the demographic data of the respondents namely: educational background, the kind of operation and working experience of the wood machining workers. The second part which consists of two sections assessed respondent's wearing of personal protective equipment. Respondents were made to respond to questions like: do you wear gloves or mittens, overall, goggles, nose mask, earplugs and safety boots. The second section addressed issues on equipment safety practices and maintenance. Respondents were made to respond to questions like: do you ensure that only trained personnel operate the machine, do you ensure that woodworkers adhere to safety regulations, do you ensure fences and guards are in place when machine is in use, do you ensure that electrical gadgets are put off before the woodworkers leave the workshop and do you ensure that woodworkers maintain and repairs faulty machines.

Objective three of this study involved experimental work. Data was collected through the conduct of experiment. This was done using SKC Air Sampler machine with model number PRCX-224, a cassette (Millipore, Bedford, MA, USA) with a pore size of 25mm diameter, 5µm Polyvinyl chloride memory filter paper (Millipore, Bedford, MA, USA) and SKC Sidekick pump (SKC Ltd, Dorset, UK) operated at a flow rate of 2.0 ± 0.1. This equipment was used to sample air particulate in the sawdust inhaled by the workers within the enclave.

The questionnaire used to gather data for objective four of this study was adapted from safety management perception questionnaire prepared by Lapidu and Waite 2001. The questionnaire was sub-divided into the woodworker's exposure to sawdust, and noise or poor ventilation injuries. On health issues related to exposure to sawdust the respondents were asked to indicate if they experience: skin irritation, eye irritation or reddening, headache, shortness in breathing, nasal cancer, coughing, bronchitis, nausea and loss of appetite. Under noise and poor ventilation, respondents were asked if they do experience hearing loss or poor eye sight.

Instrument employed by the researcher in objective five was questionnaire. Respondents were asked to indicate if they were provided with personal protective equipment like nose mask, ear plug, safety boots, overall, groves and googles. An intervention was used in objective six to assess the effect of training on practice of occupational health and safety by the machine operators. Occupational health and safety equipment, pictures and charts were used to train the participants. After the training, the participants were observed and questionnaires used for objective two was used to re-assess their practice of safety.

3.9 Validity and Reliability of Questionnaire

A pilot study was conducted at Kwadaso Timber Market to assess the validity (internal consistencies) and reliability of the questionnaires for objective one, two, four and five in order to enhance its accuracy for assessment and evaluation. Participants for the pilot study were drawn from the various machine operators and other workers at Kwadaso Timber Market. They completed the questionnaire and in addition provided suggestion for its modification to help remove any ambiguity. The reliability of the questionnaire, which was concern with its ability to measure consistently, was determined using the Cronbach's alpha. A Cronbach's alpha value of between 0.76 and 0.84 was obtained for the questionnaires used which were considered to be adequate.

3.10 Data Collection Procedure

Data for objective one of this study which assessed the availability of safety gadgets on the wood processing machines at the Sokoban Wood Village was collected using observation checklist. All the functioning 410 woodwork machines (Boring and mortising machines, moulding machines, sanding machines, surface planners, bandsaw machines and circular saw machines) were checked for the existence, non-existence or improvise of the needed safety parts. Safety gadgets inspected for on each of the machine type are as indicated in section 3.7.

Data for objective two of this study which was meant to assess practice of occupational health and safety was collected using five-point likert's scale questionnaires at a single point in time. The questionnaire was administered by the researcher to the participants directly in June 2018. A total number of 410 questionnaires were administered. The questionnaires that were successfully completed were 410 in number (Sawing operators = 206, planning operators = 71, moulding operators = 64, sanding operators = 30 and boring operators = 39). This represents a return rate of about 100%.

According to Dillman (2000) as cited in Mitchual et al. (2015) a return rate of 70% or more is a true representative sample of the population.

To determine the particulate matter, sampled air was collected at 30 cm diameter within the workers breathing zone for a full shift of eight (8) hours for time – weighted average (TWA). This was done using the SKC sampler machine (Model PCRX8-224, UK), SKC Sidekick pump (SKC Ltd, Dorset, UK) at a flow rate of 2.0 ± 0.1 L/min, the glass cassette ((Millipore, Bedford, MA, USA) and PVC membrane filter ((Millipore, Bedford, MA, USA). The cassette is made up of three parts, the inlet body, retaining ring and the outlet body. The cassette houses a mix cellulose membrane filter and has two small plugs: inlet plug and outlet plug. These plugs are removed during the sampling period. The membrane filter was 25 mm in diameter containing 0.5 µm pores and were placed inside the cassette.

Figure 3.2: A woodworker with his air sampler machine

After the sample was collected the cassette was removed and both the outlet and inlet was closed using the two plugs. The sample was then conditioned in a room at a temperature of 25°C for 24 hours. The volume of air sampled was calculated using the formulae.

$$V = \frac{rt}{1000}$$

Where V = volume of air sampled in cubic meters

r = numerical value of air pump flow rate (calibrated in litters per minutes)

t = sampled time in minutes.

The filters were then placed in the digestion sample cup, 6mL of concentrated Nitric Acid (HNO_3) solution was then added into the sample cup using the pipet. Additionally, 1mL of concentrated Hydrofluoric Acid (HF) was also added to the content of the sample cup. The solution was allowed to fume and then digested in the UNIDO-Topex microwave digestor (Schweizerische Eidgenossenschaft Confideration-Swisse). The microwave digestor had four ramp settings which automatically changes its temperature, pressure and time during digestion. **Table 3.1** illustrate the changes in time, temperature and pressure in each ramp within the microwave digestor.

Table 3.1 Time, temperature and pressure changes within the microwave digestor

No of ramp	Time (minute)	Temperature (°C)	Pressure (Psi)
1	3	150	225
2	3	180	375
3	3	200	525
4	15	220	600

After the last 15 minutes in the chamber, the digestor automatically stopped and the temperature started to drop. Figure 3.3 and 3.4 are showing samples conditioned in a room for a day and samples in the microwave digestor respectively. Figure 3.3 and 3.4 are showing samples conditioned in a room for a day and samples in the microwave digestor respectively.

Figure 3.3 Samples at room condition

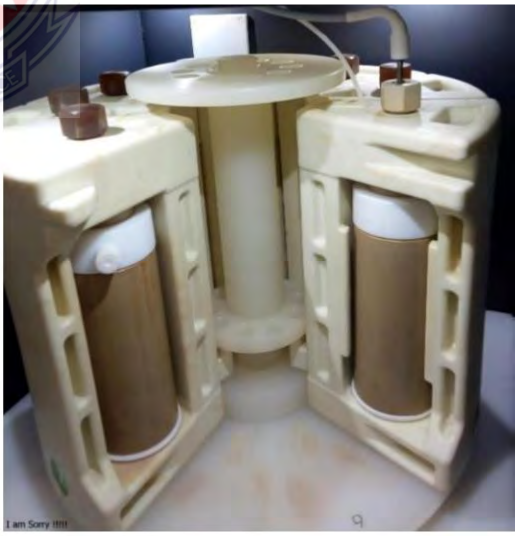


Figure 3.4 Samples in the digester machine to be digested

After digestion the temperature within the microwave digestor was allowed to drop below 50°C before opening the digestor. The sample cup was allowed to cool to room temperature then the content was transferred into a 100ML volumetric flask, diluted with distilled water to 20mL. The volumetric flasks containing the samples were left at room temperature for two days. Bulk standard solution was prepared which contains the maximum concentration of the element of interest.

The metals concentrations were then determined by X-Ray Fluorescence (XRF) Flame Atomic Absorption Spectrometer (Panalytical Zetium XRF Spectrometer) with acetylene gas burner.

Samples in the volumetric flasks were tested for various particulate matter by the Atomic Absorption Spectrometer (AAS). Using the solution volumes (ml) of the various samples (V_s) and media blank (V_b), the concentration (C) in (mg/m^3) of the individual samples in the air volume sampled was calculated for using the formulae:

$$Concentration\ (\frac{mg}{m^3}) = \frac{C_s V_s - C_b V_b}{V}$$

Where C_s= the concentration of the particulate in the samples, C_b = concentration of the average media blank, V_s = sample volume, V_b = volume of blank media and V = the volume of sampled air for the sample.

Data for objective four in this study was collected using five-point likert's scale questionnaires at a single point in time. The questionnaire was administered by the researcher to the participants directly in October, 2018. A total number of 315 questionnaires were administered. All the questionnaires were successfully completed. The breakdown was as follows: Machine operators = 88; food vendors = 18; wood sellers = 112 and furniture makers = 97.

Data for objective five in this study which was meant to assess provision of personal protective equipment's to the woodworkers in Sokoban Wood Village was collected using five-point likert scale questionnaires at a single point in time. The questionnaire was administered by the researcher to the participants directly in December, 2018.

A total number of 410 questionnaires were administered to all the key persons who operate the machines. All the questionnaires numbering 410 were successfully completed (Sawing operators = 206, planning operators = 71, moulding operators = 64, sanding operators = 30 and boring operators = 39).

The final part of this study which was concerned with the effect of training on woodwork machine operators' practice of occupational health and safety involved training of the 410 wood machine operators. The machine operators were put into ten groups with each group numbering 41. This number was due to limited space of the conference hall at the SWV. Each group was taken through occupational health and safe practice training related to woodwork. The training focused on the need to practice occupational health and safety by wearing of the personal protective equipment's such as earplugs, nose mask, gloves, safety boots and overall. Additionally, participants were given training on the various safety signs as well as the need to keep the working environment clean. Two months after the training the machine operators were re-assessed on their practice of occupational health and safety.

3.11 Method of Data Analysis

Statistical software used for the analyses was Statistical Package for Social Scientists (SPSS version 20.0). The data was analysed using descriptive and inferential statistics. Correlation analysis was also used to determine the associations between respondents' practice of safety, provision of personal protective equipment and injuries and diseases. The mean and standard deviation of the ratings for each of the items were computed and the mean compared to the theoretical mean rating (assuming normal distribution of responses) to ascertain the respondents' perception on the themes studied.

Additionally, the effect of operation and the level of education on respondents' practice of safety, provision of personal protective equipment, and injuries and diseases of the workers were determined. An item-by-item analysis of variance (ANOVA) at 5% level of significance was performed to establish possible significant difference in the respondents' ratings of the factors of this study. P-values lower than 0.05 were deemed significant. In such situations Scheffe's post hoc test was used to make pair wise comparison of the means.

3.12 Ethical Consideration

Ethical issues which were ensured in this study included issues of informed consent, invasion of privacy, anonymity of respondents, voluntarism and plagiarism. The researcher sought the permission of all participants in the research before the conduct of the study (informed consent). Introductory letter was sent to the management of the SWV and their approval received before the research commenced. The researcher made prior visits to management of the company in order to pre-arrange data gathering periods. This was to prevent unnecessary interruption in their work schedules thereby invading their privacy. Neither names nor any identifiable information from respondents was taken as a way of ensuring the ethical principle of anonymity in social research. This was to prevent possible victimization of respondents in situations that certain responses may be viewed as injurious to management or colleagues. While distributing the questionnaire, the researcher verbally informed all respondents who agreed to answer questionnaires that, their participation was voluntary. They could, therefore opt out at any stage of the research process. They could also skip questions they did not know the answers otherwise any guess they made would be taken as a correct answer for analysis of the data.

This was just to ensure that the researcher did not breach the ethical principle of voluntarism to participate in social research. Pieces of information cited from earlier studies on occupational health and safety to support analysis of the study were duly acknowledged through both in-test referencing and a bibliography. This was meant to avoid academic dishonesty or plagiarism. Findings cited in the literature review of this study were also duly acknowledged in line with the academic property law.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This section comprises of the result and discussion of the study. The presentation has been done in line with the objectives of the study. The first section deals with the socio-demographic characteristics of the respondents which include: educational background, working experience and the type of operation the workers perform. The second part assessed the availability of safety gadgets on the various wood processing machines at the Sokoban Wood Processing Village (SWV). The third section dealt with issues on practice of occupational health and safety by the wood workers at the SWV. The fourth section presents result and discussions on aerosol particulate matter inhalable sawdust that could pose health risk to the wood workers. Section five assessed the various health hazards associated with exposure to sawdust by the workers at the SWV. The sixth section assessed provision of personal protective equipment to the machine operators and lastly the seventh section present result and discussion on the effect of training on the practice of occupational health and safety by the machine operators at the SWV in Kumasi.

4.2 Socio-Demographic Data of Respondents

The socio-demographic characteristics of the respondents that were considered in this study includes: gender, work experience, educational level and the type of operation they perform at the enclave.

4.2.1Gender Distribution of Respondent

All the participants (100%) involved in the machine operation were males with no female taking part in the operation of the machines. In finding out why there were only males operating the wood processing machines, most of the respondent suggested that due to the physical activities involved in wood processing, females do not prefer taking up such jobs or training. In finding out why there were only males operating the processing machines, Jerie (2012), on occupational health and safety problems among workers in the wood processing industry at Mutare-Zimbabwe attributed that to lifting of heavy objects and tedious nature of processing wood.

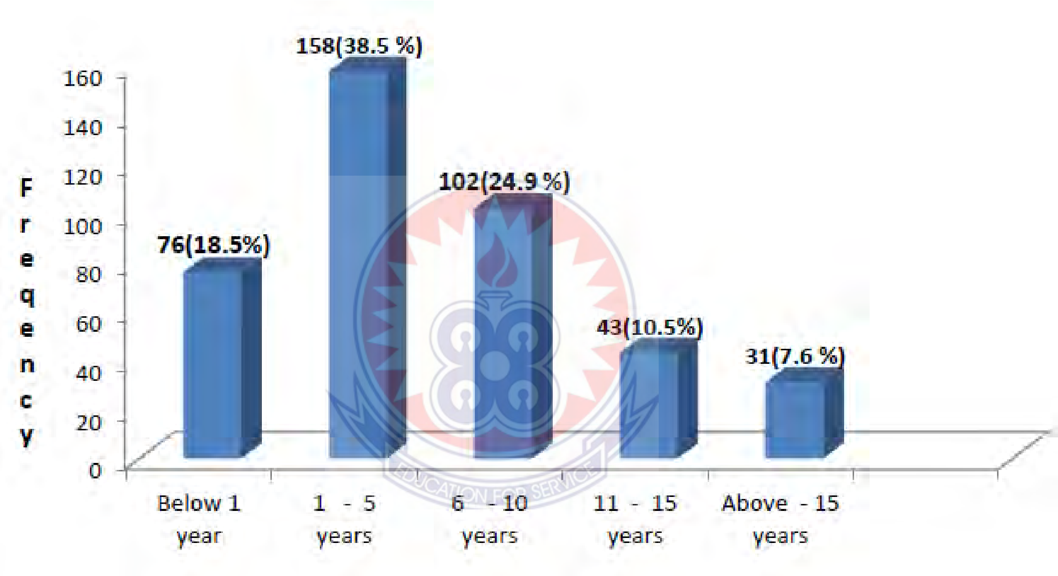
Table 4.1: Gender of respondents

Gender	Frequency	Percent (%)
Male	410	100
Female	0	0
Total	**410**	**100**

4.2.2 Working Experience

Figure 4.1 indicates the working experience of the participant of the study. The result shows that, out of the 410 participant that responded to the questionnaire, 76 participants representing 18.5% indicated that, they have been in the Sokoban Wood Village for less than one year, 158 participants which is equivalent to 38.5% have worked in the Sokoban Wood Village for between 1 - 5 years, 102 participants representing 24.9% have worked for between 6 - 10 years, 43 participants representing 10.5% have been in the Sokoban Wood Village between 10 – 15 years whiles the remaining 31 respondents representing 7.6% have been in the wood village for more than 15 years.

From the result it could be concluded that majority of the workers have had 1 - 5years working experience in the Sokoban Wood Village and as stated earlier the longer one works at a place, the more experienced he or she becomes. Bello (2010) conducted in a study that the number of years a participant has had on a job could help to reduce the rate at which accident will occur as a result of acquisition of more skills and knowledge.



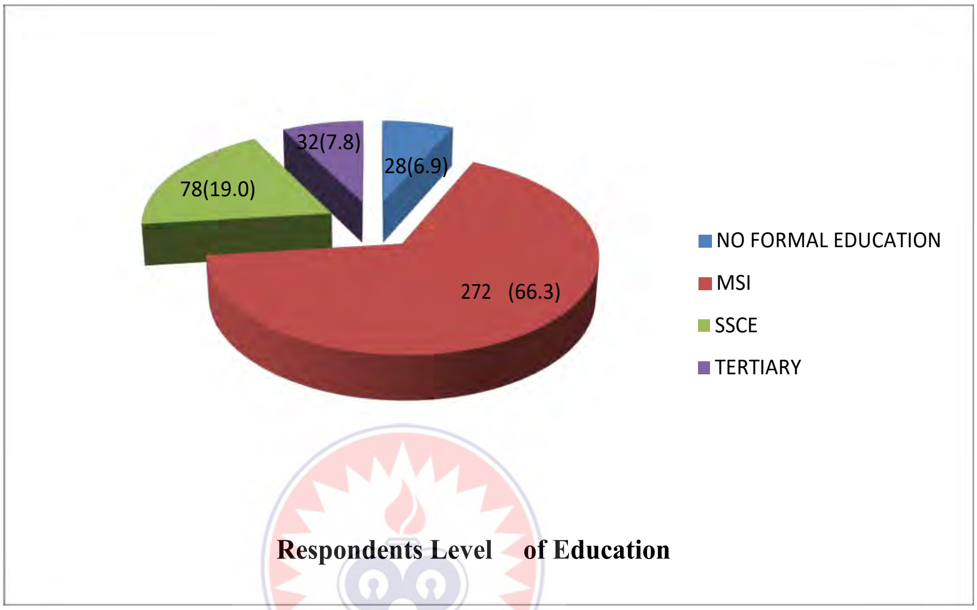
Working experience of respondents

Figure 4.1: The bar chart showing number of working experiences of the wood workers at Sokoban Wood Village

4.2.3 Educational level

The result on the level of education of the workers in the Sokoban Wood Village reveals that, 28 out of 410 respondents representing 6.9% did not have formal education, 272 respondents which form 66.3% have had middle school (MSLC) education,78 respondents representing 19.0% have gone through secondary education and 32 of the respondents making 7.8% have had their tertiary education.

This indicates that the majority of the respondents ended their education at the basic level or primary level. This result is consistent with a study conducted by Antwi et al, (2013) on safety culture at SWV. Their study revealed that the artisans have low level of education and that they are ignorant of safety signs and issues.



Respondents Level of Education

Figure 4.2 Respondent's educational qualification

4.2.4 Operations of the Respondents

Assessment of the five major operations in SWV namely: sawing, planning, moulding, sanding, boring and mortising that the participant belongs to indicated that, out of 410 participants, sawing was 206 representing 50.2%, planning 71 representing 17.3%, moulding 64 respondents representing 15.6% whiles 30 respondents representing 7.4% were in sanding and, 39 representing 9.5% were in boring.

This result clearly indicates that, there were more sawmilling operations than any other operation in the SWV, because sawmilling is the bedrock of every timber processing industry which begins its operations from the forest to the log yard all the way to edging and trimming.

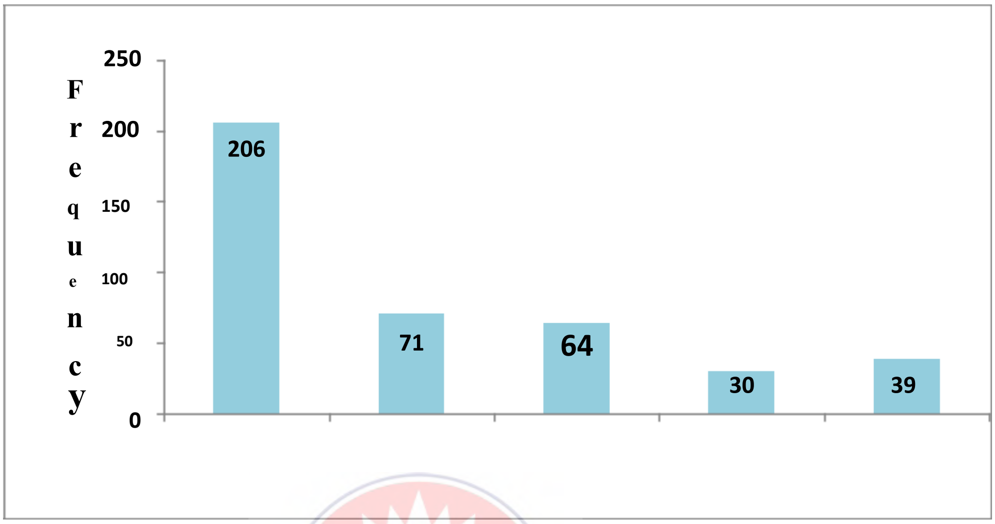


Figure 4.3 Operation of respondents

4.3 Assessment of Safety of Wood Processing Machines

ILO code of practice sets out principles concerning safety and health in the use of tools and machinery (ILO, 2015). It also defines safety and health requirements and precautions applicable to governments, workers and employers, designers, manufacturers and suppliers of machinery. Machines are used in virtually all work activities, and this present safety and health risks in a large number of workplaces all over the world. The European legislation set out the general principles of prevention and basic conditions to ensure occupational safety and health (OSH) and to eliminate the risk and factors that make work injuries and other health hazards worse (Akinbode & Owoeye, 2019). Directive 2006/42/EC of the European legislation asserted that, every machine manufacturer is required to eliminate or minimized the hazards or risks, to propose measures to control the threat or risk that can be removed (Akinbode & Owoeye, 2019). Furthermore, the manufacturer is obliged to inform the user of the residual threat of the machine, and also design the machine so that even when it is malfunctioning, risk will not occur during its operation (Akinbode & Owoeye, 2019).

Based on the above woodwork machines at the SWV were assessed for the presence, absence or improvising of their safety parts. Machines assessed were: Boring and mortising, sanding, planning, moulding, circular saw and bandsaw machines.

4.3.1 Boring and Mortising Machines

The results as shown in **Table 4.2** indicate the assessment of safety parts on the boring and mortising machines at the SWV. The study shows that with the exception of the stop bar meant to stop chisel at a predetermined depth which existed on most of the 39 machines inspected (Existed = 56.4%; Not existing = 25.8%; Improvised = 17.8%) most of the safety parts either did not exist or were improvised. This result indicates that only five (5) of the machines had Guards enclosing bit and chuck with 31 (79%) of the machines not having guards enclosing the bit and chunk. **Figure 4.4** and **4.5** for example shows boring and mortising machines without safety guard enclosing the bit and the chuck as well as machine without enclosement of chains and pulleys respectively. This exposes the operators to various forms of hazards ranging from minor cuts to severe injury.

Figure 4.4: The wood mortise without any enclosement of safety bit and chuck

Figure 4.5: Wood mortiser guard enclosing the chains and driving mechanisms.

Additionally, none of the machines have operator's manual. The absence of the operator's manual is as a result of the fact that most of the machines were acquired as "used" ones or "second hand". Thus, they were not bought with operator's manual. Besides, some of the operators indicated that their machines were bought with operator's manuals. However, the operator's manuals are missing because they have not been using them. The above suggests that the boring and mortising machines used at the SWV poses a high risk to the operators.

Table 4.2 Assessment of safety parts of boring and mortising machines

Item #	Safety gadgets	N	Exist *f* (%)	Not exist *f* (%)	Improvised *f* (%)	Chi-Square	p-value
1	Operator's manual	39	-	39(100%)	-		.000*
2	Guards enclosing bit and chuck	39	5(12.8%)	31(79.5%)	3(7.7%)	26.923a	.000*
3	Enclosement for cutting chain and driving mechanism	39	10(25.8%)	24(61.8%)	5(12.8%)	12.154a	.002*
4	Emergency stop switch	39	8(20.4%)	26(66.7%)	5(12.8%)	19.846a	.000*
5	Safety chain to bolt counter weight from dropping	39	12(30.8%)	23(59.0%)	4(10.2%)	12.462a	.002*
6	Inverted U-shape guard to cover operating treadles	39	10(25.8%)	20(51.6%)	9(22.6%)	5.692a	.058†
7	Stop bar	39	22(56.4%)	10(25.8%)	7(17.8%)	12.154a	.002*

*Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05

The above situation exposes the operators to hazards and is contrary to the requirement of FOSA 1970, Act 328 and OSHA guide lines for machine. The OSHA (2015), guide lines require that all machines should have safety guards on them to reduce accident and injury to the operators. This result confirms a study conducted by Bello (2010) for which there were no guards on the machines examined at wood processing firms in the northern part of Nigeria.

4.3.2 Moulding Machine

Wood moulding machines are used to cut different configurations of trim used for moulding in homes. The moulding machines assessed in this study were spindle moulder and wood lathe. The results in **Table 4.3** indicate the assessment of the safety devices of the 64 moulding machines at the SWV. All the operators interviewed indicated that their machines do not have operators' manuals. This is because almost of the machines were bought "used" therefore, they were not bought with manuals. Additionally, none of the machines had dust harvester and out of the 64 moulding machines 50 had their power transmission devices not enclosed. The results further show that greater number of the 64 machines assessed do not have safety gadgets. That is part that were absents were in most cases significantly higher than those that were present. For instance, about 39 of the moulding machines representing 60.9% of the 64 machines inspected do not have their cutter head covered with metal guard or cage even though 10 of the machines representing 15.6% have their metal guards being improvised. Furthermore, of the 64 moulding machines inspected 42 (65.6%) had their pulleys and belts not enclosed with guards, 14 (21.9%) of the machines had their pulleys and belts enclosement of the guard being improvised and only 8 (12.5%) had their pulleys and belt completely enclosed with guards.

Figures 4.6, 4.7 and 4.8 shows some of the moulding machines inspected without safety parts. This implies that the moulding machines used at the SWV poses danger to the machine operators.

Table 4.3 Assessment of safety parts of wood moulding machine

Item #	Safety gadgets	N	Exist *f* (%)	Not exist *f* (%)	Improvised *f* (%)	Chi-square	p-value
1	Operators' manual	64	-	64(100%)	-		.000*
2	Belt and pulleys enclosed	64	8(12.5%)	42(65.6%)	14(21.9%)	30.875	.009*
3	Cutter head covered with guard	64	15(23.4%)	39(60.9%)	10(15.6%)	3.406b	.199†
4	Guard feed rollers	64	12(18.8%)	30(46.9%)	22(34.4%)	5.281a	.071†
5	Safety shield	64	18(28.1%)	38(59.4%)	8(12.5%)	21.875a	.004*
6	Anti-kickbacks	64	17(26.6%)	32(50.0%)	15(23.4%)	2.844a	.241†
7	Power transmission devices enclosed	64	10(15.6%)	50(78.1%)	4(6.2%)	58.625a	.024*
8	Spindle block guarded	64	64(28.1%)	40(62.5%)	6(9.4%)	14.532a	.000*
9	Push button	64	14(21.9%)	33(51.6%)	17(26.6%)	6.594a	.037*
10	Dust harvester	64	-	64(100%)	-	-	.000*

*Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05 level of significance.

This result is consistent with studies conducted by Bello (2010) and Segun (2012) on the safety of wood processing machines in Kaduna State - Nigeria revealed that about 67.4% of the machines studied had no safety guards. Sogutlu and Eroglu (2008), reported that only 1% of the machines assessed in the furniture enterprises studied had machine guards to guard their cutter heads and dust hoods or extractors.

Figure 4.6: Spindle moulder cutter head uncovered

Figure 4.7: Spindle moulder with wooden improvised cutter head

Figure 4.8: Spindle moulder without safety shield

The above results notwithstanding, the Chi-square test in **Table 4.5** indicates that 3 out of the 10 safety parts assessed showed no statistically significant difference between the safety parts that existed, not existed and improvised (p-values > 0.05). These safety parts were "Cutter head covered with metal guard or cage", "Guard feed rolls with wide metals strip or bars that allow boards to pass" and "the in-feed side across the width of the machine" and "Wood clamp".

4.3.5 Bandsaw Machine

A vertical band saw machine uses a thin, flexible, continuous metal bandsaw with cutting teeth on one edge (Woodworking machine guidelines, OSHA 2017. The saw runs on two pulleys. In order to make a cut, the operator keep the stock flat on the work table, hand-feed and manipulate the stock against the blade by exerting the proper amount of force. Serious cuts or amputations can occur if the operator contacts the blade. Therefore, extreme precaution is necessary.

Table 4.4 Assessment of safety part of bandsaw machine

Item #	Safety gadgets	N	Exist f (%)	Not exist f (%)	Improvise D f (%)	Chi-square	p-Value
1	Operators' manual	50	-	50(100%)	-		.000*
2	Adjustable metal top guard	50	4(8%)	18(36%)	28(56%)	7.550c	.076†
3	Emergency power switch	50	-	-	50(100%)	-	.000*
4	Guard to enclose pulleys mechanisms and belt	50	9(18%	35(70%)	6(12%)	22.450c	.002*
5	Tension control device to protect the blade from breaking	50	5(10%)	33(66%)	12(24%)	7.850c	.785†
6	Power transmission devices enclosed	50	4(8%)	46(92%)	-	10.194c	.008*
7	Tracking device to enable blade run centrally around the pulley	50	4(8%)	30(60%)	16(32%)	20.137c	.004*
8	Dust harvester	50	-	50(100%)	-	-	.000*

*Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05 level of significance

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Table 4.4 indicates the assessment of safety parts of 50 band saw machines at the SWV. All the machines assessed do not have operators' manual and dust harvester. This is in conformity with what the boring and mortising operators indicated that most of the machines were brought as used or second hand therefore, they were not bought with manuals. Additionally, the results show that the emergency power switch for all the machines were improvised. The study further indicates that only 4 out of the 50 bandsaw machines had power transmission devices enclosed with the remaining 46 not having power transmission devices enclosed. The safety condition of the machines is similar to that of the earlier machines studied and therefore exposes the operators to a high risk of injury.

Figures 4.9, 4.10 and 4.11 show bandsaws machine without saw guard to cover the saw above and below the stock, pulley mechanisms not enclosed with guards, and bandsaw with an improvised blade guard respectively. This result is similar to that of studies conducted at other wood processing establishments. Adanur (2016), on occupational health and safety in microscale wood-product enterprises reported that, safety guards were not available on the machines been used by the woodworkers in the furniture enterprises studied in Calabar-Nigeria. Additionally, Uysal et al. (2005), on their study concluded that the machines used by the woodworkers in the sawmills studied were absolute and were without protective components or those having were inadequate.

Figure 4.9: Band saw without saw guide to support the saw above and below the cut.

Figure 4.10: Bandsaw with improvised guard

Figure 4.11: Bandsaw without enclosement of pulley mechanisms

4.3.3. Sanding machine

The wood sander is a general-purpose finishing tool. The abrasive is looped around the disc and the circular motion makes it effective for sanding with the grain of wood. Abrasive of various grades also make the sander useful for shaping. The results of technological auditing of 30 sanding machines at the study site are as indicated in **Table 4.5**. All the 30 sanding machines audited were without operator's manual or guide.

Table 4.5 Assessment of safety gadget of sanding machines

Item #	Safety gadgets	N	Exist *f* (%)	Not exist *f* (%)	Improvised *f* (%)	Chi-square	p-value
1	Operators' manual	30	-	30(100%)	-	-	.000*
2	Guard feed rollers	30	10(33.3%)	16(53.3%)	4(13.3%)	7.517a	.023*
3	Guard on the unused run	30	3(10%)	22(73.3%)	5(16.7%)	20.138a	.000*
4	Guard to close drum and disc	30	2(6.7%)	18(60%)	10(33.3%)	11.655a	.003*
5	Enclosement of power transmission	30	6(20%)	24(80%)	-	9.966b	.002*
6	Dust bag or harvester	30	-	30(100%)	-	-	.000*

*Statistically significant at 0.05 level of significance

Additionally, none of the sanding machines inspected had dust bag or harvester. Furthermore, 22 (72.4%) out of the 30 wood sanders had no guards on the unused run of the sanding belt against accidental contact to prevent the operator's hands or fingers from contact with the nip ends. Five of the machines were improvised with guards on the unused run of the sanding belt against accidental contact to prevent the operator's hands or fingers from contact with the nip ends.

The results as indicated in Table 4.6 suggest that most of the safety guards do not exist on the 30 sanding machines assessed. **Figure 4.12** and **4.13** shows disc sanders without guard to enclose the drum and feed rollers.

The absence of these safety gadgets especially the dust bag will pose health and safety risk to the operators of these machines. Furthermore, the rate at which the machine operators will inhale the dust generated will be higher since the wood sander produces fine particulate airborne aerosols (Boys, 2002).

Figure 4.12: Sander without guard to enclose drum and disc

Figure 4.13: Sander without guard feed rollers to prevent contact with in-running rolls

This situation does not conform to FOSA (2014), and OSHA (2016) regulations and guide lines on save use of the wood working machinery. The result of this study is consistent with a study conducted by Masi and Cagno, (2015) on the state of woodworker's belt sander in furniture firms in Kenya. The study revealed that, 72% of the sanders observed were without dust bags and guards to enclose drum and disc. Chi-square test at 0.05 level of significance as indicated in **Table 4.6**show that for the six (6) parts assessed on the 30 machines safety gadgets that do not exist were significantly higher than those improvised and absent (p-value > 0.05).

4.3.4 Surface Planner

Planners are most frequently used to produce smooth faces on boards and to mill them to particular thicknesses. Severe lacerations, amputations, or avulsions (tearing away) can occur if the operator's hand or arm is fed through the machine and contacts the cutting heads. Serious injury can also occur from kickback. A kickback can occur when lowering the table with the power on whilst the stock is still in the machine.

Table 4.6 Assessment of safety gadget on surface planner machines

Item #	Safety gadgets	N	Exist ƒ(%)	Not exist ƒ(%)	Improvised ƒ (%)	Chi-Square	p-value
1	Operators' manual	71	-	71(100%)	-		.000*
2	Cutter head enclosed with automatic guard	71	-	57(80.3%)	14(19.7%)	23.678a	.079†
3	Stick to push work pieces that are short	71	-	62(87.3%)	9(12.7%)	31.113a	.068†
4	Sheet metal guard to enclose pulleys and belt	71	4(5.6%)	64(90.1%)	3(4.3%)	103.127b	.000*
5	Feed rollers	71	9(12.7%)	48(67.6%)	14(19.7%)	38.056b	.061†
6	Isolating switch for cutting power supply	71	6(8.5%)	53(74.5%)	12(17.0%)	40.085b	. 059†
7	Power transmission deice enclosed	71	5(7.0%)	55(77.5%)	11(15.5%)	62.986b	.008*
8	Fence	71	51(71.8%)	14(19.7%)	6(8.5%)	48.704b	.051†
9	Push button for emergency stopping of the machine	71	3(4.2%)	63(88.7%)	5(7.1%)	60.873a	.023*
10	Dust harvester	71	-	71(100%)	-	-	.000*

*Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05 level of significance.

The results in **Table 4.7** indicate the assessment of the safety devices of the surface planner machines in the Sokoban Wood Village. The number of surface planners that were functioning was 71. The results show that with the exception of "Fence to enable the timber being edged to be processed against it" which were present for most of the surface planners assessed (51 out of 71 machines), majority of the planner machines did not have most of the safety gadgets present. For example, none of the surface planers assessed had operators' manual or dust harvester, 57 representing 80.3% do not have their cutter head enclosed with automatic guard, 62 (87.3%) out of the 71 surface planers do not have stick to push work pieces that are short and 64 machines representing 90.1% do not have their pulleys and belt enclosed in a sheet metal guard. Additionally, 63 out of the 71 surface planners do not have push button for emergency stopping of the machines.

Figure 4.14 and **4.15** are showing Surface planner without cutter head guard and Surface planner without metal guard to enclose belt and pulley

Figure 4.14: Surface planner without cutter head guard.

Figure 4.15 Surface planner without metal guard to enclose belt and pulley.

The result suggests that much need to be done to enforce safety of the planning machines at the SWV since the AS-4024.1 of 1996 Safeguarding Machinery requires that all rotating part of machinery must be enclosed to avoid injury. Gomez et al., (2010), on the assessment on woodworking machines revealed that most of the firms studied had their blades and other rotating parts not enclosed. Adanur (2016), on occupational health and safety in microscale wood-product enterprises reported that, safety guards were notavailable on the machines been used by the woodworkers in the furniture enterprises studied in Calabar-Nigeria. Additionally, Uysal et al. (2005), on their study concluded that the machines being used by the woodworkers in the sawmills studied were absolute and were without protective components or those with were inadequate.

The Chi-square test (**Table 4.7**) indicates that for 5 out of the 10 ten safety parts assessed for the 71 planner machines there was no significant difference between the part that existed, improvised and not existed (p-value > 0.05).

4.3.6 Circular saw machine

Circular saw machines are versatile and are used for crosscutting, ripping, bevel cut and to do other operations using accessories. In using it for sawing the operator adjusts the saw to the proper cutting depth and pushes the wood through the saw. All the 156 circular saw machines used at the SWV were assessed for their safety. None of the 156 circular saws machines that were assessed had operator's manual. This is consistent with that of the other machines and again it violates the ILO (2015) and the requirements of OSHA (2017). The safety condition of the circular saw machines at the SWV is similar to that of the other woodwork machines discussed. For most of the 156 machines studied only few of the safety parts existed.

For instance, out of the 156 circular saw machines 129 representing 82.7% do not have their pulleys and belts enclosed in guards. Additionally, about 123 (78.8%) and 131 (84%) of the machines do not have "emergency off/on switch" and "riving knife to prevent the timber from binding" respectively.

Figure 4.16, **4.17** and **4.18** shows circular saw machines without guard for belt and pulley as well as without blade guard in place during their operations.

Figure 4.16: Circular saw without guard for belt and pulleys

Figure 4.17: Circular saw with improvised anti-kickback

Figure 4.18: Circular saw without a blade guard

The absences of these safety gadgets make them potentially dangerous to the health and safety of the machine operators. The result of this current study is in support of the study conducted by Zaraliakos (2013), which indicated that 117 (94.2%) out 124 circular saw machines assessed were without guards to cover blade as well as riving knife to prevent the timber from binding. Top (2015), on waste generation and utilization in micro-sized furniture-manufacturing enterprises in Turkey concluded that more than two thirds ($^2{}_3$) of the 176 circular saw machines studied were without guards to enclose pulley and belt. Similarly, Ige and Onadeko (2000), investigation on respiratory symptoms and ventilators of the saw millers in Ibadan concluded that the sawmilling machines at the sawmills used for the study were without operator's manual and dust hoods and their activities poses health threats to the saw millers.

Table 4.7: Assessment the safety gadget of the circular saw machine

Item #	Safety gadgets	N	Exist f(%)	Not exist f(%)	Improvised f(%)	Chi-Square	p-value
1	Operators' manual	156	-	156(100%)	-		.000*
2	Guard to enclose pulley and belt	156	21(13.5%)	129(82.7%)	6(3.8%)	173.192a	.003*
3	Anti-kickbacks	156	14(9%)	44(28%)	98(63%)	69.692a	.062†
4	Guard for the blade	156	17(10.9%)	118(75.6%)	21(13.5%)	118.501a	.057†
5	Emergency off/on switch	156	9(5.8%)	123(78.8%)	24(15,4%)	143.808a	.001*
6	Power transmission devices enclosed	156	23(14.8%)	125(80.1%)	8(5.1%)	112.412a	.006*
7	Riving knife to prevent the timber from binding	156	20(12.8%)	131(84%)	5(3.2%)	182.192a	.000*

*Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05 level of significance.

Chi-square tests at 0.05 level of significance as indicated in Table 4.9 indicate that 4 out of the 6 safety parts that were absent were significantly higher than those that were available (p-value < 0.05).

4.4 Assessment of Adherence to Occupational Health and Safety Regulations by Machine Operators at the Sokoban Wood Village

Occupational health and safety practices is regarded as being aware and practice of safety by the woodworkers and the potential hazards to one-self and others in the workplace (Antwi et al., 2013). This part of the study assessed the adherence to occupation health and safety regulations by machine operators at the SWV. It also looked at the effect of their operation, educational background and years of experience on adherence to occupational health and safety regulation within the Sokoban Wood Village.

4.4.1 Adherence to Occupational Health and Safety Regulations

The results in **Table 4.8** indicate the mean ratings and their corresponding standard deviations of the elements on the use of occupational health and safety practices by the machine operators at the Sokoban Wood Village. The theoretical mean for the five-point Likert scale questionnaire (Never = 1, Rarely = 2, Sometimes = 3, Usually = 4 and Always = 5) used was 3.0.

Table 4.8: Descriptive statistics of ratings on the adherence to occupational health and safety regulations by machine operators

Item #	Element of adherence to occupational health and safety	Mean rating (n=410)	Standard deviation
	Personal Protective Equipment		
1	Do you wear gloves/mittens when working?	1.15	.642
2	Do you wear overall when working?	1.22	.481
3	Do you wear goggles when working?	2.04	.712
4	Do you wear face shield when working?	1.03	.874
5	Do you wear nose and mouth mask when working?	2.13	.432
6	Do you wear earplugs or ear muffs when working?	1.45	.197
7	Do you wear helmet when working?	1.09	.432
8	Do you wear safety boot when working?	1.34	.521
	Machines and Maintenance		
9	Do you ensure that guards and fence are in place during wood machining?	3.87	.742
10	Do you ensure that trained personnel operate the machine?	4.02	.710
11	Do you ensure that electrical gadgets are put off before they leave plant?	4.13	.687
12	Do you ensure woodworkers adherence to safety rules and regulations of all machines?	3.92	.714
13	Do ensure machine maintenance and repairs?	4.41	.612
14	Do ensure adequate conditioning of saws and blades?	4.33	.625
15	Do you ensure that worn out chains and ropes are changed?	4.45	.604
	Resultant mean for the use of safety practices for work	2.71	.683

The results indicate that all the eight (8) items under the use of personal protective equipment had their mean ratings lower than the theoretical mean of 3.0. As indicated in **Table 4.8,** the Item # 4 “Do you wear face shield when working” had the least mean rating of 1.03 (SD = 0.874) whilst the item # 5 “Do you wear nose and mouth mask when working” had the highest mean rating of 2.13 (SD = 0.432). This suggests that the machine operators at the Sokoban Wood Village never, rarely or do not put on personal protective equipment during wood processing. Osonwa et al. (2015), indicated that the number one-most reason for non-usage of personal protective equipment's by woodworkers was employers not providing such for employees. Other reason given by the respondents were inadequate training and education on the use of the protective equipment as well as non-enforcement of the use of the personal protective equipment.

This result is consistent with a study conducted by Mitchual et al. (2015) in the assessment of safety practices and injuries associated with timber processing at a timber firm in Ghana. The study revealed that the woodworkers in that firm do not use personal protective equipment during wood processing and this could expose them to injuries and health issues. Additionally, a study by Adanur (2016) indicated that 87.5% of the sawmill workers studied did not wear nose mask, 93.8% did not wear safety boots, earplugs and goggles during wood processing. Reinhold et al. (2015) also on their study on practical tool and procedure for workplace risk assessment indicated that 72% of the woodworkers assessed do not wear personal protective equipment's in the enterprises studied in Estonia.

The other seven (7) items which is under the adherence to "machines and maintenance" have their mean ratings exceeding the theoretical mean of 3.0. As indicated in **Table 4.8,** the Item # 9 "Do you ensure that guards and fence are in place when machines are in use" had the least mean rating of 3.87 (SD = 0.742) whilst the item # 15 "Do you ensure that worn out chains and ropes are changed" had the highest mean rating of 4.45 (SD = 0.604). The ratings of the machine operators ranging from 3.87 to 4.45 indicates that the machine operators do ensure that: worn out chains and ropes are changed before they operate the machines; guards and fence are in place during wood machining, trained personnel operate the machine, electrical gadgets are put off before they leave plant and machine operators adherence to safety rules and regulations of all machines.

Evans et al. (2005) and Ilhan et al. (2013) encapsulated that poor adherence to safety regulations is the number one-most significant factor leading to accidents in the sawmilling industry. Chinniah (2015) on analysis and prevention of serious and fatal accidents related to moving parts of machinery reported that 85% of the woodworkers studied did not practice occupational health and safety in the sawmills studied. The study further revealed that woodworkers at the sawmills studied do ensure that fence are in place during wood machining and electrical gadgets put off before they leave plant. Additionally, the woodworkers' adherence to the use of personal protective equipment's was lower compared to machine and maintenance. This may be due to the fact that the woodworkers were aware of the dangers that could result from not properly maintaining the machines. Therefore, they do report any fault the machines develop.

4.4.2. Effect of Educational Background on the Adherence to Occupational Health and Safety Practices

Table 4.9 indicates the effect of educational background on the practice of occupational health and safety by the machine operators at the Sokoban Wood Village. The item-by-item mean ratings of the respondents with no formal, MSLC/JHS, secondary, and tertiary education under the sub-title "personal protective equipment" were all less than the theoretical mean of 3.0. Additionally, with this part of the study the result indicates that generally the level of education of the respondents did not significantly influence their adherence to the use of personal protective equipment. This result suggest that the non-wearing of the personal protective equipment's does not emanate from the educational background of the operators but from other factors such as inadequate in-service training and education. It could also emanate from non-enforcement of the occupational health and safety regulations as indicated by the respondents.

Table 4.9 ANOVA on effect of educational background on the adherence to occupational health and safety regulations

Table 4.9 ANOVA on effect of educational background on the adherence to occupational health and safety regulations

Item #	Elements of adherence to OHS	No formal Education ($n_1 = 28$) Mean	SD	JHS/MSLC Education ($n_2 = 272$) Mean	SD	Secondary Education ($n_3 = 78$) Mean	SD	Tertiary Education ($n_4 = 32$) Mean	SD	F-value	p-value
	Personal Protective Equipment										
1	Do you wear gloves/mittens when working?	2.45	.51	2.62	.48	2.65	0.47	2.34	.68	1.38	.164†
2	Do you wear overall when working?	1.94	.39	2.45	.12	2.32	.11	1.65	.79	1.41	.089†
3	Do you wear goggles when working?	2.93	.92	2.34	.23	2.09	.19	2.54	.44	1.68	.545†
4	Do you wear face shield when working?	1.02	.18	1.11	.11	1.41	.13	1.14	.07	1.48	.434†
5	Do you wear nose and mouth mask when working?	2.34	.43	2.41	.37	2.76	.93	2.21	.25	3.49	.049*
6	Do you wear earplugs or ear muffs when working?	2.43	.23	2.21	.02	2.06	.17	1.24	.14	1.36	.608†
7	Do you wear helmet when working?	1.12	.07	1.24	.06	1.33	.11	1.18	.05	1.76	.306†
8	Do you wear safety boot when working?	1.43	.29	1.06	.15	1.87	.32	1.02	.19	1.35	.310†
	Machines and Maintenance										
9	Do you ensure that guards and fence are in place during wood machining?	4.45	.44	4.32	.17	4.03	.32	4.74	.57	1.88	.535†
10	Do you ensure that trained personnel operate the machine	4.45	.33	4.64	.25	4.52	.26	4.72	.18	1.44	.279†
11	Do you ensure that electrical gadgets are put off before they leave plant?	4.45	.07	4.45	.07	4.25	.12	4.63	.04	1.89	.073†
12	Do you ensure woodworkers adherence to safety rules and regulations?	4.02	.09	3.98	.14	3.85	.19	4.09	.08	2.81	.046*
13	Do ensure machine maintenance and repairs?	4.31	.13	4.46	.05	4.08	.31	4.41	.04	1.97	.078†
14	Do ensure adequate conditioning of saws and blades?	3.63	.32	3.89	.19	3.42	.54	3.76	.34	1.29	.067†
15	Do you ensure that worn out chains and ropes are changed?	4.17	.12	4.39	.05	4.21	.08	3.74	.39	3.08	.041*

*Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05 level of significance

Similarly, studies conducted on the theme "Occupational Hazards, Health Problems and Safety Measures among Sawmill Workers in North Central Nigeria", (Osagbemi, 2010) concluded that less than 20% of the sawmill workers wore protective devices/clothing and this was due to the fact that health and safety standards were neither practiced nor enforced.

Additionally, a study conducted by Mitchual et al. (2015) on assessment of safety practices in a timber firm revealed that generally educational background did not have significant effect on woodworker on the use of personal protective equipment in the Timber Company Studied. Furthermore, Chernova and Sherpovaova (2011) conducted a study on occupational health and safety challenges for small scale enterprises and also concluded that educational background does not significantly influence the woodworkers on the practice of occupational health and safety in the woodworking industry.

The item-by-item one-way analysis of variance (ANOVA) to assess the influence of educational background on the respondents' ratings on the adherence to machine maintenance indicated (**Tables 4.9)** indicate that at 5% level of significance 5 out of the 7 items showed no significant effects of the machine operators' educational background on their adherence to the items under machine and maintenance. However, 2 out of the 7 items showed that educational background of the machine operators had significant effect on their adherence to the items under machine and maintenance. Generally, the result of this study is contrarily to a study conducted by Kiwekete (2010), on psychosocial risk assessment-ensuring the well-being of employees which concluded that woodworkers with higher educational background were more likely to be aware of the dangers of not practicing safety at the wood workshops studied than their counterparts with lower educational background.

The study further revealed that those with higher educational background can read and properly comprehend the machine manuals and the signs therefore, help to practice occupational health and safety.

4.4.3 Effect of Work Experience on the Adherence to Occupational Health and Safety Regulations by Woodwork Machine Operators

Occupational health and safety regulations could be very important for several reasons, in that, good occupational health and safety (OHS) practices could reduce employee injury and illness-related cost. Other cost related to sick leave and disability benefits could also be reduced. It is worth noting that most of the above costs could be prevented or significantly reduced through implementation of sound prevention, reporting and inspecting practices, yet they persist at various work places. **Table 4.10** indicates the effect of work experience on machine operators' adherence to practice of occupational health and safety regulations at the SWV. The results indicate that at 5% level of significance, the machine operators' work experience did not have significant effect on their ratings of practice of occupational health and safety on all the 8 items under the sub-title "personal protective equipment". This is because at the study area a working culture has been created for which the operators do not adhere to the safety regulations related to their work. Therefore, their attitude does not significantly differ with work experience. However, such a culture could be broken through periodic training and enforcement of safety regulations.

The result of the present study is similar to that of Tetemke et al. (2014) and Osonwa et al. (2015). A study by Tetemke et al. (2014) on knowledge and adherence to safer regulation among textile workers in Adwa in Ethiopia indicated that neither the workers who had worked for 10 years and above nor those who had worked below 10 years do put on personal protective equipment's in the textile companies used for the study. Additionally, the result of study on woodworkers at wood factory in Calabar-Nigeria by Osonwa et al. (2015) indicated that, work experience of the factory workers does not significantly affect their wearing of personal protective equipment.

On the contrarily, this study contradicts the findings of Hadjimanolis and Boustras (2013) on health and safety policies and work attitudes in Cypriot which revealed that, the work experience of the workers studied significantly influence their practice of health and safety. Their findings further explained that the workers who had worked in the company studied for more than 20 years practiced and adhered to safety regulations more than other workers who had been in the same company for less than 20 years. The study explained that those who have been in the company for more than 20 years might have witness some of the dangers encountered by some workers and are careful to avoid them.

Table 4.10: ANOVA on effect of work experience on the practice of occupational health and safety

Table 4.10: ANOVA on effect of work experience on the practice of occupational health and safety

Item #	Elements on practice of occupational health and safety	Below 1yr (n_1 = 86)		1 – 5 yrs (n_2 = 178)		6-10 yrs (n_3 = 103)		Above 10 yrs (n_4 = 43)		F-value	p-value
		Mean	SD	Mean	SD	Mean	SD	Mean	SD		
	Personal Protective Equipment										
1	Do you wear gloves/mittens when working	1.53	.48	1.49	.54	1.58	.48	1.34	.73	1.82	.069†
2	Do you wear overall when working	2.21	.35	1.43	.57	1.31	.92	1.26	.92	0.84	.471†
3	Do you wear goggles when working	2.56	.86	2.61	.78	2.41	.73	1.97	.93	1.5	.205†
4	Do you wear face shield when working	1.02	0.33	1.04	.43	1.07	.31	1.09	.31	1.54	.215†
5	Do you wear nose and mouth mask when working	2.45	.27	2.75	.71	2.22	.27	1.52	.38	2.04	.053†
6	Do you wear earplugs or ear muffs when working	1.37	.45	1.29	.44	2.24	.29	2.03	.37	0.54	.692†
7	Do you wear helmet when working	1.14	.25	1.11	.26	1.09	.26	1.13	.24	..49	.657†
8	Do you wear safety boot when working	1.23	.21	1.19	.21	1.44	.18	1.42	.18	3.14	.066†
	Machines and Maintenance										
9	Do you ensure that guards and fence are in place during wood machining?	3.87	.67	4.54	.32	4.1	.43	4.07	.44	3.69	. 037*
10	Do you ensure that trained personnel operate the machine	4.24	.53	4.51	.93	4.22	.51	3.86	.27	2.93	.034*
11	Do you ensure that electrical gadgets are put off before they leave plant?	4.24	.56	3.85	.98	3.75	.83	3.36	.63	1.8	.147†
12	Do you ensure woodworkers adherence to safety rules and regulations?	3.71	.38	4.09	.72	4.02	.74	3.71	.73	2.69	.047*
13	Do ensure machine maintenance and repairs?	4.08	.53	3.84	.84	3.91	.81	3.36	.82	1.61	.188†
14	Do ensure adequate conditioning of saws and blades?	3.97	.58	3.71	.91	3.58	.78	3.36	.91	1.4	. 028*
15	Do you ensure that worn out chains and ropes are changed?	4.43	.62	4.01	.96	4.06	.72	3.36	0.87	2.88	.071†

* Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05 level of significance

Additionally, the results show that at 5% level of significant work experience did not have significant effect on the respondents' rating on three (3) out of seven (7) items under the sub-titled machine and maintenance. These items are: "Do you ensure that electrical gadgets are put off before they leave plant", "Do ensure machine maintenance and repairs" and "Do you ensure that worn out chains and ropes are changed". The remaining four (4) items indicates that work experience significantly influences their practice.

4.4.4 Effect of Operation on the Adherence of Occupational Health and Safety Regulations by Wood Machine Operators

The wood processing industry consists of several operations. These operations include: Sawing, planning, sanding, moulding, mortising and jointing. **Table 4.11** indicates the result of the assessment of effect of operations of the machine operators on their ratings of practice of occupational health and safety. With the exception of item # 11 "Do you ensure that electrical gadgets are put off before they leave plant" for which the mean score was above the theoretical mean of 3.0 for all the operations for all the other items the respondents were not unanimous on their ratings. On some few occasions the ratings were above the theoretical mean of 3.0 but for the majority of the items the ratings were below the theoretical mean of 3.0. It is also worth noting that it was only the sanding machine operators who indicated that they usually adhere to the use of nose and mouth mask during operations. This is consistent with a study conducted by Schneider (2005) on assessment of occupational safety and health hazards in a selected wood firm which revealed that the workers in the sanding section were more likely to wear nose mask than their counterpart in the moulding section of the firm studied because the sanding operation produces fine sawdust which can easily be inhaled by the operators.

Item-by-item one-way analysis of variance at 5% level of significance indicates that under the subtitle "personal protective equipment" the operation of the machine operators did have significant effect on six (6) out of the eight (8) items. However, with two (2) items - "Do you wear safety boot when working" and "Do you wear helmet when working" - the operation of the machine operators did not have significant influences their use of protective equipment with the rest showing significant difference in the ratings of the operators. Lombardi (2009), on factors influencing woodworkers use of personal protective eyewear indicated that the operation of the woodworker is significantly influenced by the kind of operation the woodworker performed. The study asserted that, the wood workers in the planning, sanding and the sawing department were always seen wearing nose mask, face shield and hats than those in the mortising and boring department. The above notwithstanding, generally the ratings of the operators were below the theoretical mean suggesting that the operators irrespective of their operations do not put on personal protective equipment.

Furthermore, the result in **Table 4.11** revealed that the ratings of the machine operators of the items under the subtitled "machines and maintenance" did not differ at 5% significant. Therefore, their operations did not have influence on their practice of those safety measures.

Table 4.11 ANOVA on the effect of operation on the practice of occupational health and safety
Table 4.11 ANOVA on the effect of operation on the practice of occupational health and safety

Item #	Elements on practice of occupational health and safety	Sawing Operation (n_1 = 206)		Planning (n_2 = 71)		Moulding Operation (n_3 = 64)		Sanding Operation (n_4 = 30)		Boring Operation (n5 = 39)		F-value	p-value
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
	Personal Protective Equipment												
1	Do you wear gloves/mittens when working	1.74	.71	2.72	.53	1.54	.73	1.48	.78	1.70	.85	24.41	.000*
2	Do you wear overall when working	1.41	.86	1.81	.61	1.60	.72	2.71	.48	1.12	.55	15.63	.032*
3	Do you wear goggles when working	3.21	.56	3.12	.51	1.24	.92	3.14	.57	1.21	.80	29.28	.000*
4	Do you wear face shield when working	2.32	.67	2.73	.53	1.41	.64	1.82	.71	1.45	.73	30.42	.000*
5	Do you wear nose and mouth mask when working	2.58	.93	2.78	.52	2.46	.58	3.06	.35	2.28	.58	7.45	.018*
6	Do you wear earplugs or ear muffs when working	1.32	.74	1.45	.82	1.15	.54	1.41	.73	1.20	.77	17.54	.026*
7	Do you wear helmet when working	1.10	.91	1.18	.60	1.07	.94	1.79	.65	1.10	.59	5.60	.715†
8	Do you wear safety boot when working	1.46	.65	1.06	.94	1.24	.92	1.52	.78	4.82	.58	6.14	.564†
	Machines and Maintenance												
9	Do you ensure that guards and fence are in place during wood machining?	2.69	.53	4.55	.23	3.08	.48	3.65	.38	3.09	.48	12.93	.059†
10	Do you ensure that trained personnel operate the machine	2.56	.61	3.09	.53	2.46	.62	1.94	.66	2.85	.59	12.81	.051†
11	Do you ensure that electrical gadgets are put off before they leave plant?	3.83	.64	4.00	.52	3.69	.74	1.87	.69	4.48	.20	10.61	.061†
12	Do you ensure woodworkers adherence to safety rules and regulations?	2.40	.65	3.55	.53	2.54	.71	1.48	.98	2.75	.54	9.40	.068†
13	Do ensure machine maintenance and repairs?	3.00	.82	3.91	.67	2.81	.91	1.38	.94	3.91	.67	6.93	.072†
14	Do ensure adequate conditioning of saws and blades?	2.84	.92	4.64	.21	2.46	.90	1.67	.71	1.65	.99	12.26	.056†
15	Do you ensure that worn out chains and ropes are changed?	2.74	.33	3.27	.27	2.58	.35	1.96	.61	1.82	.75	10.47	.066†

*Statistically significant at 0.05 level of significance; †Not statistically significant at 0.05 level of significance

4.5 Assessment of Exposure to Metals in Airborne Particulate Matter

The production and diffusion of dust in the woodwork industry is a function of the work organization, the presence and efficiency of ventilation systems, the skill of the individual worker and the kind of wood products that are manufactured (Kauppinen, et al., 2006). Wood dust is an accumulation of any wood particulate that is generated during the processing or handling of wood. When this dust becomes airborne it may be inhaled by workers, leading to mucosal irritation, allergies and respiratory system cancer (Mandryk, 2000 and Pellegrini, 2002). Studies have also shown that wood species contains a wide range of mineral and metals (eg. Zn, Cd, As, Cu, and Fe); if the concentration of these heavy metals exceeds certain threshold, it poses health risk or danger (Obernberger et al., 2013).

This aspect of the research work seeks to look at the metal concentration in the wood dust produced by the wood workers at the Sokoban wood village from the machine source to a distance of hundred meters away from the machine. The distance or sampling points from source of emission were represented as follows: A = 1 – 20 m, B = 21 – 40 m, C = 41 – 60 m, D = 61 – 80 m and E = 81 – 100 m from the emission source respectively.

4.5.1 Mean concentration of metal (mg/m^3) in airborne particulates of wood sellers

The results of the mean concentration of metals (mg/m^3) in airborne particulate of the wood sellers is shown in **Table 14.12.** The levels of exposure to the metals by the workers were compared to the permissible exposure limits standards (PEL) of OSHA, NIOSH, ACGIH and USEPA.

Table 4.12 Mean concentration of metal (mg/m^3) in airborne particulates of the Wood Sellers

Table 4.12 Mean concentration of metal (mg/m^3) in airborne particulates of the Wood Sellers

ELEMENTS	1M-20M (A)		21M-40M (B)		41M-60M (C)		61M-80M (D)		81M-100M (E)		F-value	P-value
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd		
As	0.630^{a}	0.167	0.557^{bc}	0.169	0.53^{dc}	0.141	0.52^{d}	0.184	0.50^{d}	0.148	0.543	0.002
Cd	0.432^{a}	0.174	0.376^{a}	0.41	0.33^{ab}	0.42	0.27^{b}	0.120	0.22^{c}	0.172	0.243	<0.001
Cu	1.763^{a}	0.175	1.521^{b}	0.127	1.49^{cb}	0.336	1.24^{c}	0.146	0.94^{c}	0.193	0.672	0.032
Fe	10.95^{a}	2.379	10.53^{bc}	1.306	10.25^{b}	1.984	10.15^{c}	0.574	10.07^{c}	0.907	2.142	0.043
Mn	1.574^{a}	0.171	1.54^{ab}	0.323	1.38^{ab}	0.325	1.16^{b}	0.116	0.98^{c}	0.578	0.853	0.024
Pb	0.523^{a}	0.208	0.43^{b}	0.175	0.36^{c}	0.165	0.22^{c}	0.111	0.21^{c}	0.145	0.421	<0.001
Zn	6.057^{a}	0.729	5.66^{a}	1.220	5.39^{a}	1.625	5.14^{a}	1.315	4.82^{b}	1.624	0.435	0.044

Figures in a row with different superscript are statistically different; figures in a row with the same superscript are statistically not

The highest mean concentrations of **As** in airborne particulate matter was recorded at sampling point **A** (0.630 ± 0.167 mg/m^3) and the lowest at **E** (0.50 ± 0.148 mg/m^3). A p-value (**p = 0.002**) was obtained indicating that the variation among the mean levels of particulate **As** at the sampling points A, B, C, D and E was significant (i.e. **A** > **B** > **C** > **D** > **E**) (**Table 4.12**). The highest levels of **As** recoded at sampling point **A** is expected because sampling was done closer to the emission source while B, C, D and E were further away. The maximum mean **As** level recorded at **A** (0.630 ± 0.167 mg/m^3) was 1.26 times higher than the PEL standard value of 0.5 mg/m^3.

The results of the current study were consistent with the study conducted by Kauppinen, et al. (2006) on occupational exposure to metals in wood dust whose results revealed that 79% of the wood workers studied were exposed to **As** in particulates at levels higher than 0.5 mg/m^{3}the maximum admissible exposure limit recommended by the World Health Organization (WHO, 2014). The high mean **As** levels recorded at all the sampling points (**A** to **E**) is an indication that the wood sellers are at risk of **As** exposure. In addition to skin cancer, long-term exposure to **As** may also cause cancers of the stomach, intestine, bladder and lungs (Huang, Yin and Yap, 2010).

The mean concentration of Cadmium (**Cd**) in airborne particulate matter ranged between sampling point **A** (0.432 ± 0.174 mg/m^3) to **E** (0.220 ± 0.172 mg/m^3) (Table 4.12). The mean concentrations recorded at all the sampling points were higher compared to the PEL standards of 0.2 mg/m^3.

It is observed that as the distance at which sampling was carried out and the emission source increased, the mean concentration of **Cd** recorded reduced. When the mean **Cd** levels at the various sampling points (**A** to **E**) were subjected to ANOVA, a p-value (p < 0.001) was obtained indicating significant differences between mean Cd levels at the various sampling points. This indicates that distance significantly influences the worker's exposure to **Cd** in airborne particular matter.

Bahattacharya, et al. (2002), conducted a study on metal concentration at a wood preservation site and concluded that, the concentration levels of the metals identified reduced as the worker moves away from the preservation chamber or tank. Cadmium has been classified as carcinogenic and exposure to high levels of **Cd** could affect the lungs, kidney and the liver (IARC, 2016).

The mean concentrations for copper (**Cu**) in airborne particulate matter ranged from **A** (1.763 ± 0.175 mg/m^3) to **E** (0.939 ± 0.193 mg/m^3). Except for sampling at distance **E** which recorded mean concentration of (0.94 ± 0.193 mg/m^3) of **Cu**, all other distances recorded mean concentrations above the PEL value of 1 mg/ ^{3}. The high levels of **Cu** in airborne particulate could pose a serious health threat to the wood sellers in the village. Although **Cu** is necessary for cellular metabolism, abnormal copper levels could lead to relevant brain impairment, restlessness and insomnia (Scheiber et al., 2014, Davidson, Phalen and Soomon, 2006). A p-value (p = 0.032) was obtained indicating that the variation among the mean levels of particulate **Cu** at the sampling points A, B, C, D and E were significant (i.e. **A** > **B** > **C** > **D** > **E**) (**Table 4.12**).

The lowest levels of **Cu** recorded at sampling point **E** is expected because sampling was done farthest away from the emission source. The minimum mean **Cu** level recorded at **E** (0.94 ± 0.193 mg/m^3) was 0.94 times lower than the PEL standard value of 1.0 mg/m^3. Gaur et al (2010), on assessment of heavy metal content in suspended particulate matter of coastal industrial town in India revealed that the concentrations of the metals analysed were reduced by 5% compared to PEL standard values as the sample points from the coast was increased.

The mean concentration of Iron (**Fe**) in airborne particulate matter recoded at the sampling points **A, B, C**, **D** and **E** were found to exceed the 10 mg/m^3 recommended PEL standard value. This also means that irrespective of the distance considered, the wood seller is exposed to significant levels of **Fe**. Exposure to high levels of **Fe** in airborne particulate by human could lead to extreme tiredness, headache and heart and liver cancer (Karar, et al., 2006). **Fe** levels at the various sampling points (**A** to **E**) at confidence level of 0.05% indicated statistically significant differences between mean **Fe** levels at the various sampling points with a p-value ($p = 0.043$). The level of exposure to **Fe** in airborne particulate by the workers at sample point **A** and **E** were 1.095 to 1.01 times higher than that of PEL standard value of 10 mg/m^3. Workers at sampling point **A** were exposed to high levels of **Fe** airborne particulate than that of workers at sampling point **E**.

The mean concentration of lead (**Pb**) in airborne particulate matter by the wood seller **(Table 4.14)** ranged from sample point **A** (0.523 ± 0.208 mg/m^3) to **E** (0.21 ± 0.145 mg/m^3). All mean concentration of **Pb** in airborne particulate recorded for the respective sample points (**A, B, C, D** and **E**) were above 0.05 mg/m^3 PEL standard indicated by OSHA, ACGIH, USEPA, and NIOSH.

This result is in agreement with the study conducted by Nwajei & Iwegbue (2007), who recorded mean concentration of **Pb** ($0.721 \pm .06$) in sawdust particles in the vicinity of sawmill in Sapele in Nigeria. The high levels of **Pb** recorded in the current study is a concern as it poses a serious threat to the health of the woodworker. Lead **(Pb)** is highly toxic even at very low exposure levels. Dahiya et al. (2005) indicated that high concentration of **(Pb)** in human body can damage the liver, kidney and the reproductive system. One-way ANOVA at the various sampling points for levels of Pb particulate in (**Table 4: 12)** indicated significant differences between the mean **Pb** levels at the various sampling points (p-value = < 0.001). The maximum and minimum mean **Pb** level recorded at **A** (0.523 ± 0.208 mg/m^3) and E (0.21 ± 0.145) was 10.46 and 4.2 times respectively higher than the PEL standard value of 0.05 mg/m^3.

The result of the current study (**Table 4.12)** showed that, mean levels of Zinc (**Zn**) in particulate recorded ranged from sampling point **A** (6.057 ± 0.729 mg/m^3) to **E** (4.821 ± 1.624 mg/m^3). Except for sampling point **E**, the mean levels of **Zn** in airborne particulate matter recorded at the remaining sampling points exceeded PEL threshold by OSHA, NIOSH and USEPA. Exposure to sawdust particles containing high level of **Zn** airborne particulate according to Karar, et al. (2006) could induce stomach irritation, headache and nausea in the worker.

4.5.2 Mean Concentration of Metals (mg/m^3) in Airborne Particulate Matter of the Food Vendors at the Wood Village

The researcher at this point analysed food vendor's exposure to metals in airborne particulate within the environment where the research was carried out. The results of the mean concentration of metal (mg/m^3) in airborne particulate of the food vendors is shown in **Table 14.13.**

Table 4.13 Mean concentration of metals (mg/m^3) in airborne particulate of the food vendors

Table 4.13 Mean concentration of metals (mg/m^3) in airborne particulate of the food vendors

ELEMENTS	1M-20M (A)		21M-40M (B)		41M-60M (C)		61M-80M (D)		81M-100M (E)		F-value	P value -
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd		
As	0.794^{a}	0.025	0.714^{b}	0.039	0.699^{c}	0.048	0.541^{d}	0.065	0.524^{d}	0.071	0.436	<0.001
Cd	0.419^{a}	0.031	0.046^{a}	0.134	0.320^{b}	0.239	0.281^{bc}	0.342	0.263^{c}	0.352	0.034	<0.001
Cu	1.664^{a}	0.160	1.452^{b}	0.216	1.296^{bc}	0.251	1.174^{cd}	0.133	1.112^{d}	0.144	0.786	0.021
Fe	10.806^{a}	0.263	10.395^{b}	0.419	10.15^{c}	0.561	10.095^{cd}	0.623	10.045^{d}	0.836	2.431	0.037
Mn	1.335^{a}	0.055	1.243^{a}	0.077	1.131^{b}	0.191	0.929^{ac}	0.133	0.830^{c}	0.173	0.842	0.027
Pb	0.453^{a}	0.127	0.425^{b}	0.141	0.404^{c}	0.148	0.365^{c}	0.234	0.343^{c}	0.246	0.042	<0.001
Zn	6.639^{a}	0.391	5.992^{b}	0.408	5.549^{bc}	0.552	5.460^{c}	0.727	5.077^{c}	0.965	1.894	0.033

Figures in a row with different superscript are statistically different; figures in a row with a same superscript are statistically not different.

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The result from **Table 4.13** indicates that, as the sampling points of food vendors increases from the source of the dust emission, the mean concentration levels of metals in airborne particulate matter reduces and therefore the level of exposure by food vendors to airborne particulate differed. Highest mean concentration level of Arsenic was recorded at sampling point **A** (0.794 ± 0.025 mg/m^3) with sampling point **E** (0.524 ± 0.071 mg/m^3) being the least. This suggest that, the food vendors within these sampling points (**A**, **B. C, D** to **E)** were exposed to high levels of **As** than the required PEL standard of 0.5 mg/m^3. One-way ANOVA at 0.05 level of significant indicated variation in the mean **As** levels between the various sampling points with (p-value < 0.001). The minimum and maximum mean **As** levels recorded were 1.05 to 1.59 times higher than the PEL standard. Investigation from Chakraborty & Gupta (2010), on chemical characterization and source apportionment of particulate matter concentration in Kanpur, India revealed that, **As** airborne particulate matter obtained were 0.75 times higher than the PEL threshold. Yadav & Satsangi (2013), on characterization of particulate matter and its related metal toxicity in South-Western India enumerated that, exposure to high levels of **As** airborne particulate was one of causes leading to high rate of lung cancers within the environment.

The mean concentration of the metals (mg/m^3) studied were all above PEL standards of (0.2 mg/m^3), (1 mg/m^3), (10 mg/m^3), (5 mg/m^3), (0.05 mg/m^3) and (5 mg/m^3) for **Cd, Cu, Fe, Mn, Pb** and **Zn,** respectively. The result of the current study is in agreement with a study conducted by Nwajei & Iwegbue (2007), on trace elements in sawdust particles in the vicinity of sawmills in Sapele in Nigeria revealed that, there was high levels of **Pb** in the sawdust sampled within the sawmill vicinity. A similar study conducted by Schlunssen, et al (2002), on dust exposure in wood workers found out that,

both wood workers and other workers within the environment were exposed to high levels of metals in airborne particulates identified in the air within their working environment. Mean concentration levels at the various sampling points (**A** to **E**) for the remaining airborne metal particulate (**Cd, Cu, Fe, Mn, Pb** and **Zn**) were subjected to ANOVA (**Table 4.13**) to determine variations in the mean levels of the metals. P-values obtained for the remaining metal particulate were lower than 0.05, indicating statistically significant differences between the mean concentrations for the various metals within the various sampling points.

4.5.3 Mean Concentration of Metals (mg/m^3)) in Airborne Particulate Matter of the Furniture Production Unit at the Wood Village

The furniture production unit in this study consist of table, chair, bed, doors, door and window frame producers. The mean concentrations levels of the metals (**As, Cd, Cu, Fe, Mn, Pb** and **Zn)** in airborne particulate matter for each location is tabulated in **Table 4. 14**.The mean levels of the various metals were compared to the permissible exposure limits standard by OSHA, NISOH and USEPA in (**Table 4.14).** The mean concentration of Arsenic (**As**) in airborne particulate matter recoded at the sampling points **A** to **E** varies from (0.650 $\pm$ 0.057 mg/m^3) to (0.520 $\pm$ 0.108 mg/m^3) respectively hence higher than PEL standard. The maximum and minimum mean levels of **As** airborne particulate were 1.3 and 1.04 times higher than permissible exposure limits threshold (0.5 mg/m^3) respectively. A p-value ($p = 0.004$) was obtained indicating that, the variation among the mean levels of **As** airborne particulate at the various sampling points **A**, **B**, **C**, **D** and **E** were significantly different (**A** > **B** > **C** > **D** > **E**).

Table 4.14 Mean concentration of metals (mg/m^{3}) in airborne particulate matter by the furniture makers

Table 4.14 Mean concentration of metals (mg/m^{3}) in airborne particulate matter by the furniture makers

ELEMENTS	1M-20M (A)		21M-40M (B)		41M-60M (C)		61M-80M (D)		81M-100M (E)		F-value	P-value
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd		
As	0.650^{a}	0.057	0.617^{b}	0.064	0.579^{bc}	0.089	0.543^{c}	0.095	0.520^{d}	0.108	0.543	0.004
Cd	0.532^{a}	0.044	0.476^{ab}	0.057	0.431^{ab}	0.061	0.367^{bc}	0.067	0.320^{c}	0.081	0.243	<0.001
Cu	1.982^{a}	0.121	1.721^{b}	0.127	1.415^{bc}	0.136	1.343^{bcd}	0.146	1.039^{d}	0.178	0.672	0.032
Fe	11.243^{a}	0.028	10.928^{a}	0.036	10.45^{bc}	0.051	10.24^{c}	0.064	10.097^{d}	0.087	2.142	0.043
Mn	2.574^{a}	0.027	1.973^{a}	0.032	1.375^{a}	0.033	1.161^{a}	0.044	0.976^{b}	0.072	0.853	0.024
Pb	0.082^{a}	0.021	0.073^{b}	0.038	0.065^{bc}	0.050	0.062^{c}	0.081	0.057^{c}	0.095	0.421	<0.001
Zn	7.157^{a}	0.172	6.657^{a}	0.191	6.392^{a}	0.278	5.837^{ab}	0.315	4.921^{b}	0.412	0.435	0.044

Figures in a row with different superscript are statistically different; figures in a row with the same superscript are statistically not different.

This suggest that, the furniture makers were exposed to high levels of **As** in airborne particulate matter and hence could poses more health threat to the furniture makers. The high levels of **As** in particulate exposed to may be due to the chemicals used in preparing most of the preservatives and finishes been used to preserve the products in the enclave. A study conducted by Kauppinen, et al. (2006) on occupational exposure to wood dust revealed that, 79% of the wood workers studied were exposed to Arsenic at level higher than 0.5 mg/m^3, the maximum admissible level recommended by the Scientific Committee for Occupational Exposure Limits.

The mean concentrations of Cadmium (**Cd)** in airborne particulate recorded ranges between sampling point **A** (0.532 ± 0.044 mg/m^3) to **E** (0.320 ± 0.081 mg/m^3). Mean concentrations of **Cd** in airborne particulate matter recorded were above the permissible exposure limit of 0.2 mg/m^3 threshold. The least mean concentration at sampling point **E** was 1.6 times higher than the PEL standard of 0.2 mg/m^3. These high levels of **Cd** in airborne particulate could expose the workers to a serious health treat. A p-value (< 0,001) indicate statistically significant differences in the mean levels between the various sampling points. Similarly, as the sampling point of the furniture makers increases from sampling point **A** to **E**, their exposure to **Cd** particulate matter decreases (**Table 4.14).** This suggest that, distance (point of sampling) significantly influences the worker's exposure to high levels of **Cd** particular matter. Bahattacharya, et al (2002), conducted a study on metal concentration at a wood preservation site and concluded that, the concentration levels of the metals identified were reducing as the worker moves away from the preservation chamber or tank. Pisaniello, Connell and Muriale (1991) on their study on wood dust exposure during furniture manufacturing postulated that, 82% of the furniture manufacturers studied were exposed to high level of metal concentrations above the thresholds. Mean concentrations of copper (**Cu**) in airborne particulate matter recorded ranged from sampling point **A** (1.982 ± 0.672 mg/m^3) to **E** (1.039 ± 0.142 mg/m^3) (**Table 4.14)**. The result indicates that all the mean concentrations of **Cu** were above the threshold of 1 mg/m^3 for OSHA, ACGIH, EPA and NIOSH, and could pose a serious health threat to the furniture makers in the study area. The highest mean concentration level at sampling point **A** was 1.94 times higher than that of the PEL standard of 1 mg/m^3. The high mean levels of **Cu** in airborne particulate could be attributed to the presence of the chemicals used during the preparation of the adhesives and the finishes in spraying and polishing of their finished product

Mean concentrations of Iron (**Fe**) in airborne particulate ranged from sample point **A** (11.243 ± 0.028 mg/m^3) to E (10.097 ± 0.087 mg/m^3). The minimum and maximum mean concentrations were 1.01 and 1.124 times respectively higher than PEL standard of 10 mg/m^3. A p-value (p = 0.043) obtained indicating that, the variation among the mean levels of **Fe** in airborne particulate at the various sampling points A, B, C, D and E were significantly different. Khare & Baruah (2010) on elemental characterization and source identification in North-East India indicated that, there was high level of 7 mg/m^3 of **Fe** in the sawdust studied for the various element which was about 40% higher than the EPA and NIOSH, permissible exposure limits.

The mean concentration of lead (**Pb**) in airborne particulate recorded by the furniture makers ranged from sampling point **A** (0.082 ± 0.021 mg/m^3) to **E** (0.057 ± 0.095 mg/m^3) of sampling point **E**.

The mean concentrations for the various sampling points were between 1.64 and 1.14 times higher than the PEL standard. Exposure to high mean levels

of **Pb** may be as a result of the chemicals in the finishes they applied to the finished product. A study conducted by Dartey, et al. (2009), on airborne **Pb** levels in storage battery and welding workshops found out that the workers and the people within the environment were expose to air **Pb** levels that were too high compared to international standards. Again, a study by Mugica-Alvarez et al. (2012) on concentrations and properties of airborne particles in Mexico asserted that high exposure to **Pb** will induce weakness, brain damage and even death in human. The mean air **Pb** concentrations were found to reduce as the worker moves away from the emission points (Abdel-Hameed & Khoder, 2000). The mean concentrations of **Pb** in airborne particulate recorded by the furniture makers were subjected to ANOVA (**Table 4.14**) to determine variations in the mean levels of the metals. A p-value (< 0.001) obtained is lower than 0.05, indicating statistically significant differences between the mean concentration levels for the various sampling points. This agrees with studies by Dartey, et al. (2009), on airborne lead levels in storage battery workshops where significant air lead levels were recorded between the various distances from the source of emission.

4.5.4 Mean Concentration of Metal (mg/m^3) in Airborne Particulates of Machine Workers at Sokoban Wood Village

Various machines at the machine shop produces different amount of dust. This part of the work assessed the exposure to metals in airborne particulate matter by the machine operators during wood processing activities in the Sokoban Wood Village.

The results of the mean concentration of metals (mg/m^3) in airborne particulate of the machine operators is shown in **Table 4.15.**

The mean concentrations of **As** in airborne particulate of the various machine operators varied from 0.63 ± 0.013 mg/m^3 for Sander machine operators to 0.46 ± 0.715 mg/m^3 for Mortiser machine operators (**Table 4.15)**. The mean concentration levels recorded for **As** in airborne particulate by five (5) different machine operators were higher than OSHA and EU permissible exposure Limit (PEL) of 0.5 mg/m^3. These mean concentrations exceeding the threshold could be harmful to the lives of the operators who are exposed to these high levels of **As**. However, mean concentration of **As** by the Mortiser operators (0.461 ± 0.715 mg/m^3) was 0.92 times less than the OSHA and EU PEL thresholds of 0.5 mg/m^3. This also suggest that the operators at the Mortiser machines were less exposed to **As** in airborne particulate than the operators operating the other five (5) machines. This could be possible since the Bandsaw operators do not produce much dust compared to operations such as sanding, planning and sawing. The mean concentration of **As** in airborne particulate of the machine operators were subjected to ANOVA to determine variations in the mean levels of the metals (**Table 4.15**). A p-value (< 0.001) obtained was lower than 0.05, indicating statistically significant differences between the mean concentration levels for the various machine operatio

Table 4.15 Mean concentration of metals (mg/m^3) in airborne particulate matter by the various machine operators

Table 4.15 Mean concentration of metals (mg/m^3) in airborne particulate matter by the various machine operators

	MACHINE OPERATORS													
ELEMENTS	Surface Planner		Sander		Circular Saw		Spindle Moulder		Mortiser		Band Saw			
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	F-value	P-value
As	0.61^{a}	0.020	0.63^{ab}	0.013	0.52^{c}	0.167	0.60^{ab}	0.016	0.461^{c}	0.715	0.53^{d}	0.097	0.143	<0.001
Cd	0.39^{a}	0.184	0.41^{a}	0.130	0.31^{b}	0.095	0.31^{b}	0.129	0.28^{b}	0.148	0.33^{b}	0.192	0.24	<0.001
Cu	1.18^{acd}	0.098	1.54^{b}	0.589	1.53^{b}	0.258	1.13^{acd}	0.135	1.06^{cd}	0.022	1.14^{d}	0.169	0.536	0.024
Fe	11.91^{ace}	0.085	12.26^{bd}	0.365	10.21^{ce}	0.697	11.39^{d}	0.268	9.60^{d}	0.533	10.89^{e}	0.519	1.894	0.037
Mn	1.31^{a}	0.147	1.17^{a}	0.104	1.05^{a}	0.076	1.14^{a}	0.103	0.95^{a}	0.118	0.85^{b}	0.154	0.441	0.028
Pb	0.12^{acd}	0.081	0.19^{bd}	0.027	0.14^{bd}	0.032	0.13^{cd}	0.052	0.08^{acd}	0.082	0.11^{d}	0.046	0.037	<0.001
Zn	5.31^{abcd}	0.233	5.70^{ad}	0.094	5.14^{ab}	0.230	5.54^{bcd}	0.317	4.36^{cd}	0.498	5.42^{d}	0.256	1.012	0.031

Figures in a row with different superscript are statistically different; figures in a row with a same superscript are statistically not different.

The mean exposure levels for (**Cd**) and (**Cu**) in particulate matter were above PEL threshold of 0.2 mg/m^3 and 1 mg/m^3 respectively. The mean exposure levels for **Cd** in airborne particulate matter ranged from Sanding machine operators (0.41 ± 0.130 mg/m^3) to Mortising machine operators (0.28 ± 0.148 mg/m^3). The highest mean concentration of recorded by the Sanding operators was 2.05 times higher than PEL standard of 0.2 mg/m^3. Similarly, mean exposure level of **Cu** ranged from Sanding machine operators (1.54 ± 0.589 mg/m^3) to Mortising machine operators (1.06 ± 0.022 mg/m^3) respectively. These high exposure levels of **Cd** and **Cu** in particulate matter exceeded the OSHA and USEPA PEL threshold of 0.2 mg/m^3 and 1 mg/m^3 respectively. The high values recorded is likely to poses more danger and harm to the health of these machine operators, hence can cause all kinds of respiratory related diseases to the operators. A p-values (< 0.001) and (p = 0.024) obtained for **Cd** and **Cu** respectively were lower than 0.05 level of significant, indicating variations in the mean concentrations between the various machine operations.

The mean concentration of **Mn** in airborne particulate recorded by Mortiser operators (0.95 ± 0.118 mg/m^3) and Bandsaw operators (0.85 ± 0.154 mg/m^3) were below the ACGIH, OSHA and NIOSH PEL standards (**Table 4.15)**. This implies that, the operators operating Mortiser and Bandsaw machines were not exposed to high levels of **Mn** as their counterparts in the other four (4) machine operators namely, Sanding, Sawing, Planning and Spindle machine operators.

The current study is consistent with Hursthouse et al (2004), on exposure to respirable and inhalable dust during sanding and sawing of medium density wood indicated that, the workers in the sanding section were inhaling more dust than the workers at the sawing section.

Generally, Mortiser operators had the lowest mean concentrations in six (6) out of seven (7) metals analysed. This could be due to less volume of dust produced from the machine during operations. Cormier, Merlaux and Duchaine (2000), on respiratory health impact of working in sawmills in Eastern Canada postulated that, the sawmill workers operating the circular saw, lathing machine and the surface planner's machines do produces wood chips and dust than that of the mortiser and the bandsaw machining operators.

4.5.5 Comparison of Mean Concentration of Metals (mg/m^3) in Airborne Particulate Matter at the Various Working Environment Within the Sokoban Wood Village

Comparison of mean concentrations of **As, Cd, Cu, Fe, Mn, Pb** and **Zn** in airborne particulate matter for the various working environment within Sokoban Wood Village is tabulated in **Table 4. 16**.

The mean concentrations of **As** for the various activities within Sokoban Wood Village varied from furniture makers (0.742 ± 0.061 mg/m^3) to Food Vendors (0.443 ± 0.021 mg/m^3). The minimum mean concentration of **As** in airborne particulate by Food Vendors (0.443 ± 0.021 mg/m^3) was 0.89 times lower than the permissible exposure limits (PEL) standards of 0.5 mg/m^3. This suggest that, the food vendors were not expose to high level of **As** in airborne particulate may not expose them to any serious danger.

Table 4.16 Comparison of Mean Concentration of Metals (mg/m^3) in Airborne Particulate Matter at the Various Working Environment Within the Sokoban Wood Village

Table 4.16 Comparison of Mean Concentration of Metals (mg/m^3) in Airborne Particulate Matter at the Various Working Environment Within the Sokoban Wood Village

Elementals	Operators		Wood Sellers		Food Venders		Furniture Makers		F-Value	P-Value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Arsenic (mg/m^3)	.663^{a}	.056	.512^{b}	0.44	.443^{c}	.021	.742^{d}	.061	0.481	.032
Cadmium (mg/m^3)	.418^{a}	.027	.301^{b}	.017	.287^{b}	.079	.363^{c}	.673	.043	.001
Copper (mg/m^3)	1.74^{a}	.267	1.15^{b}	.119	1.23^{c}	.317	1.98^{d}	.511	0.865	.043
Iron (mg/m^3)	11.9^{a}	.079	10.21^{b}	.126	10.01^{b}	.178	10.9^{c}	.872	1.89	.037
Manganese (mg/m^3)	.531^{a}	.147	.492^{b}	.256	.385^{c}	.341	.541^{d}	.075	0.563	.013
Lead (mg/m^3)	.072^{a}	.129	.069^{b}	.132	.068^{c}	.153	.088^{d}	.063	.037	.001
Zinc (mg/m^3)	5.20^{a}	.094	5.16^{b}	.122	5.07^{b}	.157	5.37^{c}	.048	1.98	.033

Figures in a row with different superscript are statistically different; figures in a row within the same superscript are statistically not different.

The mean concentration of **As** in airborne particulate recorded by Furniture makers (0.742 ± 0.061 mg/m^3) was 1.48 times higher than the required PEL standards. This could be due to chemicals Boliden (BIS) and CCA which contain high amount of **As** used for industrial wood preservation. Again, the mean concentration levels of **As** in airborne particulate for the various activities were subjected to ANOVA (**Table 4.16**) to determine variations in the mean levels of the metal. A p-value (0.032) obtained is lower than 0.05, indicating statistically significant differences between the mean concentration levels for the various activities.

The mean concentrations of **Cd** and **Cu** in airborne particulate revealed that, both metals had all their mean concentrations higher than PEL threshold of 0.2 mg/m^3 and 1 mg/m^3 respectively (**Table 4.16)**. The mean concentrations of **Cd** in airborne particulate varied from Machine operators (0.418 ± 0.027 mg/m^3) to Food Vendors (0.287 ± 0.079 mg/m^3) whiles the mean concentrations of **Cu** in airborne particulate varied from furniture makers (1.98 ± 0.511 mg/m^3) to Wood Sellers (1.15 ± 0.119 mg/m^3) respectively. This implies that, the workers in the various activities were exposed to high levels of (**Cd)** and (**Cu)** particulates. The highest and lowest mean concentration of **Cd** were 2.09 and 1.44 times higher than permissible exposure limit threshold of 0.2 mg/m^3. These could be dangerous and harmful to the health of the workers, hence can cause all kinds of respiratory related diseases to the workers within the Sokoban Wood Village. The highest and the lowest mean concentrations of **Cu** were 1.98 to 1.15 times higher than the required PEL standards of 1 mg/m^3. Also, the P-values **(**0.001) and (0.043) obtained were statistically lower than 0.05, indicating statistically significant differences between the mean concentration levels for the various activities.

Mean Lead **(Pb)** concentrations for the various activities within the enclave varied from Furniture Makers (0.088 ± 0.063 mg/m^3) to Food Vendors (0.068 ± 0.027 mg/m^3). The mean concentration levels were higher than the recommended 0.05 mg/m^3. The highest and lowest mean concentration of **Pb** in airborne particulate was 1.76 and 1.36 times higher than PEL standards of 0.05 mg/m^3. Airborne **Pb** levels exposed to workers in a mechanical workshop were found to be too high compared to international standards (Dartey, et al. 2009). High exposure to **Pb** according to Mugica-Alvarez et al., (2012), will induce weakness, brain damage and even death in human. The mean concentration levels of **Pb** in airborne particulate for the various activities were subjected to ANOVA (**Table 4.16**) to determine variations in the mean levels of the metal. A p-value of (= 0.001) was lower than 0.05, indicating statistically significant differences between the mean concentration levels for the various activities.

4.6. Health Hazards Associated with Wood Processing at the Sokoban Wood Village

Exposure to occupational hazard within work environment has been reported to have a significant effect on the health of factory or industrial workers (Tobin et al, 2016). Most often, industrial workers are exposed to inhalable substances such as fumes, dust, smoke and smog, which may consequently lead to occupational lung diseases. In some instance, wood factory workers are exposed to severe injuries at workplace leading to disability, morbidity and mortality (Holcroft & Punnett, 2009) therefore affecting their source of livelihood.

In the wood industry, wood dust is one of the main forms of hazard to the health of woodworkers especially among those who are directly involved. Studies have shown that woodworkers who are constantly exposed to wood dust are increasingly susceptible to respiratory problems, nasal and lung cancer, eye irritation and dermatitis, (Ige & Onadekon, 2000; Feron et al., 2001). Exposure of workers to the hazard of wood dust is a reality in wood processing industries or factories (Agu et al., 2016). The use of PPE by workers at workplace is believed to minimize their exposure to work hazard and injuries (Agbana et al., 2016).

The results in **Table 4.17** indicate the means of the respondents' ratings of health hazards and injuries they experience from wood processing as well as engaging in other commercial activities at the Sokoban Wood Village. The theoretical mean for the five-point likert scale was 3.00. The result shows that, two (2) out of the twelve (12) items had their mean ratings lower than the theoretical mean of 3.0. These items were "I do experience bronchitis" and "I do experience hey fever". This suggest that the machine operators never or rarely do experience of bronchitis or hey fever during wood processing. The other ten (10) items had their mean ratings greater than the theoretical mean of 3.0. This means that the workers in the Sokoban Wood Village sometimes "Do experience skin irritation/dermatitis", "Do experience headaches", "Do experience eye irritation", "Do experience coughing", "Do experience nasal cancer", "Do experience shortness in breathing", "Do experience nausea", "Do experience loss of appetite", "I do experience hearing loss" and "I do experience poor eye sight". These were possible since the machines assessed had no dust extractors or hoods attached to the various machines in the study site which has led to high concentration of sawdust particulate within the working environment.

Similar studies involving 60 respondents from three constituencies in the Tamale Metropolis in Ghana indicated: exposure to sawdust, cut-type of injuries, fractures, sprains, catarrh, waist pains, eye problems and dizziness are the range of injuries and illness associated with wood processing (Ochire-Boadu et al. 2014).

Additionally, Osagbemi et al. (2010) indicated that exposure to sawdust constituted about 40.5% of the health problems that workers experienced, followed by stress and exhaustion after work (25.7%) and eye irritation (14.0%). Bean and Butcher (2006), on wood dust exposure hazards indicated that, 84% of sawmill workers studied had exposure to high level of sawdust inhalation within their working environment. Wood processing risk such as wood dust, noise and ventilation also accounted for 87% of worker's exposure to health hazards in Zimbabwean wood processing industry (Jerie, 2012). A study by Mazibuko (2005), on hearing conservation; best practices in occupational health and safety concluded that, 57% of the sawmill workers studied in Kenya were experiencing high levels of hearing loss, with 43% having poor eye sight as a result of wood processing.

Table 4.17: Descriptive statistics on ratings of respondents on effect of wood processing on the health of workers in Sokoban Wood Village

Item #	Elements of health hazards of wood processing on woodworkers	Mean Ratings (n = 315)	Standard deviation
	Exposure to sawdust		
1	I do experience of skin irritation/dermatitis	3.05	.20
2	I do experience of headaches	3.12	.13
3	I do experience of nausea	3.22	.22
4	I do experience of eye irritation	3.13	.13
5	I do experience of coughing	3.08	.18
6	I do experience of bronchitis	2.49	.31
7	I do experience of nasal cancer	3.02	.22
8	I do experience of shortness in breathing	3.09	.18
9	I do experience of hey fever	2.20	.36
10	I do experience of loss of appetite	3.28	.28
11	I do experience of hearing loss	3.64	.56
12	I do experience of poor eye sight	3.69	.31

The above result in **Table 4.17** confirms what the medical officer at the health post situated in the study area also asserted. The medical officer of Sokoban Wood Village health post revealed that, what most workers do report to the health post are shortness in breath, headache and skin rashes as a result of skin irritation. He further explained that only few people come to the health post and complain of asthma, hey fever, bronchitis and other wood processing related diseases. This suggests that, the timber industry needs to do more to protect the health and safety of its employees since the human and economic costs of occupational accidents and diseases remain high and requires concerted efforts to control them.

4.6.1 Comparison of Ratings of Respondents' Operation of the Effect of Wood Processing on the Health of the Worker

The comparison of the respondents' ratings of health hazards and injuries associated with wood processing for the five major operations and the three other activities in Sokoban Wood Village which were studied in this research is shown in **Table 4.18.** The result indicates that at 5% level of significance, there was statistically significant difference in the ratings of the respondents on the occurrence of health problems and injuries related to wood processing for eight (8) out of twelve (12) items. Statistically significant differences between the respondents' ratings occurred for the items: "I do experience skin irritation", "I do experience of headaches", "I do experience of nausea", "I do experience of eye irritation and reddening", "I do experience coughing", "I do report loss of appetite", "I do experience hearing loss" and "I do experience poor eye sight".

Paired-wise comparison of means revealed that, on the item "I do experience skin irritation" statistically significant differences of the mean response occurred when sawing operators were compared to moulding operators, sanding operators, food vendors, wood sellers and the furniture producers within the Sokoban Wood Village. Meanwhile, when the sawing operators were compared to the planning operators and boring operators the result in **Table 4.18,** indicated no statistically significant difference between their means ratings. Similarly, when food vendors were also compared to the wood sellers the result did not show any statistically significant differences in their mean ratings at 5% level of significance. Item "I do experience eye irritation and eye reddening" also from **Table 4.18,** revealed that mean ratings between food vendors and wood sellers compared did not shown any statistically significant differences between them, all other operations and activities compared indicated statistically significant differences in their mean ratings. Again, when the mean ratings on the item "I do experience loss of appetite" were compared between the various activities in **Table 4.18,** the result further indicated that there were statistically significant differences between their mean ratings. Statistically significant differences occurred when all the operations and activities were compared. Exception was when sawing operators were compared to moulding operators and the furniture producers. Furthermore, no statistically significant difference also occurred when wood sellers were compared to furniture producers.

On the item "I do experience of hearing loss" the result revealed that, statistically significant differences existed when sawing operators were compared to all other operations and activities in the Sokoban Wood Village. No statistically significant difference between the mean ratings occurred when sawing operators were compared to the planning operators. Again, no statistically significant difference in respondents mean ratings also occurred when sanding operators were compared to that of the wood sellers. Comparison of mean ratings on the item "I do experience of poor eye sight" further revealed that there were statistically significant differences in the mean ratings between planning operators and all the other operators and activities in Sokoban Wood Village. Exception was when planning operators were compared to sanding operators. When food vendors were compared to wood sellers and furniture producers from Table 4.21, also indicated no statistically significant differences in the mean ratings at 5% level of significant.

This result is consistent to the study conducted by Bello (2010) on occupational health and safety of small and medium scale sawmills in Kaduna State in Nigeria. In his study he concluded that woodworkers operating sanding, planning and sawing machines were at a high risk of been exposure to sawdust. Similarly, Mitchual, et al. (2015), on assessment of occupational health and safety practices and injuries associated with wood processing in a timber firm studied also asserted that, the kind of operation the woodworker does significantly influences the worker's exposure to sawdust.

Table 4.18: ANOVA for Ratings of respondents of wood processing effect on the health of workers in Sokoban Wood Village

	Element on the use of safety practices for machine operators	Before Mean	Training SD	After Mean	Training S D	F-Value	P-Value
	Personal Protective Equipment?						
1.	Do you wear gloves/mittens when working?	1.15	.044	3.59	.024	1.30	. 011*
2.	Do you wear overall when working?	1.22	.038	4.14	.018	2.41	. 046*
3.	Do you wear goggles when working?	2.04	.031	3.61	.022	1.65	. 016*
4.	Do you wear face shield when working?	1.03	.045	1.45	.031	1.24	. 059†
5.	Do you wear nose and mouth mask when working?	2.13	.029	3.87	.020	5.08	. 013*
6.	Do you wear earplugs or ear muffs when working?	1.45	.035	4.45	.013	1.04	. 021*
7.	Do you wear helmet when working?	1.09	.042	1.09	.038	2.31	. 055†
8.	Do you wear safety boot when working?	1.34	.024	3.34	.023	1.11	. 027*
	Machines and Maintenance						
9.	Do you ensure that guards and fence are in place during wood machining?	3.87	.020	4.27	.016	3.419	.718†
10.	Do you ensure that trained personnel operate the machine	4.02	.019	4.09	.017	1.012	.528†
11.	Do you ensure that electrical gadgets are put off before they leave plant?	4.13	.017	4.73	.010	3.336	.078†
12.	Do you ensure woodworkers adherence to safety rules and regulations?	3.92	.024	4.02	.019	3.51	. .472†
13.	Do ensure machine maintenance and repairs?	4.41	.012	4.61	.011	3.419	.319†
14.	Do ensure adequate conditioning of saws and blades?	4.33	.015	4.53	.012	.378	.711†
15.	Do you ensure that worn out chains and ropes are changed?	4.45	.011	4.55	.012	.068	.092†
	Resultant mean for the use of safety practices	2.71	1.115	3.76	.987		

Figures in a row with different superscript are statistically different; figures in a row with the same superscript are statistically not different.

4.7 Provision of personal protective equipment (PPE) to wood machine operators

Health and safety equipment includes, safety boots, apron or overall, helmet, goggles, nose and mouth mask, ear plugs, face shield are important for job-related occupational health and safety purposes. The provision of personal protective equipment's to wood factory workers has become imperative with the sole aim of protecting workers from occupational injuries and health hazards (Bello, 2010). The Factories, Offices and Shops Act of 1970 (Act 328 section 34; g) indicates that the employer should provide for the protection of person or a class of persons working in a factory, an office or a shop against risk of bodily injury or injury to health arising out of use of machinery, plant or equipment. The result in **Table 4.19** indicates the ratings of the wood machine operators on provision of personal protective equipment by their employers.

Table 4.19: Provision of personal protective equipment (PPE) to wood machine Operators

Table 4.19: Provision of personal protective equipment (PPE) to wood machine Operators

Item	Element on provision of personal protective equipment	Mean rating (n = 410)	Standard deviation
1	I am provided with gloves/mittens during processing wood	1.67	.07
2	I am provided with overall during processing wood	1.48	.08
3	I am provided with safety boot during processing wood	1.11	.16
4	I am provided with goggles during processing wood	1.08	.18
5	I am provided with face shield during processing wood	1.12	.16
6	I am provided with nose and mouth mask during processing wood	1.18	.11
7	I am provided with earplugs during processing wood	1.29	.09
8	I am provided with helmet during processing wood	1.07	.18
	Resultant mean for elements on provision of personal protective equipment	1.30	.08

The mean ratings of the machine operators on the provision of personal protective equipment for the 8 items assessed ranged from 1.07 for item "I am provided with helmet during processing wood" to 1.67 for item "I am provided with gloves/mittens during processing wood". The resultant mean rating for the 8 items was 1.30. The mean ratings were lower than the theoretical mean of 3.0, suggesting that the machine operators were never or were rarely provided with personal protective equipment for their work. Further interview of the machine operators indicated that, the operators were employed on contract bases and that they were supposed to buy their own personal protective equipment. This is contrary to the requirement by OSHA (2017) which indicate that when there is occupational exposure, the employer shall provide at no cost to the employee the appropriate personal protective equipment such as but not limited to gloves, gown/coat, face shield, nose mask and eye protection. Bello (2010) asserted that**,** insufficient supply and non-use of personal protective equipment were the number one cause of injuries (45%) in the woodworking industry in Nigeria. Osonwa et al. (2015), on utilization of personal protective equipment among wood factory workers in Calabar municipal, South Nigeria reported that 79% of the wood factory workers were not provided with any form of personal protective equipment by their employers. Reasons for non-provision of personal protective equipment by employers according to Osonwa et al. (2015) was that workers do not use them whenever they were supply to them. The employers indicated that, some of the workers indicated they do not feel comfortable in using them therefore, do not see the need to acquire them (Ntow et al. 2006; Truong et al., 2009). Low educational status and lack of knowledge of personal protective equipment's among employers of labour may also largely contribute to non-provision of personal protective equipment's at workplace (Arcury et al., 2015). According to Muchemedzi (2006), lack of knowledge of the importance of personal protective equipment's use among workers in wood industry may influence their low desire to acquire the personal protective equipment's for work.

4.8 Effect of Training on Woodworkers' Practice of Occupational Health and Safety

Lack of comprehensive occupational safety and health policy, poor sawmill layout, poor infrastructure and funding, insufficient number of qualified occupational safety and health supervisors/advisors, poor tools, equipment and general lack of adequate information are among the main problems in the management of safety and health in most sawmills in Ghana. The Seoul declaration 2008 state that a safe and healthy working environment should be considered as a fundamental human right and it encourages government to consider ratification of the ILO Promotional Framework for Safety and Health Convention 2006 (no 187) as a priority (Hope, 2009).

Adequate training of employees and the use of appropriate strategies helps to improve on the management of hazards. Employers who provide employees with training on safety and proper job procedures experience fewer accidents (Divite et al., 2016). This part of the study assessed the effect of training of woodworkers on the practice of occupational health and safety practices.

The results in (**Table 4.20)** subtitled personal protective equipment indicates that, all the eight (8) items assessed had their mean rating values less than the theoretical mean value of 3.0 before receiving training. This suggest that the machine operators never or rarely do not wear or put on personal protective equipment. On the contrary, for the same items, six (6) out of the eight (8) items assessed after the training, had their mean ratings higher than the theoretical mean rating of 3.0. This implies that the machine operators studied started putting on the personal protective equipment after the training. Exceptions in **Table 4.20,** was items "Do you wear face shield when working" and "Do you wear helmet when working" under the subtitled personal protective equipment which had their mean ratings below the theoretical mean rating of 3.0 before the training and after training. This suggest that, whether the machine operators are trained or not trained they will not put on face shield or helmet during wood processing. Employers who provide all new employees with training on safe and proper job procedures experience fewer accidents (Divite et al., 2016).). Essaiyas at al. (2016), on training of wood processing workers in Nigeria indicated that training helps to reduce or avoid the occurrance of accidents in a workplace. He further asserted that workers entered the timber industry not as trained wood industry workers with a requisite professional knowledge. This had exposed most of the workers to some untold level of hazards.

Effect of training in **Table 4.20,** under subtitled machine and maintenance revealed that all the seven (7) items assessed had their mean rating values above the theoretical mean value of 3.0 for both before and after training. Comparing the mean ratings before and after training of the machine operators in **Table 4.20,** indicates that for all the seven (7) items there was no statistically significant differences between the two. This suggest that future training should focus on the use of the personal protective equipment.

Table 4.20: Descriptive statistics of ratings on the use of safety practices by the machine operator's before and after training.

Table 4.20: Descriptive statistics of ratings on the use of safety practices by the machine operator's before and after training

	Element on the use of safety practices for machine operators	Before Mean	Training SD	After Mean	Training S D	F-Value	P-Value
	Personal Protective Equipment?						
1.	Do you wear gloves/mittens when working?	1.15	.044	3.59	.024	1.30	. 011*
2.	Do you wear overall when working?	1.22	.038	4.14	.018	2.41	. 046*
3.	Do you wear goggles when working?	2.04	.031	3.61	.022	1.65	. 016*
4.	Do you wear face shield when working?	1.03	.045	1.45	.031	1.24	. 059†
5.	Do you wear nose and mouth mask when working?	2.13	.029	3.87	.020	5.08	. 013*
6.	Do you wear earplugs or ear muffs when working?	1.45	.035	4.45	.013	1.04	. 021*
7.	Do you wear helmet when working?	1.09	.042	1.09	.038	2.31	. 055†
8.	Do you wear safety boot when working?	1.34	.024	3.34	.023	1.11	. 027*
	Machines and Maintenance						
9.	Do you ensure that guards and fence are in place during wood machining?	3.87	.020	4.27	.016	3.419	.718†
10.	Do you ensure that trained personnel operate the machine	4.02	.019	4.09	.017	1.012	.528†
11.	Do you ensure that electrical gadgets are put off before they leave plant?	4.13	.017	4.73	.010	3.336	.078†
12.	Do you ensure woodworkers adherence to safety rules and regulations?	3.92	.024	4.02	.019	3.51	. .472†
13.	Do ensure machine maintenance and repairs?	4.41	.012	4.61	.011	3.419	.319†
14.	Do ensure adequate conditioning of saws and blades?	4.33	.015	4.53	.012	.378	.711†
15.	Do you ensure that worn out chains and ropes are changed?	4.45	.011	4.55	.012	.068	.092†
	Resultant mean for the use of safety practices	2.71	1.115	3.76	.987		

Some of the workers asserted that, it is not because they do not want to wear the PPEs but they are not provided for by their employers. This clearly shows that when wood workers are giving frequent training on the need to wear PPEs and provided for by their employers will help reduce accident occurring

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter gives the conclusion and recommendations of the study.

5.2 Conclusions

Occupational health and safety are one of the issues which if neglected could significantly affect the operational efficiencies of wood processing industries. An injury and health related problems associated with wood processing could seriously affect the socio-economic condition of the worker, his dependents and the company. The result of this study suggests that, none of the wood processing machines assessed had operator's manual, safety code or sign on the machine. Machines were absolute, majority of the machines were of no safety parts on them. Few of the machines had some of their safety facilities been improvised. The result of the study came out that, the respondents rarely do wear personal protective equipment during processing of wood. This exposes the workers at the SWV to a high risk of occupational hazard. The workers at SWV adhere to maintain the various wood processing machines they are working with within the enclave whenever they see something wrong with the machines. Additionally, the educational background of the respondents did not significantly influence their practice of occupational health and safety issues relating to their work. Again, the number of years the woodworker had worked, had no significant effect on the use of personal protective equipment as well as the operations of a respondent not having any significant effects on the practice of occupational health and safety when it comes to machine and maintenance.

The study revealed that, there was heavy concentration of airborne particulate such as Arsenic, Cadmium, Copper, Iron, Lead, Manganese and Zinc in the sawdust the workers within the enclave were exposed to. The metal concentrations of the sawdust exposed to by the workers were above OSHA and EPA permissible exposure limits (PEL) thresholds. It came out clearly that distance and type of operation significantly influence the workers exposure to airborne particulate within the enclave.

The workers in the SWV enclave sometimes or usually do experience headaches, nausea and small cut. Few workers complain of asthma, lack of appetite, nasal cancer, bronchitis and other wood processing related diseases. Again, the kind of operation and activity the woodworker does significantly influences the workers exposure to sawdust.

The study again revealed that, personal protective equipment was never provided for by employers of the machine operators when operating machines or performing jobs that required their use and workers exposure to dust and noise was due to lack of control at source and inadequate protective clothing (goggles, ear plugs, and nose and mouth masks. Reasons cited by the operators for non-usage of PPE include; no provision by employer, had no money to buy, inconveniences, and not necessary.

Furthermore, it was revealed that training significantly influence the woodworker's practice of occupational health and safety in the wood processing industry. Most workers were seen putting on personal protective equipment such as earplugs, nose mask, hand grooves, googles, overalls and safety boots after they had received training. Moreover, the employers were constantly maintaining their machines whenever any of the parts gets spoiled.

5.3 Recommendations

The study suggests that, further studies should be conducted to assess the relationship between the provision and the actual usage of personal safety equipment in the firm studied.

Additionally, it is also recommended that occupational health and safety practices should be promoted and enforced in the wood processing industry studied through adoption of health and safety as a personal and organizational value. Again, it is recommended that there should be task force within the enclave to enforce the wearing of personal protective equipment before an operator operates the wood processing machine. There should be regular education of both the old workers and newly employed in the various wood processing industries in Ghana. Furthermore, studies must be conducted in other wood processing industries in Ghana in other to generalized the situation of occupational health and safety in Ghana as a whole. Also, studies must be conducted to find out other particulate matter if any in the sawdust the woodworkers are exposed to and their effect on the woodworkers in Ghana.

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APPENDIX

QUESTIONNAIRE FOR OPERATORS

I am a student of University of Education Winneba, Kumasi-Campus. This questionnaire is intended to investigate into the problem with personal safety and health hazards associated with wood processing work. The information needed is for academic purpose and confidentiality is guaranteed.

Please, indicate by ticking (√) the appropriate box where applicable.

Part One: Personal Data

1. Gender: Male ( ) Female ( )
2. How long have you been in this company?

   a) Below 1 year ( ) b) 1 -5 years ( ) c) 6 -10 years ( )

   d) 11 -15 years ( ) e) Above 15 years ( )
3. What is your level of education?

   a) No non formal education ( ) b) M.S.L.C/J.H.S ( )

   c) S.S.S.C.E/G.C.E.O Level ( ) d) Tertiary Level ( )

4. Which operation do you belong to?

a. Planning ( ) b) Sawing ( ) c) Moulding ( )

d) Sanding ( ) e) Boring and Mortising ( )

Part Two: Practices of occupational health and safety by wood workers

This part of the questionnaire is to assess the occupational health and safety practices by wood workers. Please place a check mark (√) in the appropriate column

		Place a Check Mark (√) in the Appropriate column					
Item #	**Question**	**Do not know**	**Never**	**Rarely**	**Some times**	**Usually**	**Always**
A. Personal protective equipment							
5	Do you wear gloves/mittens when working						
6	Do you wear overall when working						
7	Do you wear goggles when working						
8	Do you wear face shield when working						
9	Do you wear nose and mouth mask when working						
10	Do you wear earplugs or ear muffs when working						
11	Do you wear helmet when working						
12	Do you wear safety boot when working						
B. Machines and Maintenance							
13	Do you ensure that guards and fence are in place when machines are in use						

14	Do you ensure that trained personnel operate the machine						
15	Do you ensure that electrical gadgets are put off before they leave plant						
16	Do you ensure that they adhere safety rules						
17	Do ensure that they maintain and repairs machine						
18	Do ensure that saws and blades are adequately conditioned						
19	Do you ensure that worn out chains and ropes are changed						

<u>Part three: Provision of personal protective equipment (PPE)</u>

This questionnaire is design to assess provision of personal protective equipment to the woodworkers by the management at the work place. Answer each question to the best of your knowledge. Please place a check mark (√) in the appropriate column

Item #	Question	Never	Rarely	Sometimes	Usually	Always
Element on provision of personal protective equipment						
20	I am provided with gloves/mittens during wood processing					
21	I am provided with overall during wood processing					

22	I am provided with safety boot during wood processing					
23	I am provided with goggles during wood processing					
24	I am provided with face shield during wood processing					
25	I am provided with nose and mouth mask during wood processing					
26	I am provided with earplugs during wood processing					
27	I am provided with helmet during wood processing					

Part four: Assessment of safety gadgets on the wood processing machines

This observation check list is design to identify the safety gadgets on the various wood processing machines been operated by woodworker in the sawmilling industry in Ghana.

Please place a check mark (√) in the appropriate column

BORING AND MORTISING MACHINES

Item #	Question	Exist	Does not exist	Improvised
28	Operators manual to guide operation of machine			
29	A guard enclosing the bit and the chuck			

30	Enclosement of the cutting chain and driving mechanism			
31	emergency stop switch			
32	Safety chain to anchor or bold counter weight from dropping			
33	Operators manual to guide operation of machine			
34	Inverted U-shaped guard that covers Operating treadles			
35	Stop bar to stop chisel at a predetermined depth			
36	Wheel for movement of the table to back and front			

MOULDING MACHINE

Item #	Question	Exist	Does not exist	Improvised
28	Operators manual to guide operation of machine			
29	The belts and pulleys completely enclosed with sheet metal or heavy mesh guards			
30	Cutter head covered with metal guard or cage			
31	Guard feet rolls with wide metals strip or bars that allow boards to pass			
32	Safety shield			
33	Anti-kickbacks fingers installed in the in-feet site across the width of the machine			

34	Wood clamp			
35	Power transmission devices enclosed			
36	Lock for rise and fall motion			
37	Spindle block and cutters			
38	Push button control			

SANDING MACHINE

Item #	Question	Exist	Does not exist	Improvised
28	Operators manual to guide operation machine			
29	Guard feed rollers with a semi cylindrical guard to prevent contact with in-running rolls			
30	A guard on the unused run of the sanding belt against accidental contact to prevent the operator's hands or fingers from contact with the nip ends			
31	Guard to enclose drum and disc sanders			
32	Fixed guards enclosing power transmission pulleys			
33	Dust bag for the extraction of dust			

SURFACE PLANNER

Item #	Question	Exist	Does not exist	Improvised
28	Operators manual to guide the operation of the machine			
29	Cutter head enclosed with an automatic guard or cage			
30	Stick to push work pieces that are short			
31	Sheet metal or heavy mesh guard to enclose belt and pulleys			
32	Guard feet rollers with a wide metal strip or bar that allow boards to pass			
33	Provide barriers at the loading and unloading ends to keep hands out of point of operation			
34	Power transmission system enclosed			
35	Isolating switch for cutting out the power supply			
36	Fence to enable the timber being edged to be processed against it			
37	Hand wheel for adjusting the height of the table			
38	Push button for starting and stopping the machine			

BAND SAW MACHINE

Item #	Question	Exist	Does not exist	Improvised
28	Operators manual to guide the operation of the machine			
29	Adjustable metal top guard to provide a barrier for the blade except at the point of operation			
30	Emergency power switch			
31	Pulley mechanisms fully enclosed with guard			
32	Installation of break on one or both wheels to minimize the potential of coasting after the saw has been shut off.			
33	Tension control device to protect the blade from breaking			
34	Top saw guide assembly to support the saw immediately above and below the cut			
35	Tracking devices to enable saw blade to run or track centrally around the pulley rims			

CIRCULAR SAW MACHINE

Item #	Question	Exist	Does not exist	Improvised
28	Operators manual to guide operation of machine			
29	A guide for the belt and pulley			
30	An anti-kickback device			

31	A blade guard			
32	An emergency off/on switch			
33	Riving knife to prevent the timber form binding			

QUESTIONNAIRE FOR MACHINE OPERATORS, FOOD VENDORS, WOOD SELLERS AND FURNITURE MAKERS

Part 5: Health hazards and injuries associated with wood processing

This questionnaire is design to identify the effects of sawdust on the health of the worker in wood working industry in Ghana. Please place a check mark (√) in the appropriate column

Item #	Question	Never	Rarely	Sometimes	Usually	Always
21	**Exposure to sawdust**					
22	I do experience of skin irritation/dermatitis					
24	I do experience of headaches					
25	I do experience of nausea					
26	I do experience of eye irritation					
27	I do experience of coughing					
28	I do experience of bronchitis					
29	I do experience of nasal cancer					
30	I do experience of shortness in breathing					
31	I do experience of hey fever					
32	I do experience of loss of appetite					

	Noise/poor ventilation injuries				
33	I do experience of hearing loss				
34	I do experience of poor eye sight				