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Exploring the Economic Effects of Industrial Fires in Ghana

A Case Study of Manufacturing Industries in Tema Metropolis.

BY

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College of Art and Built Environment in partial

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MASTER OF SCIENCE

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CERTIFICATION

I hereby declare that this submission is my own work towards the MSc. Construction Management and that, to the best of my Knowledge, it contains no material previously published by another person, or material which has been accepted for the award of any other degree of the University, except where due acknowledge has been made in the text.

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ABSTRACT

This study is aimed at exploring the economic effects of industrial fires (A case study of manufacturing industries in the Tema metropolis). It undertakes a review of accidental fires and its economic effects on industrial buildings. Advocates argue that industrial accidental fires have huge effects on the economy. The objective of the research was to identify the causes and economic implications of fire outbreaks in industrial buildings. Hence, the specific objectives included: to identify major causes of industrial or institutional fires; to identify the economic loss of fire outbreaks in industrial buildings; and identify preventive measures to avoid fire outbreaks in industrial buildings. The research design was survey research which employed both quantitative and qualitative tools. The qualitative method involved the use of openended questionnaires whiles the quantitative procedures involved the use of closedend questionnaires etc. Data collected from the survey was analyzed using descriptive statistics (cross tabulation, percentages, etc). Simple random sampling technique was employed as a means to select respondent industries. Respondents were made up of senior officers especially safety officers in manufacturing industries. The sample size was seventeen (17) manufacturing industries in Tema. The survey revealed that, the major cause of accidental fires in manufacturing industries was overheating of equipment. It was also realized that manufacturing industries despite their importance in the economy were faced with a lot of challenges. Some of these were temporary relocation of firms and increase in payments of insurance premiums as a result of accidental fires. Lastly the study revealed that the best ways to prevent accidental fires in industrial buildings included compliance with safety standards during designing and construction of houses and industrial structures or buildings.

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LIST OF ABBREVIATIONS

CEO:	Chief Executive Officer
VALCO:	Volta Aluminum Company
IGCSE:	International General Certificate of Secondary Education
IB:	International Baccalaureate
GDP:	Gross Domestic Product
NADMO:	National Disaster Management Organization
GNFS:	Ghana National Fire Service
AGI:	Association of Ghana Industries
VRP:	Volta River Project
ERP:	Enterprise Resource Planning
TOR:	Tema Oil Refinery
GPRTC:	Gas Piping and Technology Committee
ISO:	International Organization for Standardization
GIC:	Ghana Investment Center
CIA:	Central Intelligence Agency
CNN:	Cable News Network
NGOs:	Non-Government Organizations
GSS:	Ghana Statistical Service
LEL:	Lower Explosive Limit
SMYS:	Specified Minimum Yield Strength
MSDS:	Material Safety Data Sheet
LFL:	Lower Flammable Limit
UFL:	Upper Flammable Limit
NFPA:	National Environmental Policy Act
REMI:	Regional Economic Models, Inc.

EUROSTAT: Statistical Office of the European Union

PPE: Personal Protective Equipment

EC: Elimination Communication

EEC: European Economic Community

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Finally, special thanks to my friends for their contributions to my academic success and to all study members of MSc Construction Management of KNUST, Department of Building Technology

DEDICATION

This work is dedicated to the Almighty God for His numerous blessings on me and to the following people Ophelia Konadu (my wife), Mr. Adjei Owusu (GNFS HQS Accra) and Mr. Mathew Tay (District Coordinating Director) ANDA-Nkawie.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

All the way through, the world has validated the high socio-economic and ecological costs of unrestrained fires (Cavallini et al., 2007). Unfortunately, government‟s responses to forest, industrial, commercial and public buildings fires is skewed towards overpowering and cost effective measures to tackle fires. Fire eruption is certainly not a pleasant incident for both industries and domestic activities. When there is fire outburst, it brings economic, emotional and physical implications to the residents and owners of the particular property. There are various causes of fire outbreaks and there exist various means of protecting or preventing fire outbreaks. Nevertheless, it is economical to prevent the fire from starting before it destroys properties.

As said earlier, there are various means by which a property can be engulfed by fire. Sometimes both industrial and domestic fires occur as a result of lack of attention by occupants. Fire is at times essential for forest restoration, or delivers concrete benefits for local communities: fire destroys forests, important properties and has dire social and economic consequences on the affected communities, government and the world as a whole. Fire become problematic when they burn wrong places but at a wrong temperatures (Frederick and Rickets, 2001).

Fire problems have got the attention of government around the world due to the increasing destruction of properties, forest and other domestic facilities which affects the world‟s economy in both the long and short run (New York Times, March 13th 2009).

Fire outburst in the country in the early part of 2013 left a number of market men and women in despair because of the loss of capital and other assets. Measures have been

put in place by

the government to investigate the causes of the outbreak of fires at the market centers in order to prevent future occurrence (Zainabu, 2013).

1.2 PROBLEM STATEMENT

In recent years Ghana has experienced various forms of fire outbreaks emanating from fires in domestic buildings, public buildings, industrial buildings and forests. The opportunity of finding oil in large quantity also has a great potential of increasing fire outbreaks if the needed measures are not put in place. According to Mast (2005) majority of industries around the world depend on oil as a source of energy.

There is no doubt that, the oil found in Ghanaian Waters has brought numerous companies both local and international to establish in Ghana. National Disaster Management Organization (NADMO) in 2014 reported that there have been about 478 incidences of fire outbreak nationwide as at 2013.The report also stated that, about GH₵15 million was recorded as the cost of the damage caused by the fires.

Robinson (2014) said 17 people died and 50 received various degrees of injuries in 2,106 fire outbreaks recorded by the Ghana National Fire Service (GNFS) across the country between January and May 2014. The damages caused to properties were estimated at GHC 7,372,781.10. There were 55 industrial fire outbreaks. Severe industrial fires bring about loss of properties, loss of life, financial loss, and destruction of the environment. Examples of industrial fires include Tema Oil refinery pipeline which exploded and killed one person and destroyed a lot of properties belonging to TOR Robison (2014). Another incident is the Gas explosion which killed three persons in Tema Industrial area. The explosion which occurred at about 11:30 am was said to have been caused by expired gunpowder, used to manufacture matches which was stored in an unventilated store room Robison (2014). Multiple Taiwan gas blast killed

25 people during a series of gas explosions in the southern Taiwan city of Kaohsiung .In view of these lives and economic losses there is the need to research into the main causes of fire outbreaks in industrial buildings and identity the effective preventive measures to avoid the unwanted happening.

1.3 RESEARCH AIM

The principal aim of the research is to explore the economic effects of industrial fires in Ghana.

1.3.1 Study Objectives

Specifically, the research seeks to:

- Identify the major causes of industrial fires;
- Identify the economic effects of fire outbreaks in industrial buildings and
- Identify measures that can prevent fire outbreaks in industrial buildings.

1.4 RESEARCH QUESTION

The research questions which the survey was based on are:

- What are the major causes of industrial fire?
- What are the economic effects of industrial fire?
- What are the fire safety measures available to prevent industrial fires?

1.5 IMPORTANCE OF STUDY

The study is to create awareness on the causes, economic losses as well as prevention of fire outbreaks in industrial buildings. This will therefore bring to light the causes of fire out breaks and opportunities that pertain in preventing fire outbreaks in industrial buildings in Ghana. The study would help create awareness that fire prevention and fighting should be looked at holistically by all stakeholders specially Government, Ghana National Fire Service, Directors of Industries, Employees and the General Public as a whole. The Ghanaian economy depends so much on the taxes collected from

industries which also provide a great volume of employment to Ghanaians, hence the need for assessment, particularly on issues concerning prevention and controlling of fire outbreaks.

The study would also provide a comprehensive understanding that can be used to analyse the effects and prevention of fire outbreaks in industrial buildings upon which recommendation would be provided for the study.

1.6 SCOPE, DELIMITATION AND ASSUMPTION

The research work was modelled to identify potential causes, prevention of fire outbreaks and its economic effects on the Ghanaian economy. The scope of the work was limited to industries (manufacturing) established in Ghana (in Tema to be specific). Tema metropolis was chosen because Tema metropolis has the highest number of manufacturing industries in Ghana. Although, there were some limitations on the ground of getting information from respondents but this was overcome to give the success of the study. In the study, the researcher assumed that participants were highly qualified engineers and safety officers. It is assumed that participants answered questionnaire base on their personal experience.

1.7 METHODOLOGY

Basically, two sources of seeking information were used for the study (primary and secondary). Primary data comprised of data from the respondents direct through questionnaires and interview guide. Secondary source of data had to do with data from work of scholars, students and experts from the internet. The industries in the Tema Metropolis formed the sample frame. The selection of this region was based on the grounds that Greater Accra region contains the highest number of industries or companies that deal in manufacturing. The sample size was seventeen (17) manufacturing industries. The respondents include: managers/CEO‟s, Engineers,

operation managers and safety professionals/Managers. The sampled industries were surveyed based on simple random techniques. Data collected was explored descriptively using percentages, mean standard deviation, bar and pie charts) via Statistical Package for Social Scientist (SPSS).

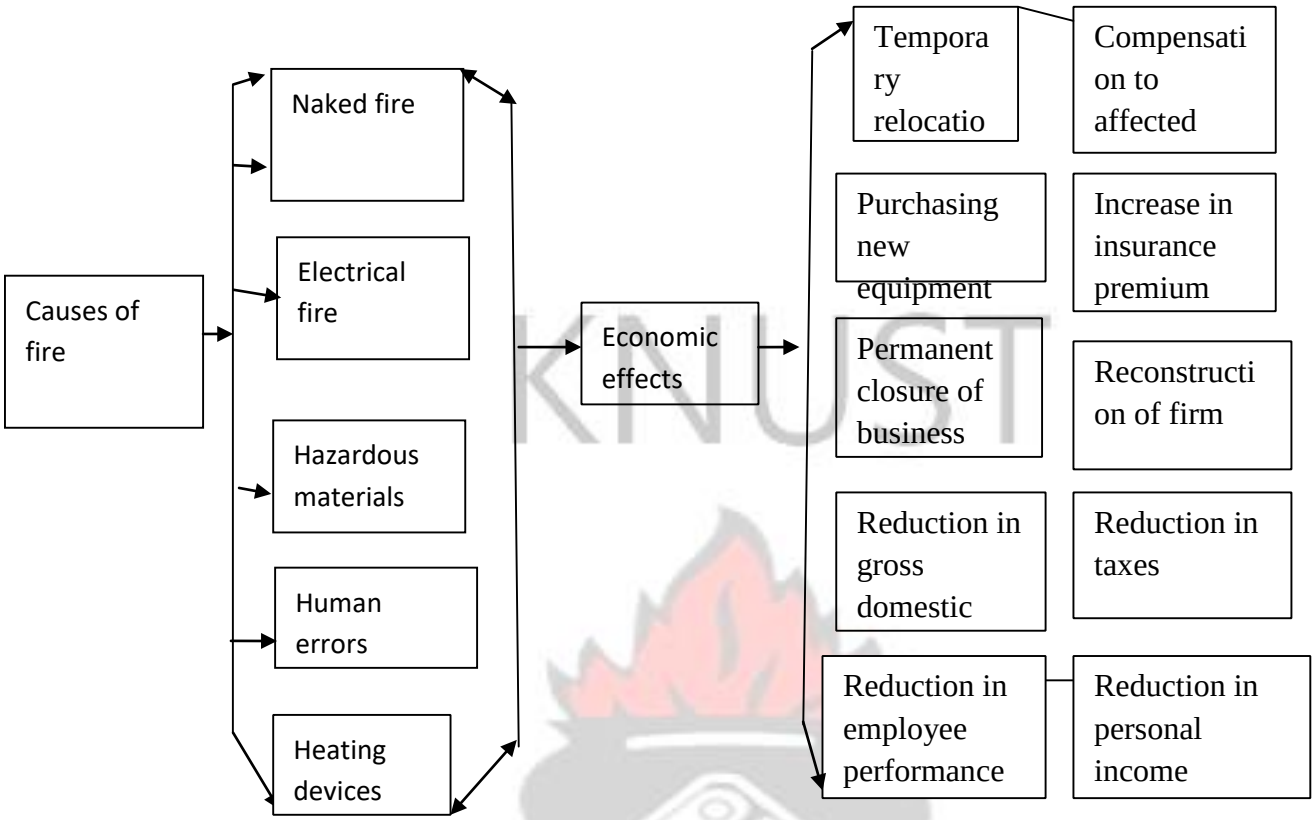
1.8 ORGANIZATION OF THE STUDY

This research was structured along five chapters. Chapter one highlights background of the study. Chapter two talks about what others have done concerning the topic. Chapter three treats the methodology. Chapter four discusses results from the field.

Chapter five talks about general conclusion.

1.9 CONCEPTUAL FRAME WORK

The figure 1 shows a simple conceptual frame chain of causes of fires and its overall effects on the economy which has analyzed in detailed in chapter 4 of this survey.



Source; Author"s Construct, 2015

Figure 1.1: Concept of the Study

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This section of the work will consider the following areas: definition of fire, definition of industrial fires, major causes of industrial fires, economic effects of outbreaks and applicable fire safety methods to prevent fire outbreaks and various research conducted by other researchers in this area are all dealt with in this chapter.

2.2 DEFINITION OF TERMS

The researcher defined some key terms that are relevant to the study

Fire is defined as the fast engulfing substances through a reaction process. Fire comes about when a flammable material is open to high temperature (Wikipedia). According to Barnet (2008), fire can be defined as a chemical reaction between elements resulting in rapid oxidation of flammable materials and resulting in the evolution of heat and fuel. The essential elements that can cause fire are oxygen, heat and fuel. The absence of any of these would mean there is non-existence of fire (Cox and Trait, 1998). A fire can be put off by the removal of one or more of the essential elements of a fire. The removal of heat from a fire is normally termed "cooling". The removal of oxygen term as "dilution" and the removal of fuel termed "starvation". A fire can also be extinguished by the inhibition of combustion.

Flashover is a term commonly used to describe a stage in the escalation of a fire. It can be explosive if preceded by the sudden opening or collapse of a wall or door, which provides the necessary air to reach flash point of the volatiles.

Clark and Nancy (1994) see industry as an activity which involves causing something to exist for economic purposes. Manufacturing is the making of commodities for use or sale by hand or machine.

2.3 THE CONCEPT OF INDUSTRIAL FIRES

Industrial fires are fires that occur in the industries as result of exposure to combusting materials like fuel and other flammable materials. Industrial fires are sometimes caused by electrical faults as a result of the age of the cables used and even the installation process of the electrical cables.

Manufacturing industries continue to be the leading industry that has a high frequency of fire outbreak due to the various kinds of chemicals and flammable materials used in production. Sedex, 2013 provides this statistic of fire globally: Services Sector 12%, Agriculture (Large) 12.1% and Industrial Sector 15.2%. Due to non-compliance of fire

safety in the manufacturing sector, there is no doubt about the frequent fire outbreak in the manufacturing sector. The fire outbreak at the Tema Oil Refinery, which occurred on 19th January 2010, is one of the destructive fires, killing one worker, injuring two others and destroying nine fuel tankers, pipelines and other properties belonging to the Tema Oil Refinery. (Daily Graphic of January 20, 2010)

2.4 MANUFACTURING IN GHANA

Industries in Ghana contributes 25.3 percent of total Gross Domestic Product (CIA , 2008). Nevertheless, Ghana's manufacturing industry is growing at a 7.8 percent rate, as a result of government industrial policies. Recently a glassmaking firm has been established in the country (Ibid).

2.5 History Of Manufacturing Industries In Ghana

The drive to increase the quota of the industrial sectors to Gross Domestic Product from 10% in 1960 to 14% in 1970 brought the creation of more industries in 1957, after Ghana gained independence (Clark and Nancy, 1994).

The effort to bring about this change hit some challenges like devaluation of the cedi, shortage of hard-currency to import raw materials (Ibid). The move for industrialization was to stimulate capital and rigorous manufacturing which originated in the middle of the 1960s with the creation of the Akosombo Dam. The Dam was created to enhance the activities of VALCO to produce more for export and local consumption (Frisedman and David, 2006).

Due to the dependence of the Akosombo Dam on climate, a drought hit the country in 1983 to 1985 which resulted in the shutdown of the VALCO. There was also devaluation of the country‟s currency in 1983 making it expensive and uneconomical to import raw materials for production (Clark and Nancy, 1994). During the 1990s, a lot of companies in the country were closed down due this phenomena creating

unemployment in the country and making the country unattractive for foreign natives to invest in the country‟s industrial sector. i.e. affecting direct capital inflows.

The economic recovery program adopted by the government was a grim and impossible for the country to support the local industries to revive their business. (Adu, 2013). Governments around the world seek the welfare of the people in their country, the government of Ghana in 1986, inaugurated the GIC to assist in creating new enterprises (Keith, 1976).

2.6 CHALLENGES OF THE GHANA FIRE SERVICE

According to Friedman and David (2006), there is implicit evidence of the economic implications on funding and service delivery in fire service. Among some of the challenges facing the departments are as follows:

- Accommodation is an issue in the Fire Service since there have not been adequate residence for personnel and this has really imposed a huge challenge on the department;
- Inadequate availability of vehicles is a huge problem facing the Fire Service department. Vehicles are not available and even those available are broken down due to poor maintenance;
- Again, inadequate coordination on the part of GNFS constrains effective use of the different stakeholders at its disposal. In the end logistics, deployment and placing of firefighting crews and equipment is poorly accomplished. Increasing reliance on the Police Force reflects not only a growing view at the policy level of fire purely as a hazard and a reactive approach to fire risk, but also poor reaction time to an escaping fire. The average preparation time to respond to a fire alert can be range between 17 hours and 3 days, by that time the fire has

spread and become more difficult to contain, a factor that escalates both extent of fire damage and cost of suppression (GhanaDistrict.com,2013).

- Moreover, another constrain is the general lack of fire management skills in the country. Basic fire management training with a focus on fire prevention, not only was the depth of knowledge impacted limited but also members involved, given the vast areas affected (Rantsudu,1997). As a result in addition to poor management and limited personnel, firefighting skills have mostly been at the rudimentary level for both the government and GNFS. This partly explains the reliance on the police who however, are not strictly trained fire fighters (GhanaDistrict.com, 2013).

2.7 MAJOR CAUSES OF INDUSTRIAL FIRE

According to Ayarkwa et, al (2010) causes of fire outbreaks are classified into three main categories;

- Age wiring
- Over loading of electrical circuits
- Misuse of electrical cords

Ofakor (2006) also classified causes of fire outbreaks into three main categories;

- Mechanical causes
- Human carelessness
- Arson

According to the acting head of public relation of the Ghana National Fire Service, Robinson (2014) said periodic fire safety audit conducted by the service had found out that most companies did not adhere to fire safety advice, which causes fire outbreak.

In U.S.A, the principal reasons of domestic fire in one –and two- family dwellings is incendiary or suspicious (Federal Emergency heat Agency, 1986).

2.7.1 Fault From Electrical Wirings

According to Craighead, 1995, many of fires in both industries and homes are caused by electrical wiring. Some wiring are very old in some industries and even in the homes. Misuse of electrical apparatus can lead to fire outbreak in the industry, occasionally; electrical faults can occur on apparatus and can be a result of lack of regular services (Jack and Raymond, 1976).

2.7.2 Arson

Tranmere and Tarnney, et al (1993) views Arson as a crime of intentionally setting up a fire in both homes and industries with the help of gasoline or kerosine. It is not just the spontaneous outburst of the fire in the property but rather and intentional cause (Kumar and Kris 2008). These people are known as Arsonist. There are four main elements. These are malicious which is explained to mean the action of bringing about hazard of burning, burning, dwelling and of another.

2.7.3 Gas Leakage

Leakage of gas is the situation whereby gas in pipeline leakages in the face flame or sometimes explodes causing a lot of life and properties (Kletz, 2001). Gas leakage can cause fire. This phenomenon can be experienced in many industries both new and old. (Ibid).

Gas companies or industries are required to do due diligence of the transporting and installation of gas operating equipment (Mannan and Sam, 2005).

2.7.4 Smoking Cigarettes

Aside the implication cigarette has on the health of the smoker, it also contributes to most industrial and domestic fires when it comes into contact with flammable substances.

It is difficult to locate or classify a fire that was actually caused by Cigarettes. Improperly discarded cigarettes have been blamed for most industrial fire out breaks. In the Westchester Hilton hotel fire that caused the death of twelve people, investigation revealed that it was as a result of smoking cigarettes (Abdullah, 2011). In the U.S.A and most European countries, cigarette is the major cause of domestic fires (Institute of Food and Agriculture science, 1998).

2.7.5 Over Heating Equipment

Heating equipments are also a cause of industrial and domestic fires. This is as a result of the fact that when these equipments are over heated, they can explode causing fire at the location. In the US, there is a precise definition of flammable liquid as one with a flash point below 100 degrees Fahrenheit (38 degrees Celsius). Lessflammable liquids (with a flashpoint between 100 degrees and 200 degrees Fahrenheit) are defined as combustible liquids. When two or more of the elements of fire come into contact with an overheated equipment, fire will engulf the area being it home or industry. (Winter 1994).

Overheating of electrical equipment is caused by overloading of electrical points. If a load draws too much current, the system components upstream of the load have to carry that current. The main protection against overload is the overcurrent protection device which should open. If it does not open, the high current will cause over heating distributed along the portion of the system upstream of the excessive load.

2.7.6 Flammable Material

Flammable materials are substances that can ignite easily and burn rapidly. They can be common materials that are at most work sites in gas, liquid and solid forms. The Ghana Building Code, L.I 1963, 1996 recommends that provision must be made for inflammable materials to be stored in place well ventilated and protected from sources

of fire. As stated, flammable materials are harmful and can cause fire in the areas found (Noto and Kawamura, 1979). Examples of flammable materials are

celluloid, petrol, spirit etc.

2.7.7 Flammable Gases

Flammable gases can ignite fire in locations they are found if care is not taken. There are several flammable gases and these can be classified as inert gasses, oxidizers, and other flammable gasses. There are different kinds of flammable gases some examples are Ethylene, Hydrogen, Methane, Butane (Megan and Joshua 2013).

Fire results in the production of smoke flame and gases. Some of these gases are very toxic and harmful to the health and safety of occupants or victims of a fire.

Some of the toxic gases, which are produced during a fire are acetic acids, acrolein, ammonia, carbon monoxide, hydrogen chloride, nitrogen dioxide, sulphur dioxide and hydrogen cyanide. These gases when inhaled continuously over a relatively short period can affect the health of the victim. Prolonged inhalation on the other hand can adversely cause the death of victims of fire (Hall 1987).

2.7.8 Flammable liquid

Flammable liquid is a liquid that can catch fire. According to Clark and Nancy (1994). There exist various liquids that can catch fire in the presence of combustible substances. According to them, there are various classification of flammable liquids which are Class IA, IB, IC, Class II, Class IIIA, IIIB. Examples of flammable liquids are Acetone, Biodiesel, Dimethyether, Diesel, Ethanol, Gasoline and others. However, it is not the liquid itself that catches fire, but the vapor cloud above the liquid that will burn if the vapor's concentration is between the Lower Flammable Limit (LFL) and Upper Flammable Limit (UFL) of the flammable liquid.

2.7.9 Growth of Fire

The growth of a fire depends on the amount and disposition of combustible material within the building, either in the form of unfixed materials or parts of the fabric such as wall and ceiling linings, which can contribute to fires. At the beginning of a fire, materials near the source of ignition receive heat and their temperature rise until, it reaches a flashpoint. Ignition of the material then occurs and it begins to produce the heat instead of merely receiving it (Jack and Raymond, 1976).

2.7.10 Fire Grading / Load

There are three ways of grading fires. These are ordinary, high and low. Based on the content and operations conducted in the building or the flame spread rating of its internal finishes of the building or its ventilation. The term „fire-grading" has a twofold application.

(1) It is applied to the classification or grading of the elements of structure of buildings in terms of their degree of resistance to fire.

(2) With a broader meaning, it is applied to the classification of buildings according to the purpose for which they are used, that is, according to occupancy, and according to the resistance of the elements of which they were constructed. This grading of buildings is considered from two points of view, firstly in terms of damage and exposure hazard, for which the protection is mainly provided by structural precautions, and secondly in terms of personal hazard, for which protection is provided primarily by easy means of escape (Jack and Raymond, 1976).

The intensity of improvement and the proportion, of which high temperature is on the loose, is dependent on a more comprehensive set of a condition. These are;

(1) Area and shape of the building opening

(2) Thermal insulation properties of the building fabrics

(3) Position of flammable materials

(4) The kind of fuel and amount of fuel and etc.

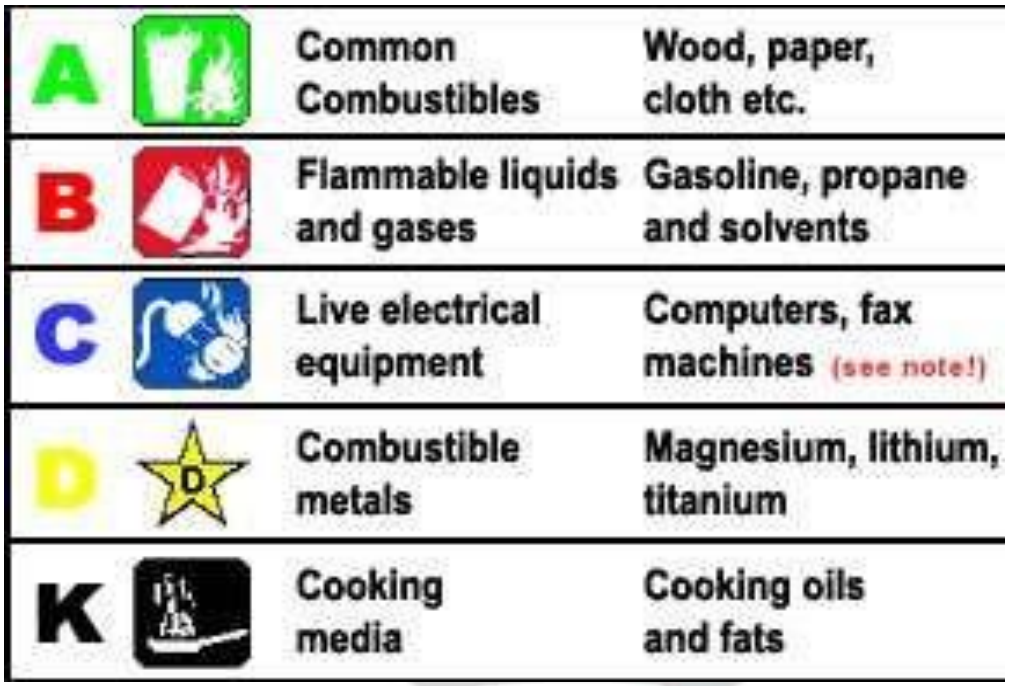
Table 2.1: Fire Grading / Load

Grade of occupancy	Small fire load	Reasonable fire load	Great fire load
Fire load KJ / m2	Not exceeding 9495 (18991on limited isolated areas	9495 to 18 991(not exceeding 37 982 on limited isolated areas)	18 991 to 37 982 (not exceeding 75 964 on limited isolated areas)
Building types	Domestic and institutions	Retail shops, eg footwear, clothing, furniture, groceries. Factories and workshops generally	Warehouses, etc, used for bulk storage of materials of nonhazardous nature
Equivalent severity of fire in hours of standard	1	2	4

2.8 Fire Categories

Fire is categorized into five main classes based on these fire extinguishers by using some symbols. (Franklin, 2005)

Figure 2.1: Fire Extinguish chart 1



Source: Fire Detection and Suppression System.

Table 2.2: Classification of Fires

Class of fire	Causes	Type of fire extinguisher use
Class A	Driven by common materials such as wood, etc	The frequently used extinguisher is water
Class B	Fueled by flammable and combustible liquids.	Dry chemical, foam, vaporizing liquids, carbon dioxide and water fog
Class C	Arise in electrical apparatus where nonconducting quenching proxies.	Dry chemical, carbon dioxide, and vaporizing liquids
Class D	Transpire in explosive metals such as magnesium	Special powders such as sodium chloride, dry sand or salt.
Class K	Occur in cooking medium	cooking oil, fat, alcohol

Source; (Fire Detection and Suppression Systems (Third Edition) 2005.

2.9 ECONOMIC EFFECTS OF INDUSTRIAL FIRE

Barnett (2008) acknowledges that destructive nature of fire on buildings, occupants and its effect on the national economy cannot be overemphasized. The Ghana National Fire Service, GNFS (2010) recorded about 2,200 fire outbreak nationwide between January and November 2009, and 3,249 for the same period in 2008. 478 fire prevalence was recorded nationwide in 2013 as reported by NADMO. (Vebe Ghana of December 12, 2013) The disaster cost 15 million Ghana cedis (GH₵15m) on the economy (NADMO) said on Thursday (Vebe Ghana of December 12, 2013).

2.9.1 Fire Damage on Wyoming's Economy

Fires have had adverse effect on the economy of Wyoming affecting the various aspects of its economy (Jack and Raymond, 1976).

2.9.2 Temporary Relocation and Reduction in Taxes

A temporary relocation is the protective measure in which an industry could be evacuated for a period of time. There are several reason why an industry can be relocated. Some of which are for a redevelopment of the industry and as a result of earlier fire outbreak to prevent reoccurrence (Amy and Justin, 2005). The instantaneous effect of industrial fire outbreak can lead to the reduction of real income of government. In the longer term, however, it hinders economic development (Rohr 2002).

2.9.4 Reduction in Personal Income and Employee Performance

Poverty is the state of lack of the essential life supporting factors. Domestic and industrial fires contribute enormously towards creating poverty in a country. Affected people of fire outbreaks are thrown into poverty temporarily and if measures are not put in place such people would be poor (Sealy and Worthington, 2007).

2.9.5 Increase in Insurance Premium

There are several ways fire outbreaks affect the total economy and insurance companies in particular. Insurance companies pay high premium to companies which insure with them, thereby decreasing the profit of the company. It affects the economy of the state, since it will affect the national income because taxes that are accrual to government would be reduced. Also, it will affect employees of the affected companies in terms of income reduction and also retrenchment of employees by employers of affected companies (Sealy and Worthington, 2007).

2.9.6 Reconstruction of Firm and Compensation to Affected Persons

Reconstruction of a firm as a result of fire outbreak is typically the transformation of a firm. The occurrence of fire can put most industries into bankruptcy and hence investors will decide to take dividends of a corresponding value in the new industry (Sealy and Worthington, 2007).

2.10 FIRE SAFETY MEASURES TO PREVENT INDUSTRIAL FIRES

Fire safety is the proactive measures put in place by companies and individuals to prevent and respond to fire (Sedex, 2013).

According to the National Building Code of Canada fire protection is reducing the likelihood of unacceptable fire hazard in companies and households. (Canadian Wood Council, 2002). Thus, fire security in an edifice can be attained through the incorporation of proactive measures by the owners of the structure. Fire officers‟ guesstimate that, a minimum of 50 percent of lives perished due to housing fires can be avoided by fire detection devices, installing firefighting equipment developing and practicing an evacuation drills (Institute of Food and Agricultural Sciences, 1998).

2.10.1 Fire protection

According to Jack and Raymond (1976) fire protection is the defense of inhabitants, innards, and buildings. Fire protection comprises of all the measures taken to prevent and control fire. Passive fire protection is concerned more particularly with prevention and consistent control by statutory regulations.

Fredrick and Ricket (2001) identified some two different facets of fire fortification: life and property fortification. The fire protection system comprises ten main components, which apply in varying degrees to different buildings or different parts of a building.

According to EVERETT (1905) fire prevention is broadly regarded as;

- Preventing the origin of fire
- Controlling fires
- Preventing the spread of fire from “risk” to “risk”

From the above explanations the researcher also classified fire prevention into two main categories;

- Installation of Early Warning Signs
- Installation of Firefighting Equipments

It is the responsibility of the engineers to meet standard specifications while providing service such as putting up buildings for clients to make firefighting easier (Frederick and Ricket, 2001).

A study by Ayarkwa et al, (2010) cited by Banett (2008), UK fire statistics 2008; Frederick and Ricket (2001) posits that of all, buildings should include provision of the needed apparatus for prompt firefighting

2.10.2 Proper Storage of Hazardous and Regular Safety Auditing

Some Hazardous substances are ignitable and as such these materials are to be properly stored for the prevention of fire in the homes and in the industries (Joseph and Keith, 1976). Ventilation is important to the prevention of flammable liquid fires and

explosions. It is important to ensure that air blowing through the building is constant and prevent the accumulation of any flammable vapors.

2.10.3 Regular Maintenance of equipment in the workplace

There is the need for regular maintenance of facilities and their equipments in order to avoid the place catching fire. If possible it is necessary to change old electrical wires in the building and in the manufacturing industry to prevent fire.

Also, measures should be put in place to protect the place, that is household and the industry from catching fire due to minor fires.

2.10.4 Provision of exit signage

Providing signs like "no smoking" at the work place especially factories is a means of preventing and protecting the factory against fire. These signs are mandatory in the Ghana building code (Ibid). Though this exist, the conforming to the installation of these signs is not adhered to hence the cause of some fires in industries and homes. Facilities should provide these signs to prevent people from abusing these facilities in a way which can cause fire to destroy lives and properties.

2.10.5 Regular inspection by fire officers and evacuation drills

Fire officers in the country as well as the mandating authority in building should make it a schedule to inspect every household and manufacturing industry in the country as to whether they are conforming to specifications as far as fire safety is concerned.

2.10.6 Installing of firefighting equipment

Firefighting equipment should be installed at the work place, industries and even in the homes to alert the occurrence of fire at any point in time. This should be a policy in the country as far as constructing an edifice is concerned. Installing these firefighting equipment should not end there but people or users of the facility should be educated on how to use these equipment to fight if the unforeseen happens.

2.11 FIRE DETECTORS

Fire detectors are used because the earlier it is detected the better it can be controlled and quenched. Most fire detectors are automatic. The objective of this equipment is to alert the outbreak of fire and sometimes an alarm may be connected to the local fire brigade or private fire station on the premises. Fire detectors have various types, some of which are as follow; (Hall, 1987)

1. Smoke Detectors
2. Heat Detectors
3. Laser beam Detectors.

2.11.1 Smoke detector

Figure 2.2: Smoke Detector COFEM with approved EN 54-7

A **smoke detector** detects smoke in buildings so as to discover the cause of the smoke in order to prevent the building from being engulfed by fire.

These detectors are usually used to detect smoke in a room, and afterwards raise an alarm. These detectors usually react more quickly than heat detectors, but they are very sensitive and a great care is required when installing them where products of combustion are generated by normal production process (Hall, 1987).

2.11.2 Heat Detectors

Figure 2.3: Heat Detector

This device detect heat in the building, the device also has a fixed temperature of the room so as to detect excessive heat that could bring about fires within the building.

There is a wide range of heat detectors on the market, and the basic principle of operation of the fire detector is that, when the temperature within the building rises to a flashpoint it will automatically trigger off and comes with an alarm sound to alert occupants of the building. These are spot or point detectors using bimetal strips or coils. Detectors which use thermocouples and solid state detectors (thermostat) use electrical principles to operate the alarm. A fixed temperature detector operates on the fusion of a force melting point alloy and is applicable for use in areas where there are relatively high and rapidly fluctuating air temperatures, such as kitchens and boiler rooms (Hall, 1987).

2.11.3 Laser Beam Detectors

The laser beam has been developed as a combined heat and smoke detector and will detect heat and smoke from any type of fire. It does not suffer the falling off of

sensitivity with increase in heights as in some detectors. The system consists basically of two units, a pulse transmitter emitting infrared rays, which is optically copied to a photo sensitivity receiver positioned at a maximum range of 100 meters. When the pulsation beam is attenuated by smoke or the refractive index of the air is change by rising waves, appropriate circuits activate relays and warning signals.

2.12 FIXED APPARATUS

These are firefighting equipment and apparatus which are included in the design of the building. These apparatus aid the fire brigade to fight fire when it occurs.

2.12.1 Hose reel

This is a tube that is connecting to the water source in order to prevent and quench fire. (Burberry, 1992).

Figure 2.4: Hose reel

Hose reels should be sited in positions where they can be used without exposing the users to danger from fire, example stair case landing.

A force of 200 kilo Pascal is required and if the town‟s main is not capable then a pumping station is required.

2.13 MEANS OF ESCAPE

When designing a building, it is important and obligatory by the building regulation code to design escape routes in case of fire. Components of escape route design are based on factors such as the building type, the building contents and the building

occupancy etc. One of the many ways to ensure that escape routes are affective and are free from smoke in the event of fire is by pressurization. In industrial buildings, staircase and lobbies can be pressurized to clear means of escape. The air pressurization level is usually between 25 and 50 pa depending on the height of the building and the degrees of exposure.

Another means of providing effective escape route is to always ensure that routes are not obstructed (AQUA Group, 1980). According to Burberry (1992), the means of escape should be sign posted. The sign should be fixed on lower level because smoke rises and in passages the top will be obscure first.

2.13.1 Adequate ventilation in production room and building according to building and fire safety codes

Ventilation is the means of allowing in fresh air into a building by providing ventilation vents and windows to accommodate fresh air. This process removes odour and also act as a means of detecting fire in a system. Ventilation is an important part of structural firefighting tactics, and involves the expulsion of heat and smoke from a fire building, permitting the firefighters to more easily and safely find trapped individuals and attack the fire. If a large fire is not properly ventilated, not only will it be much harder to fight, but it could also build up enough poorly burned smoke to create a smoke explosion, or enough heat to create a flashover. Contrarily, poorly placed or timed ventilation may increase the fire's air supply, causing it to grow and spread rapidly (AQUA Group, 1980).

2.13.2 Adequate fire safety awareness

The mode of training is suitable for all employees, even if they are not regular computer users. The aim is to provide employees, staffs and the general public with awareness and understanding of the threats posed by fire (Weibke and Redlich, 2001).

There are a number of fire safety awareness measures some of which are listed below;

- Orientation training
- Intermittent reminder training
- Monitoring and evaluation of the awareness of employees and occupants about fire awareness measure.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In order to help achieve the goals of the study, there was the need to follow some methods to carry out the study which would enable and enhance future reference.

Methodology is a way of going about task assigned in order to achieve success of task (Christou et al., 2008).

3.2 PHILOSOPHICAL POINT OF THE RESEARCH

The research was of the opinion, exploring the Economic Effects of Industrial Fires in Ghana, (A Case Study of Manufacturing Industries in Tema Metropolis) need to be undertaken in an unbiased manner which can be replicated; in answering the research question; what are the major causes of industrial fire, what are the economic effects of industrial fires and what are fire safety measures to prevent industrial fires? The objectivism ontological position was followed.

3.3 RESEARCH DESIGN

The research design tells the method or how the study is going to be conducted. Literature says qualitative method with facts is more than numeric. There are also a quantitative method which deals with numeric. However, this study combined the two approaches to derive the mixed approach.

3.4 RESEARCH STRATEGY

The qualitative aspect of the study involved the use of interview guide for the officers of the manufacturing industries. This was triangulated with the quantitative methods which involved the use of questionnaires. The questionnaires were used to collect data from the workers in the various manufacturing industries

3.5 METHODS OF DATA COLLECTION

This section highlights the means by which information was gathered for the study. Collecting information is very important in every research, because it gives an idea as to what is happening in the background (Bernard, 2002). It is therefore vital to select the way in which the data will be obtained. (Bernard et al., 1986; Tongco, 2007).

3.5.1 Desk Survey

This method of data gathering is very important to every research work because it paves the way for the primary data gathering by alerting the sort of questions to ask on the field in order to triangulate the data gathered using this method.

3.5.1.1 Internal Secondary Sources

These are published within companies or organizations, such as annual reports, information booklets, brochures, magazines, financial information memoranda and financial reports.

3.5.1.2 External Secondary Sources

According to Wahab (1996), this source of data collection is the most accurate source of information as it contains the original research. Alternatively, this source of information includes textbooks, technical journals, newspapers, magazines and internet sources.

3.5.2 Field Survey: Primary Data Source

This method is characterized by gathering information with data collection tools like questionnaires and interview guides. Naoum (2007), acknowledges three approaches to this method: the survey approach, the case study approach and the problem-solving approach (action research). This study used surveys because according to Robson (2002), surveys are used for comparatively huge number of respondents with limited

time. Robson (2002) added that two types of surveys exist: the descriptive survey and the analytical survey.

3.5.3 Descriptive survey

Burns et al. (2001) in explaining descriptive survey intimated that it is a study that calls the manifestation, rate of features of an occurrence occurs logically, assist in getting Intel. This method is aimed at describing the situation as it is (Polit et al., 2006). Naoum (2007), added that the survey ask questions like How?, Who?, What? among others. More accurately, the survey used numbers to weigh opinions in a

particular objective.

This type of study has the advantage of providing baseline information with a lot of flexibility for collecting data from a huge sample (Mouton, 2001). Due to this benefit associated with the method, the study employed it.

3.6 DATA COLLECTION INSTRUMENT

3.6.1 Questionnaire development

Questionnaire was designed to collect quantitative data from the respondents from the industries in the study area. The questions were clear and well structured. The opened and closed ended questions were used to collect various information from respondents. The research objectives as well as the research questions were the basis for the development of the questionnaire for the study. The questionnaire was designed to suit the understanding of the respondents in order to get the needed information for the study. As said earlier, simple language and grammar were used to design the questionnaire which limited the time to answer or administer the questionnaire.

3.6.2 Questionnaire Format

The format of the questions were both close and open ended questions. The close questions in the questionnaire were given some options that is A-D for respondents to

choose. This type of questionnaire was quantitative with the aim of getting views in quantitative form to triangulate the responds of the senior officials of the industries. Open ended question on the other hand was the qualitative questionnaire aimed at getting broad horizon of answers to a question. This was to allow for comprehensive probing of the answers given by the respondents. This research however designed a questionnaire covering seven pages as provided in the Appendix.1

3.6.3 Questionnaire Design and Distribution

The questionnaire was structured in four areas. There was the bio data, causes of fires, part three focused on the economic effects of industrial fires and part four also focused on the preventive measures to avoid industrial fires. There was the need for orderliness in the questions and also to ensure consistency in the answering as well as the flow of reading the questionnaire to the respondent or the respondent answering the questionnaire him or herself.

3.7 RESEARCH POPULATION AND SAMPLING TECHNIQUE

3.7.1 Research Population

Based on this knowledge, population was taken from manufacturing industries in Tema Metropolis.

3.7.2 Sampling Technique and Sample size determination

According Naoum, 1998, sample is using part of a population to represent an entire population. Thus, sampling is to select a quota in a population to characterise the whole populace. Using Sample has the advantage of being cost effective and time conscious. The sample frame used in this study was based on report published by GNFS in their 2014 mid – year report. According to GNFS, in 2014 between January and June they recorded 55 incidences of industrial fires nationwide. 75% of the fires recorded

happened in Greater Accra region of Ghana. According to the report Tema Metropolis alone recorded 51% representing 21 manufacturing industries.

Therefore 21 manufacturing industries were used as the sample frame for the study.

Using the formulae propounded by Brews and Miller (2003) in their A-Z of statistics.

This is show below:

$$\frac{N}{1 + N(\partial)\text{^}2}$$

Where; N is the sample frame,

a, is the margin of 0.1%

In the context of this research, the sample size was 17 manufacturing industries in Tema Metropolis. The targeted respondents included managers, engineers and safety officers within the industries.

3.7.3 Analysis of Simple Random Samples

Simple random sampling as sampling method was deployed to select respondents from the sample at random basis.

Importantly, simple random sampling has the advantage of allowing the researchers to analyze outcomes statistically. Methods are available to the selection of respondents from a sample using the simple random sampling and one of such ways is the draw method where all the subjects in the frame is given a special number and put together in a bowl and selected blind-folded at random.

3.8 METHODS OF DATA ANALYSIS

3.8.1. Content analysis

Content analysis was done for the qualitative data collected through the interview guide for the authorities of the manufacturing industries. This was necessary due to the fact that there was the need to support arguments for the analysis.

3.8.2 Statistical Treatment

Likert (1932), provides a means of rating questionnaires in survey. This method was adopted for the study. Table 3.1 shows the scale adopted for the study.

Table 3.1: Adopted Scale

Scale	Percentage (%)	Interpretation
5	17.6	Least
4	5.9	Lower
3	29.4	High
2	29.4	Higher
1	17.6	Highest

Source: field survey 2014

Questions in the questionnaire were assigned the scales to show the extent to which respondents agreed to the statements in the questionnaire.

3.9 ETHICAL CONSIDERATIONS

To engage people in a research by seeking their views, there is the need for confidentiality to ascertain information on accidental fires and its economic effects on industrial building in Tema Metropolis. Respondents were assured of confidentiality with regards to the information they are providing for the study.

3.10 PROFILE OF RESEARCH AREA (TEMA)

Tema also known as Harbor Town is the capital of the Tema Metropolitan District a city in the Greater Accra region of Ghana. It is 16 mile east of Accra. It has a population of approximately 161,612 (Ghanaweb.com, 2013).

The community is noted for Manufacturing which constitutes about 9% of Ghana‟s GDP which provides employment for over 250,000 people (2009). There are around 25,000 registered firms, though more than 80% of them are small size enterprises and around 55% of them are located within the Greater Accra/Tema region. Notable

industries in Tema includes aluminum processing, cement and small commercial ship building (Ghanaweb.com, 2013).

3.10.1 Climate

Tema is characterized by a dry equatorial climate. It lies in the driest part of Southern Ghana, experiencing average annual rainfall of about 750 millimeters. Average temperatures of 30^0C (GhanaDisrict.com, 2013).

3.10.2 Economy

The economic activities in Tema comprises of seaport, fishing harbor, education and manufacturing industries.

3.10.3 Sea port

Tema port, has a water-enclosed area of 1.7 square kilometers (0.66 sq. mi) and a total area of 3.9 square kilometers (1.5 sq. mi). Tema serves as a place of market for landlocked countries of Africa. Tema port handles 80% of imports and export in Ghana (Nexus Commonwealth network Ghana, 2014)

3.10.6 Industry

According to Tema Metropolitan Assembly (2013), the key industrial products are aluminum, steel products, fish products, petroleum products, among others. Main industries in Tema are VALCO, Tema oil refinery, Nestle Ghana ltd, Wahome steel ltd, Tema shipyard, pioneer food canneries, there is also the free zone enclave.

3.11 ORGANIZATIONAL PROFILE

The researcher did a brief background check on the some organizations that were of the interest of the researcher. Below are some of the organizations.

3.11.1 Chemico Limited

Chemico limited is located in tema, Ghanaian Company working in farming, agricultural chemicals, and mining business activities. Products or services that chemico limited usually offer is Home Oxygen Therapy.

3.11.2 Tema Oil Refinery

The tema oil refinery was conceived in 1960 as part of the Ghana goververnment industrialization programme. The tema oil refinery is linked to an oil jetty at the tema harbor by a 24 inches diameter crude oil pipeline. The crude oil is pumped from storage tanks to topping unit where it is gradually heated in a train of heat exchanges from ambient temperature of 330-350 degree centigrade. It is then distilled at approximately atmospheric pressure into various fractions; LPG 2%, VIRGIN NAPTHA 25%, S.R. KEROSENE 14%, GAS OIL 33%, REDUCED CRUDE 26%

(GhanaDistrict.com, 2013).

3.11.3 Volta Aluminum Company (VALCO)

This company was founded by Kaiser Aluminum and now wholly owned by the government of Ghana. However, the company has partnership with Alcoa in the United States. In 1961 Valco invested in the Akosombo Dam hydroelectric power project to provide energy for its aluminum smelters. Valco deals in aluminum production (Geological 2008).

3.11.4 Ferro Fabrik Limited

Ferro Fabrik limited is located in Tema, Ghana. The company works in industrial equipment, steel products business.

3.12 CHAPTER SUMMARY

This study was conducted to explore the economic effects of industrial fires in Ghana, (A case study manufacturing industrial in Tema Metropolis). As indicated, the study

made use of the already existing data as far as the topic of the study is concerned and also explore with questionnaire and interview guides to triangulate what literatures have said on the topic. This gathered information would then be analyzed to bring about the findings upon which recommendation would be made.

CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

This chapter presents the analysis of the information collected from the field of study. The chapter has been structured under headings and subheadings for easy understanding.

4.2 BACKGROUND INFORMATION

The background information that were of interest to the researcher were; names of institution, current educational qualification, years of experience, years worked, kind of products produced and major raw materials and chemicals use in production.

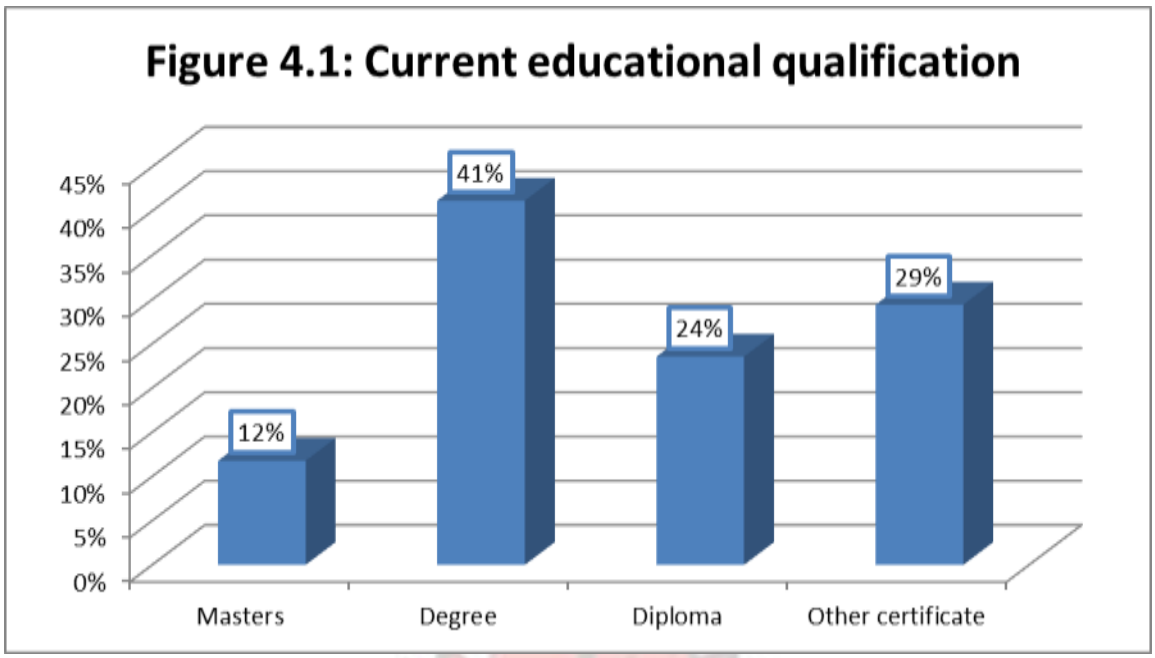


Figure 4.1: Current educational qualification

Source: Field Study, 2014 Note: Frequencies are at Appendix 2

Figure 4.1 showed the current educational qualification of respondents. The educational qualifications of respondents were mainly of degree (7) representing 41.2 percent of the respondents. The next qualification was certificate (5) representing 29.4 percent, then Diploma (3) representing 17.6 percent and masters (2) representing 11.8 percent.

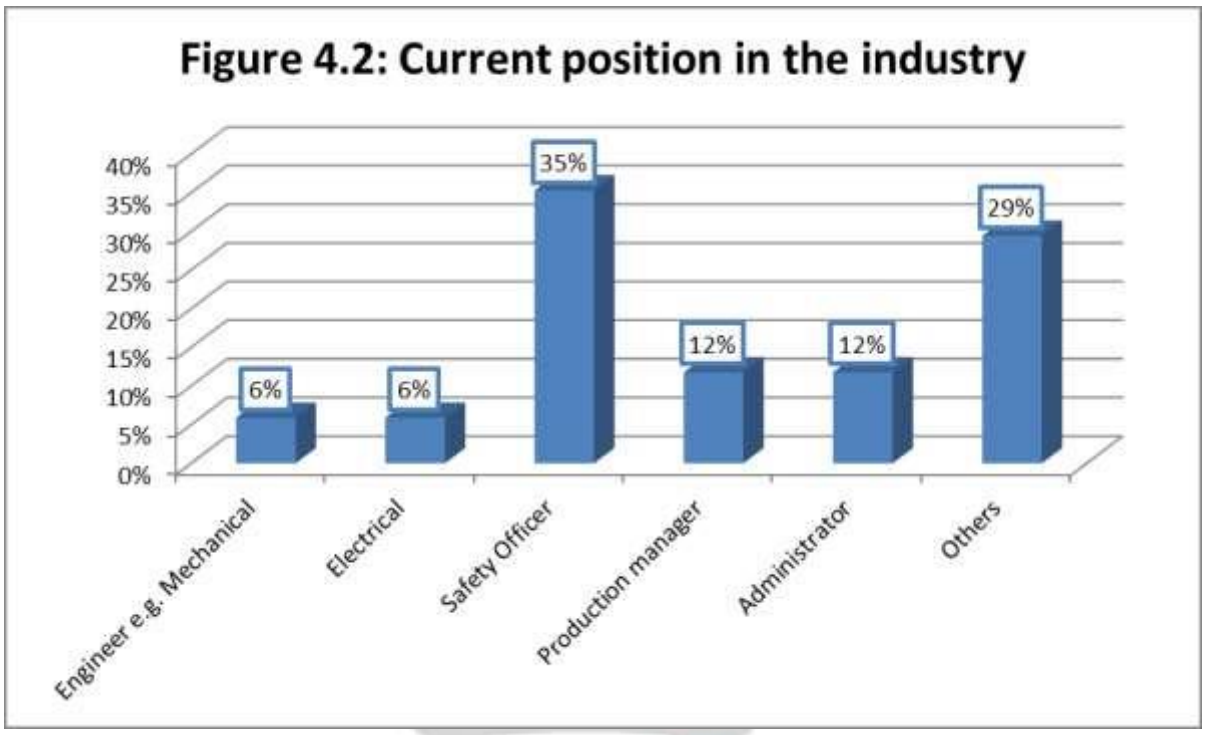


Figure 4.2: Current position in the industry

Source: Field Study, 2014

Respondents were asked to indicate their current positions in the department/company. It was observed from figure 4.2 that majority of them were safety officers representing 35 percent. Production managers and administrators were 12 percent each and engineers e.g. mechanical and electrical comprise 6 percent each. It was observed that 29 percent were in other department comprising; senior managers and personal officers.

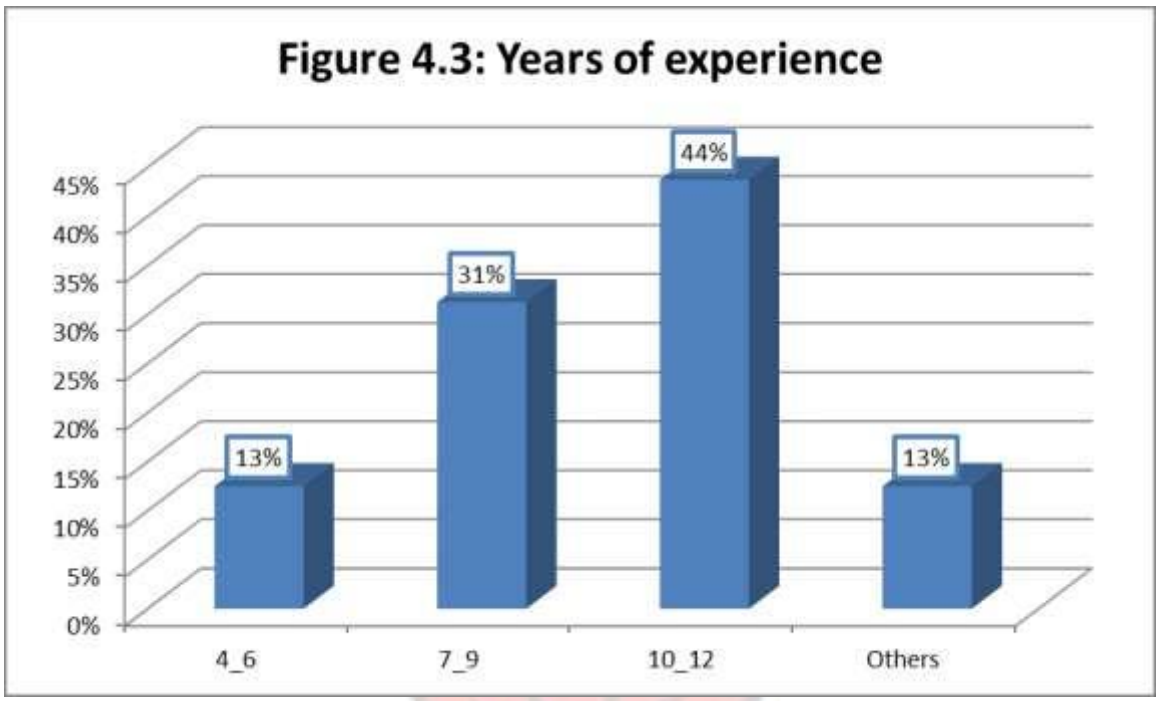


Figure 4.3: Years of experience

Source: Field Study, 2014

Figure 4.3 denoted respondents‟ years of experience in the current position in the department. Quite a number of respondents have had a number of working experiences in the department; 44 percent of the respondents have 10-12 years of experience, 31 percent had 7-9 years of experience and 13 percent have 4-6 years of experience. Others representing 13 percent of respondents have had working experience more than 13 years.

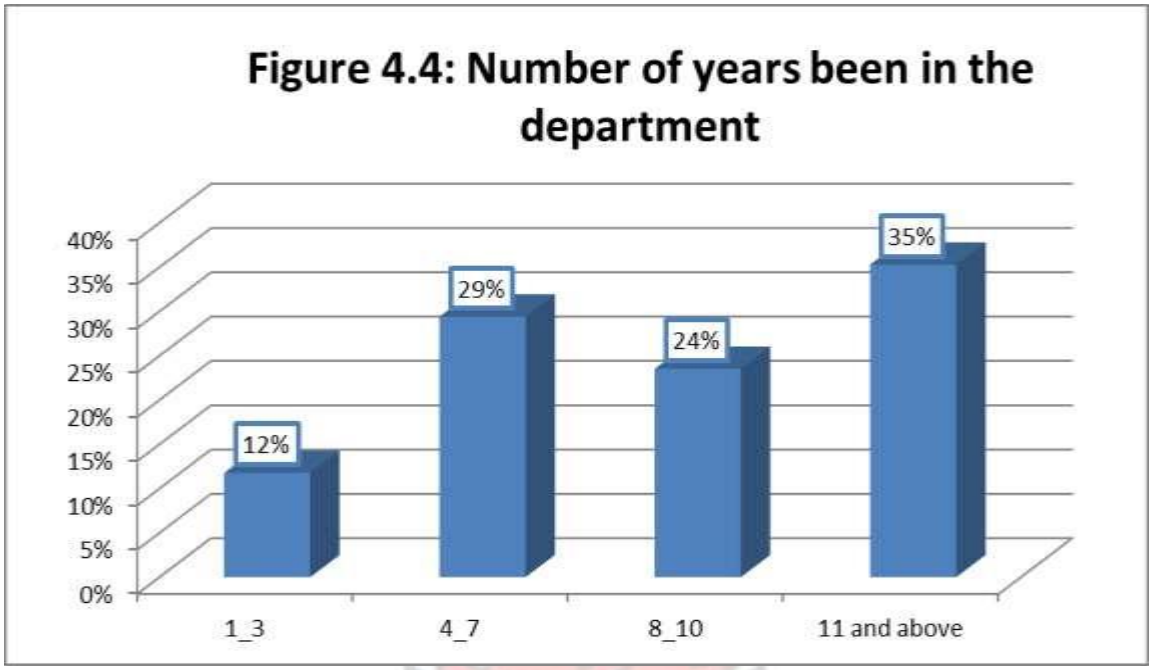


Figure 4.4: Number of years been in the department

Source: Field Study, 2014

Figure 4.4 showed the number of years respondents have been in the department. It was found that 35 percent maximum have been in the department for 11 and above years, 29 percent have been in the department from 4-7 years, 24 percent from 8-10 years and 12 percent between 1-3 year.

4.3 MAJOR CAUSES OF INDUSTRIAL OR INSTITUTIONAL FIRES

Respondents were asked to rank the following causes of fire that posses high risk to industrial building. Table 4.1 shows how these variables were ranked by respondents in percentage terms and table 4.2 shows the average ranking for each variable with chi-square to test whether respondents‟ rankings exhibit some significant difference.

Table 4.1: Frequency Distribution of the Major Causes of Industrial Fires

	Highest risk	Higher risk	High risk	Low risk	Less risk
Electrical Fire					
Poor wiring	18%	6%	12%	29%	35%
Inadequate cable rate used	6%	24%	29%	41%	0%
Voltage fluctuation	24%	18%	47%	12%	0%
Over loading of sockets	12%	18%	24%	29%	18%
Lack of maintenances	53%	18%	12%	6%	12%
Hazardous Material					
Flammable liquids	24%	35%	29%	6%	6%
Flammable gases	47%	35%	0%	0%	18%
Flammable chemical	18%	18%	41%	6%	18%
Paints	0%	6%	29%	47%	18%
Adhesives	0%	12%	6%	41%	41%
Human Error or Attitude					
Inadequate fire safety awareness	47%	24%	18%	6%	6%
Inexperience H & S officers	24%	12%	35%	24%	6%
Irregular fire auditing	18%	24%	47%	6%	6%
Arsonist	12%	6%	12%	41%	29%
Naked Fires					
Fireworks	18%	12%	18%	24%	29%
Cooking fire	24%	12%	29%	18%	18%
Candle fire	6%	18%	18%	41%	18%
unextinguishd discarded cigarette	6%	6%	24%	35%	29%
Heating Devices					
Faulty equipment use	41%	35%	12%	0%	12%
Incorrect voltage used	18%	12%	35%	24%	12%

Overheating of equipment	41%	18%	18%	24%	0%

Source: Field Study, 2014

Lack of maintenances was observed to be ranked by 53 percent of the respondents as highest risk cause of industrial fires. Voltage fluctuation was ranked the second highest risk, where 24 percent ranked it as highest, 18 percent ranked it as higher risk and 47 percent ranked it as high risk. In all, at least 89 percent of the respondents ranked voltage fluctuation as high (thus; 24+18+47=89).

With the hazardous materials, flammable gases, flammable liquids and flammable chemical had their rankings skewed to the riskiest direction. Flammable gases was ranked as follows; highest risk representing 47 percent, higher risk 25 percent. With flammable liquids, 24 percent considered it to be highest risk, 35 percent considered it to be higher risk and 29 percent considered it to be high risk. Few percentages considered it to be low and less risk representing 6 percent each.

Inadequate fire safety awareness was ranked by 47 percent and 24 percent as highest risk and higher risk respectively under human error or attitude.

Naked fire was generally not considered to have high risk. Candle fire, unextinguished discarded cigarette and fireworks were ranked basically by most of the respondents as low risk as shown in table 4.1. Cooking fire was the variable most of the respondents ranked it as high risk.

Faulty equipment use and overheating of equipment were ranked as higher risk, where 41 percent of the respondents each ranked them as highest risk.

Table 4.2: Descriptive Statistic and Chi – Square Test of Major Causes of Industrial Fires

	N	Mean	Std. Deviation	Rankings	Over all Ranking
1. Electrical Fire	**17**	**2.82**	**0.64**		**2**
Lack of maintenances	17	2.06	1.44	1	
Voltage fluctuation	17	2.47	1.01	2	
Inadequate cable rate used	17	3.06	0.97	3	
Over loading of sockets	17	3.24	1.3	4	
Poor wiring	17	3.59	1.5	5	
2. Hazardous Material	**17**	**3.12**	**0.7**		**4**
Flammable gases	17	2.06	1.48	1	
Flammable liquids	17	2.35	1.12	2	
Flammable chemical	17	2.88	1.32	3	
Paints	17	3.76	0.83	4	
Adhesives	17	4.12	0.99	5	
3. Human Error or Attitude	**17**	**2.94**	**0.56**		**3**
Inadequate fire safety awareness	17	2	1.23	1	
Irregular fire auditing	17	2.59	1.06	2	
inexperience H & S officers	17	2.76	1.25	3	
Arsonist	17	3.71	1.31	4	
4. Naked Fires	**17**	**3.53**	**0.94**		**5**
Cooking fire	17	2.94	1.44	1	
Fireworks	17	3.35	1.5	2	
Candle fire	17	3.47	1.18	3	
Un extinguished discarded cigarette	17	3.76	1.15	4	
5. Heating Devices	**17**	**2.47**	**1.01**		**1**

Faulty equipment use	17	2.06	1.3	1
Overheating of equipment	17	2.24	1.25	2
Incorrect voltage used	17	3	1.28	3

Source: Field Study, 2014

Lack of maintenances was ranked as the highest variable among the variables under electrical fire with mean value of 2.06. There was significant difference among the rankings of the variables. As observed from table 4.1, 53 percent ranked lack of maintenance as highest risk, 18 percent ranked it as higher risk, 18 percent ranked as high risk, 6 percent ranked it as low risk and 12 percent ranked it as less risk. It was observed that more than 50 percent ranked it as highest risk.

The variable with the highest hazardous material was Flammable gases with mean value of 2.06, followed by flammable liquids with mean value of 2.35 and flammable chemical with mean value of 2.88. These variables were ranked by respondents as higher risk cause of fire that posed high risk to industrial building. Adhesives and paints were ranked averagely as low risk cause of fire.

Inadequate fire safety awareness was ranked the highest risk among the categories of human error or attitude with mean value of 2.00. Other variables considered by respondents as high risk were irregular fire auditing and inexperience H&S officers with mean value of 2.59 and 2.76 respectively. These three variables were ranked as higher risk cause of fire that posses high risk to industrial building. Arsonist was considered to have low risk cause.

Cooking fire was averagely ranked as higher risk cause of fire with mean value of 2.94. Naked fire‟s variables were averagely generally considered as high risk cause of fire with mean values range from 3.35-3.76.

Faulty equipment use and overheating of equipment were ranked averagely as higher risk cause with mean values of 2.06 and 2.24 respectively. That means averagely

respondents ranked these variables under heating devices as higher risk cause of fire that posed high risk to industrial building.

4.4 ECONOMIC LOSS OF FIRE OUTBREAKS IN INDUSTRIAL BUILDING

The question, "from your experience which of these economic losses do you consider to be significant to industrial fires?" Table 4.3 and table 4.4 presented how respondents ranked the variables expressed in percentage terms and descriptive statistics on the variables with emphasis on mean, standard deviation and chi-square.

Table 4.3: Frequency Distribution of the Economic Effects of Industrial Fires

	Highest	Higher	High	Lower	Least
Temporary relocation	31%	25%	13%	13%	19%
Purchasing new equipment	35%	29%	18%	12%	6%
Permanent closure of business	35%	12%	12%	18%	24%
Reduction in gross domestic products	25%	19%	31%	19%	6%
Reduction in employee performance	18%	29%	29%	6%	18%
Compensation to effected persons	18%	35%	35%	12%	0%
Increase in insurance premium	31%	38%	25%	0%	6%
Reconstruction of firm	18%	24%	24%	24%	12%
Reduction in taxes	13%	31%	13%	31%	13%
Reduction in personal income	25%	19%	13%	38%	6%

Source: Field Study, 2014

Table 4.3 showed how respondents ranked the economic effects of industrial fires expressed in percentage terms. It was observed that 35 percent of the respondents ranked purchasing new equipment and permanent closure of business as highest effect each. Increase in insurance premium and temporary relocation equally ranked as highest by 31 percent each.

Table 4.4: Descriptive Statistic and Chi-square Test of Economic Losses

	N	Mean	Std. Deviation	Ranking
Increase in insurance premium	16	2.12	1.088	1
Purchasing new equipment	17	2.24	1.251	2
Compensation to effected persons	17	2.41	0.939	3
Temporary relocation	16	2.62	1.544	4
Reduction in gross domestic products	16	2.62	1.258	5
Reduction in employee performance	17	2.76	1.348	6
Reduction in personal income	16	2.81	1.377	7
Permanent closure of business	17	2.82	1.667	8
Reconstruction of firm	17	2.88	1.317	9
Reduction in taxes	16	3.00	1.317	10

Source: Field Study, 2014

It was observed that all the variables were highly significant. The Mean rank ranged from 2.12 to 3.00. These Mean range with non-significant difference in ranking showed average respondents rankings on variables measuring economic losses as highly significant. Increase in insurance premium, purchasing new equipment and compensation to affected persons were the most variables ranked higher. The remaining of the variables were averagely ranked high.

4.5 PREVENTIVE MEASURES TO AVOID FIRE OUTBREAKS IN INDUSTRIAL BUILDINGS

Table 4.5: Frequency Distribution of the Preventive Measures

Preventive measures	Most important	More important	Important	Less important	Not important
Proper storage of hazardous materials	47%	47%	0%	0%	6%

Regular safety auditing	41%	29%	24%	0%	6%
Provision of fire stops around pipes or ducts	24%	24%	18%	29%	6%
Adequate ventilation of production room	35%	18%	12%	29%	6%
Regular maintenance of equipment	53%	35%	6%	0%	6%
Adequate fire safety awareness	47%	29%	18%	0%	6%
Provision of exit signage	18%	6%	41%	35%	0%
Installing of firefighting equipment	25%	63%	6%	0%	6%
Regular evacuation dills	12%	24%	41%	24%	0%
provision of fire alarms and detectors	29%	53%	12%	0%	6%
Proper encasement of electrical wiring	29%	18%	35%	12%	6%
Building according to fire safety standards	71%	12%	12%	0%	6%
Regular inspection by fire services officers	25%	56%	13%	6%	0%

Source: Field Study, 2014

The fire safety measures considered to be important to avoid industrial fires were ranked accordingly by experienced respondents. Majority of the respondents representing 71 percent ranked building according to local building and fire safety codes as the most important fire safety measure, with 12 percent ranking it as more important and important respectively. This meant that this variable was considered as significantly important. 53 percent and 35 percent of the respondents ranked regular maintenance of equipment as most important and more important respectively. Proper storage of hazardous materials was ranked as significantly important, where most of the respondents ranked it as most important and more important with 47 percent each.

Table 4.6: Descriptive Statistic and Chi – Square Test of Preventive Measures

	N	Mean	Std. Deviation	Ranking
Building accord to fire safety standards	17	1.59	1.121	1
Proper storage of hazardous materials	17	1.71	0.985	2
Regular maintenance of equipment	17	1.71	1.047	3
Adequate fire safety awareness	17	1.88	1.111	4
Regular safety auditing	17	2.00	1.118	5
installing of firefighting equipment	16	2.00	0.966	6
provision of fire alarms and detectors	17	2.00	1.000	7
Regular inspection by fire services officers	16	2.00	0.816	8
Proper encasement of electrical wiring	17	2.47	1.231	9
Adequate ventilation of production room	17	2.53	1.419	10
Provision of fire stops around pipes or ducts	17	2.71	1.312	11
Regular evacuation dills	17	2.76	0.970	12
Provision of exit signage	17	2.94	1.088	13

Source: Field Study, 2014

Building according to fire safety standards, regular maintenance of equipment, proper storage of hazardous materials and adequate fire safety awareness were variables that were averagely ranked as the most important among the fire safety measures. The rest of the variables were averagely ranked as more important with mean values ranging from 2.00-2.94.

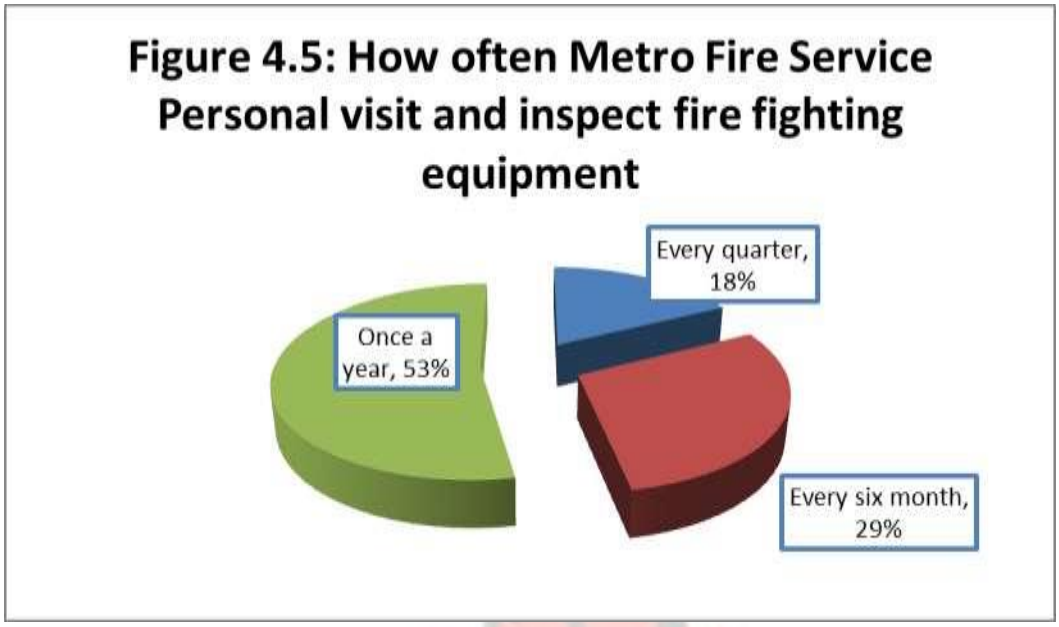


Figure 4.5: How often metro fire service personal visit and inspect firefighting equipment Source: Field Study, 2014

Figure 4.5 showed how often Metro Fire Service Personal visit and inspect firefighting equipment. It was observed that 53 percent of the respondents visit and inspect firefighting equipment once a year, 29 percent visit and inspect every six months and 18 percent said quarterly.

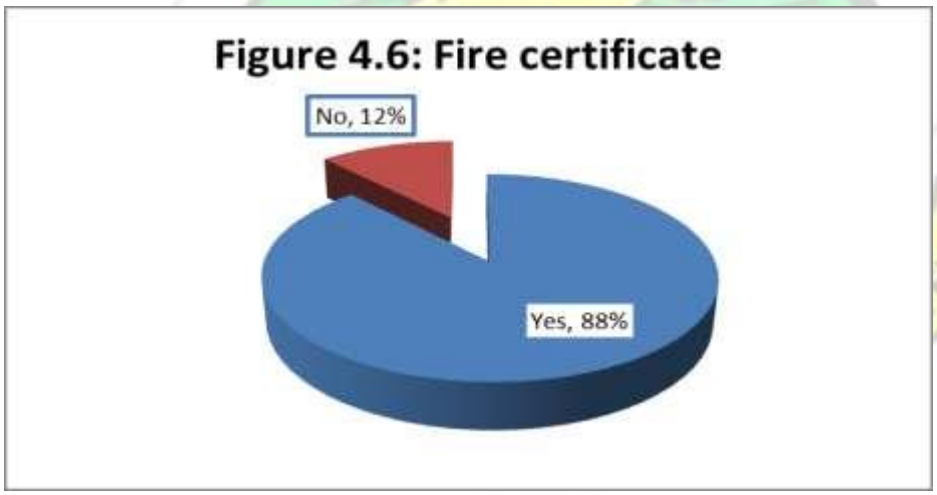


Figure 4.6: Fire certificate Source: Field Study, 2014

Majority of the respondents said they have fire certificate, representing 88 percent and 12 percent said they do not have fire certificate.

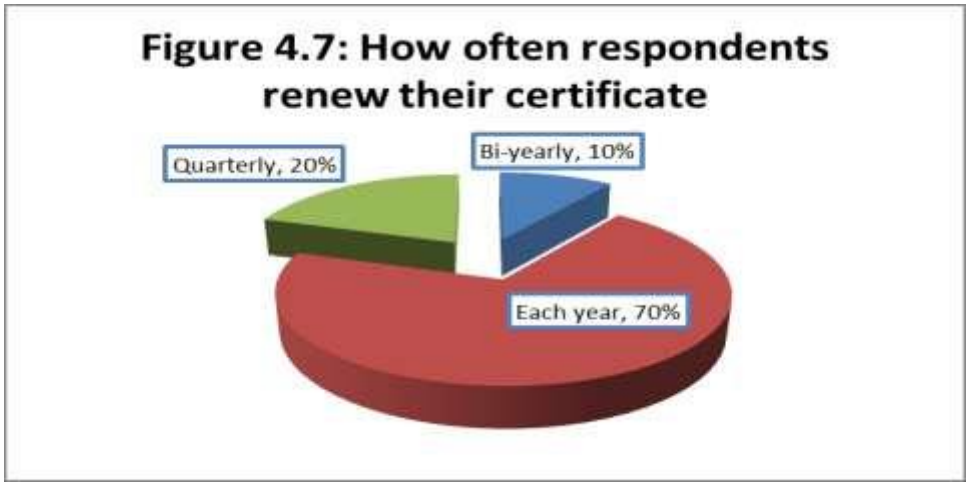


Figure: 4.7 Respondents renew their certificate Source: Field Study, 2014

The 88 percent of the respondents who said they have fire certificate indicated that they renew it each year representing 70 percent. It was observed that 20 percent renew their certificate quarterly and 10 percent said bi-annually.

The 12 percent of the respondents who said they do not have fire certificate indicated they have applied and it was ongoing.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATION

5.1 Introduction

The research work aimed to explore the economic effects of industrial fires as well as preventive measures to avoid industrial fires. This chapter thus, presents the summary of the findings from the study, the conclusions and recommendations made from the study.

5.2 Summary Of Findings

Respondents sample featured CEO‟s/managers, mechanical engineers, electrical engineers, production managers and safety officers. Majority of the respondents were safety officers. Also, the majority of the respondents have an industrial experience of

10-12 years; while most of these were senior staffs. In addition, the findings address the set objectives of the study as follows:

5.2.1 Causes of industrial fires

The major causes of industrial fires were grouped into five main categories. These included electrical fires, hazardous materials, human error, naked fires and heating device. Among the five major causes of fires, heating device had the highest mean score of 2.47; followed by Electrical fire with mean score of 2.82; and human error had a mean score of 2.94. Hazardous material had a mean score of 3.12 and the least among the five causes was naked fire with mean score of 3.53. Three (3) main items were listed under heating device in which faulty equipment used was the main sub causes of fires under heating device with a mean score of 2.06 followed by "overheating of equipment" with a mean score of 2.24.

"Electrical fires" which were the second major causes of fire had five (5) items listed as sub causes of fire outbreak, these were poor wiring, and inadequate cable size used, voltage fluctuation, over loading of sockets and lack of maintenance. Among these five "lack of maintenance of electrical wiring" scored the highest risk with respondent ranking of 53% and a mean score of 2.06. Also, "voltage fluctuation" has 24% and a mean score of 2.47. "Inadequate cable size" used was the third highest cause of electrical fire with mean score of 3.06.

It can also be inferred from the results of the mean scores of major causes of fire that "human error" was a major cause of industrial fires. Four (4) sub causes of fire were listed under "human error". These are inadequate fire safety awareness, inexperience health and safety officer, irregular fire auditing and arsonist. Among the four, "inadequate fires safety awareness" appeared as the highest cause of fire that attributes to human error with mean score 2.00. Irregular fire audit had a mean score of 2.57, and

the least among these four was arsonist with a mean score of 3.71. “Hazardous material” was the fourth major cause of industrial fires five (5) sub causes of fire under hazardous material were listed. Among the five sub causes flammable gases had the highest ranking of 47% with mean score of 2.06. Followed by “flammable liquid” which ranked 24% and with a mean score of 2.35. Flammable chemical was the third highest with mean score of 2.88. The least among the five major causes of industrial fires was naked fires. Cooking fires was the highest ranked with 24% and mean score of 3.47.

5.2.2 Economic Effects of Industrial Fires

The study revealed ten economic effects of industrial fire, namely:

“Temporary relocation,” “purchasing new equipment”, “permanent closure of business,” “reduction in gross domestic product,” “reduction in employee performance,” “compensation to effected persons,” “increase in insurance premium,” and “reconstruction of firm,” “reduction in tax” and “reduction in personal income”.

It was observed that 35 percent of the respondents ranked “purchasing new equipment” and “permanent closure of business” as highest effects. “Increase in insurance premium” and “temporary relocation” equally ranked as the second highest by 31 percent respectively. “Increase in insurance premium” had the highest mean score of 2.12, whiles “purchase of new equipment” has a mean score 2.24, “temporary relocation” and “reduction in gross domestic product” had the same mean score of 2.62 respectively.

5.2.3 Fire Safety Measures

Preventive measures to avoid industrial fires had thirteen possible factors, which were ranked based on their means. These preventive measures were; proper storage of hazardous material, regular safety auditing, provision of fire stops around pipes or ducts, adequate ventilation of production room, regular maintenance of equipment,

adequate fire safety awareness, provision of exit signage, installation of firefighting equipment, regular evacuation drills, provision of fire alarm systems and detectors, proper encasement of electrical wiring, building according to fire safety standards and regular inspection by the fire service officers. Among these preventive measures, building according to fire safety standards scored the highest ranking with 71% being the most important fire safety measure to consider in order to avoid industrial fires with a mean score of 1.59. Regular maintenance of equipment was the second ranked most important with respondent percentage of 53(%) and mean score of 1.71. Also proper storage of hazardous materials and adequate fire safety awareness were both ranked the third most important preventive measures with respondent percentage of 47(%) each. Proper storage of hazardous materials had a mean score of 1.71 whiles adequate fire safety awareness had a mean score of 1.88.

5.3 CONCLUSIONS

This research work covered major causes of industrial fires and their economic effects. The main conclusions of the study are presented in the next section.

5.3.1 Causes of Industrial Fires

From the study conducted it has been revealed that, the major causes of industrial fires are: faulty equipment, overheating of equipment, poor wiring, poor cables, voltage fluctuation and over loading of sockets.

5.3.2 Economic Effects of Industrial Fires

On the effect of industrial fire on the economy, the major economic effects are increases in insurance premium for manufacturing companies. Purchasing of new equipment as a result of industrial fires also has a big effect on their finances. Compensation to effected persons and in some cases permanent closure of businesses had posed economic challenges to the industry.

5.3.3 Preventive measures to avoid industrial fires.

This research has revealed the paramount approach to avoiding industrial fires in general is complying with fire safety standards during the design and construction stages. Regular maintenance of equipment, proper storage of hazardous material as well as fire safety awareness are the appropriate measures to avoid industrial fire in Ghana.

5.4 RECOMMENDATIONS

- The Ghana National Fire Service following the study recommended that: Metropolitan, Municipal and District Assembly development control teams should to inspect the compliance of fire safety before the construction of any industrial buildings.
- Metropolitan, Municipal and District Assemblies should employ the services of electrical Engineers to inspect and supervise all electrical installation works within industrial buildings.
- The Government should assist manufacturing industries financially to replace obsolete machines or equipment to reduce unnecessary overheating due to old age of equipment.
- Flammable materials must be properly stored.
- Fire safety training should be provided regularly for employees within the manufacturing industries.
- Ghana National Fire Service should perform safety audits on industrial buildings every quarter to ascertain fire safety conditions of industrial buildings.
- Regular maintenance of electrical installations and equipment will help reduce the high occurrence of industrial fires.
- There must be punitive action against industries that do not comply with fire safety regulations.

5.5 FURTHER STUDIES

Future research may focus on the compliance to fire safety standards by manufacturing industries during the design and construction stages.

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APPENDICES

APPENDIX 1

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI

Department of Building Technology

RESEARCH QUESTIONNAIRES

On

EXPLORING THE ECONOMIC EFFECTS OF INDUSTRIAL FIRES IN GHANA (CASE STUDY MANUFACTURING INDUSTRIAL IN TEMA METROPOLIS)

The main objectives of this study are:

- Identify major causes of industrial or institutional fires;
- Identify the economic loss of fire outbreaks in industrial building; and
- Identify preventive measures to avoid fire outbreaks in industrial buildings.

Please respond to the following questions by either ticking the appropriate box or by writing your answer in the space provided. Please Note: All information provided will be treated strictly confidential. This questionnaire is structured in four sections namely:

- Background information of respondent;
- Major causes of industrial accidental fires; Economic effects of industrial accidental fires; and Fire safety measures to prevent industrial fires.

For any further information or clarification please contact me on **Tel:0243326548/Email:frankgyasi370@gmail.com**

SECTION 1: BACKGROUND INFORMATION

Name of Institution /industry /Firm_____

Address_____

Email_____

Telephone_____

1) Please indicates your current educational qualification

(a)Masters ☐ (b) Degree ☐ (c) Diploma ☐ (d) other certificate ☐

2) What is your current position in this Department /Company?

(a) Engineer, e.g. Mechanical ☐ (b) Electrical ☐ (c) Operations manager ☐

(d) Safety officer ☐ (e) Planner ☐ (f) Production manager

(g) Administrator ☐ (h) others please specify_____

3) Years of experience

(a) 1-3 ☐ (b) 4-6 ☐ (c) 7-9 ☐ (d) 10-12 ☐ (h) if others please specify…

4) **How long have you been in this Department /Company**?

(a) 1-3 ☐ (b) 4-7 ☐ (c) 8-10 ☐ (d) 11 and above ☐

5) What kind of products do you produce?

---

6) What are your major raw materials and chemicals use in production?

SECTION 2: MAJOR CAUSES OF INDUSTRIAL FIRES.

From your experience which of these are the causes of fire that oppose high risk to industrial building? Please rank the causes by ticking the appropriate rating. **1=Highest Risk, 2=Higher Risk, 3=High Risk, 4=Low Risk, 5= Less Risk**

		Rating	**Comments**

No	Causes	1	2	3	4	5	
	ELECTRICAL FIRE						
1	Poor wiring						
2	Inadequate cable rate used						
3	Voltage fluctuation						
4	Over loading of sockets						
5	Lack of maintenances						
	HAZARDOUS MATERIAL						
1	Flammable liquids						
2	Flammable gases						
3	Flammable chemical						
4	Paints						
5	Adhesives						
	HUMAN ERROR or ATTITUDE						
1	Inadequate fire safety awareness						
2	Inexperience H&S officers						
3	Irregular fire auditing						
4	Arsonist						
	NAKED FIRES						
1	Fireworks						
2	Cooking fire						
3	Candle fire						
4	Unextinguished discarded cigarette						
	HEATING DEVICES						

1	Faulty equipment use						
2	Incorrect voltage used						
3	Overheating of equipment						

SECTION 3: ECONOMIC EFFECTS OF INDUSTRIAL FIRES.

From your experience which of these economic losses do you consider to be significant to industrial fires? Please rank the by ticking the rating box

1=Highest, 2= Higher, 3=High, 4=Lower, 5=Least

No	Economic losses	Rating					Comment
		1	2	3	4	5	
1	Temporary relocation						
2	Purchasing new equipment						
3	Permanent closure of business						
4	Reduction in gross domestic products						
5	Reduction in employee performance						
6	Compensation to effected persons						
7	Increase in insurance premium						
8	Reconstruction of firm						
9	Reduction in taxes						
10	Reduction in personal income						
	If Others Please Suggest						
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

SECTION 4: FIRE SAFETY MEASURES TO PREVENT INDUSTRIAL FIRES

From your experience which of these fire safety measures do you consider to be important to avoid industrial fires? Please rank the by ticking the rating box

1= most important, 2= more important, 3= important, 4= less important, 5= not important

No	Preventive Measures	Rating					Comments
		1	2	3	4	5	
1	Proper storage of hazardous materials						
2	Regular safety auditing						
3	Provision of fire stops around pipes or ducts						
4	Adequate ventilation of production room						
5	Regular maintenance of equipment						
6	Adequate fire safety awareness						
7	Provision of Exit signage						
8	Installing of firefighting equipment						
9	Regular evacuation dills						
10	Provision of fire alarms and detectors						
11	Proper encasement of electrical wiring						
12	Building accord to local building and fire safety codes						
13	Regular inspection by fire services officers						
	If Others Please Specify						
14							
15							
16							
17							
18							

19							
20							

7) **How often does the Metro Fire Services Personal visit and inspect firefighting equipment**?

Every Quarter ☐ Every Six Month ☐ Once a Year ☐ Once Every Two ☐ Years

Do you have fire certificate? Yes ☐ No ☐

If **Yes** how often do you renew it? If **No** have you made the necessary effort to certify your company?

Thank you