Development of Key Performance Indicators Model for Manufacturing Safety in Paint Manufacturing Firms in Kenya

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A thesis submitted in partial fulfilment for the degree of Master of Science in Mechanical Engineering in the Jomo Kenyatta University of Agriculture and Technology.

2016

DECLARATION

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

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This thesis has been presented for examination with our approval as the university supervisors.

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DEDICATION

I dedicate this thesis to my lovely wife, Janice, and my adorable daughter Vivienne who have been a great source of moral support to me during the entire period, and to my mentor, Prof. Stephen Mutuli.

ACKNOWLEDGEMENTS

I wish to thank my two able supervisors, Prof. Bernard W. Ikua and Dr. Thomas O. Mbuya, for their guidance, and invaluable input that they made in this thesis. I sincerely appreciate the time and effort that they dedicated to go through my work and make important contributions. I also wish to acknowledge the efforts of Dr. Aghahowa Enoma (Ghana) and Prof. Stephen Allen (South Africa) when I sought their assistance while trying to get hold of material that was important for this research.

I remain grateful to the respondents who took their time to sit and be interviewed, fill the validation questionnaires and respond to follow up emails and telephone calls. Without their input, this research work would have been practically impossible. I want to also acknowledge the financial support and moral support of my employer, University of Nairobi. This support was critical in ensuring that I complete this thesis, and the entire course, with the least financial constraints. Lastly, my diligent classmates who shared a lot of information which was necessary to enable completion of this thesis, I'm grateful. God bless all.

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LIST OF ABBREVIATIONS

AZF	Azote Fertilisant
BSC	Balanced Score Card
CI	Continuous Improvement
CSF	Critical Success Factor
DHHS	United States Department of Health and Human Services
DOSHS	Directorate of Occupational Safety and Health Services, Kenya
EC	European Communities
EEAA	Egyptian Environmental Affairs Agency
GHEA	Greater Horn of East Africa
HS	Harmonized System
ISO	International Organization for Standardization
KAM	Kenya Association of Manufacturers
KARA	Kenya Alliance of Resident Associations
KES	Kenya Shillings
KPC	Kenya Pipeline Company
KPI	Key Performance Indicator
MIC	Methyl Isocyanate

MoEMR	Ministry of Environment and Mineral Resources, Kenya
MSDS	Material Safety Data Sheet
MTBF	Mean Time Between Failures
OEE	Overall Equipment Effectiveness
PMS	Performance Management System
PPE	Personal Protective Equipment
PPM	Parts Per Million
SAICM	Strategic Approach to International Chemicals Management
UCC	Union Carbide Corporation
UNITAR	United Nations Institute for Training and Research
VOC	Volatile Organic Compound

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ABSTRACT

Manufacturing safety is a key priority in the success of any business, as it can affect both the present and future competitive position of an organization. Several factors can lead to accidents in the manufacturing environment: poor maintenance, mis-operation of equipment, unsafe acts by workers and inferior design/ fabrication of equipment among others. Organizations must measure safety in order to find areas of weakness, and then implement actions aimed at raising safety levels.

Fatal chemical accidents have occurred in several countries of the world. The India's Bhopal gas leak tragedy at the Union Carbide Corporation plant in December 1984 is considered the world's worst industrial disaster. In that accident, 10,259 persons lost their lives. In Kenya, notable chemical industry accidents have been reported from the paint manufacturing industry. In July 2006, a fire accident in a paint manufacturer's premises at Libra House, Nairobi, resulted in over 10 casualties.

Industrial accidents in the chemical industry indicate a need for both leading and lagging indicators of safety in the workplace. The purpose of this study was to formulate and validate a set of key performance indicators that can be used in the measurement and reporting of manufacturing safety in the paint industry. The aim of doing this is to monitor manufacturing safety and ensure a safe working environment for the workers on a continuous basis. The study involved 6 expert interviews that were used to collect data on the safety measurement of the paint manufacturing industry. 21 Key Performance Indicators (KPIs) were formulated from the interviews stage. These were validated using a structured questionnaire. The questionnaire was administered to all 23 firms in Kenya using a combination of personal delivery and telephone based methods. 11 responses were received in the validation stage.

The final results consisted of 21 KPIs, with fire safety being the most relevant KPI. The other KPIs included waste disposal, space utilization, plant air quality, spillage management, safety gear, general health of workers, worker skill, warehousing/ material handling function, risk response, communication, noise exposure, maintenance function, accident and incident rates, general cleanliness of premises, worker commitment and integrity, level of lighting, cost of accidents, management input, documentation and water supply. The KPIs were tested on a micro enterprise dealing with paints manufacturing and the results obtained showed the level of safety was at 4.84, with the least score being on lead exposure at 1.85 and the highest being fire safety at 6.97.

Implementation of these KPIs while recognizing the relevance of each KPI relative to the other KPIs will lead to accurate reports on the level of safety in paint and allied products manufacturing industry. The gathered information can be used to implement activities directed towards reducing the level of worker exposure to health and safety risks within the factory.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

1.1.1 Manufacturing safety

The global economy has brought new challenges into the business world. Such challenges include increased competition for diminishing raw resources, competitive global markets, fast technological innovations, and need to protect the environment on a larger scale. To survive in the face of these challenges, three competitive priorities, i.e. quality of the product/ service, cost of production and cycle time have been emphasized (Ansari & Modarress, 1997).

Another important priority for business success that has not received due attention is safety at the workplace (Ansari & Modarress, 1997). This has partially been attributed to the difficulty of implementing safety programs given the available resources and skills in most organizations (Le Coze, 2012). Industrial accidents have the ability to influence an organization’s present and future competitive position (Mearns & Håvold, 2003). An example is the Piper Alpha disaster on the United Kingdom (UK) North Sea in 1986 which claimed 184 lives and led to the closure of Occidental’s operations on the UK Continental shelf (Mearns & Håvold, 2003).

An injury-free working environment creates a positive employee attitude, results in higher quality of outputs and lower production costs due to decreased rework and scrap, lost time, worker’s compensation and lost workdays. The ultimate safety goal of a business should thus be to provide a productive and safe working environment for all employees. Organizations should therefore aim at creating a positive safety climate within the workplace. Zohar (1980) defines safety climate as “a summary of molar perceptions that employees share about their work environments; a frame of reference for guiding appropriate and adaptive task behaviours." Safety climate simply reflects the workers' attitudes towards safety (Clarke, 2006).

Several factors have been identified as the major causes of industrial accidents (Raouf, 2004). These include poor maintenance, incomplete check and mis-operation of equipment. Other factors include unsafe acts by workers, poor supervision, inferior design or fabrication of equipment and equipment parts, outside disturbance and natural disasters.

Industrial safety has been of concern in every other industry. For instance, in the United States of America (USA) alone, 44,000 to 98,000 patients die each year in the healthcare industry due to treatment errors, costing the government between $17 and $29 billion (Katz-Navon *et al.*, 2007). In the UK manufacturing sector, 41 fatalities, 6,809 major injuries, and 32,550 over three day absences were recorded during the 2002/03 period (Clarke, 2006).

In India, an injury rate of 1.25 per every 1,000 employees was recorded in 2004 (Adebiyi & Charles-Owaba, 2009). In Iran, for every 1,000 employees, 140 accidents are reported annually, with another 852,500 occupational accidents including 1,597 fatalities being recorded in France in year 2000 alone (Fadier & De La Garza, 2006). In 2003, Kenya recorded 2,147,321 occupational accidents involving more than 4 days' absence (Hämäläinen, Saarela & Takala, 2009), of which 2,284 were fatal.

The chemical industry has witnessed many fatal accidents over the last five decades. In June 1974, the Nypro (UK) site at Flixborough exploded killing 28 people and injuring another 36 (Health and Safety Executive [HSE], 1975). The cause of the explosion, according to the court of inquiry, was a leakage of cyclohexane from a bypass pipe fixed two months earlier to enable repairs on a malfunctioning reactor tank. The cyclohexane vapour cloud explosion completely destroyed the plant.

On 10 July 1976, a safety valve failed at a Swiss owned chemical plant located in Seveso, Italy (Gerber, Jensen & Kubena, 2007). This led to release of over 27 kilograms of highly toxic dioxin into the environment (De Marchi, Funtowicz & Ravetz, 1997), exposing over 37,000 residents to the toxic gas.

The India's Bhopal gas leak tragedy at Union Carbide Corporation (UCC) plant in December 1984 is considered the world's worst industrial disaster (D'Silva, 2006). The overall cause of the accident was largely maintenance related (Raouf, 2004). Water leaked into a tank containing 42 tons of methyl isocyanate (MIC) causing an exothermic reaction. About 30 metric tons of MIC were released into the atmosphere within 45 minutes (Varma & Varma, 2005). According to Kalelkar and Little (1988), most safety valves and lines at the UCC plant were in poor condition. Several vent gas scrubbers were also out of service. The disaster led to the death of 10,259 residents within two weeks, and has caused over 558,125 injuries since it occurred (Dubey, 2010).

An explosion at the Azote Fertilisant (AZF) fertilizer factory in France on 21 September 2001 killed 25 people and injured another 2,500 (French Ministry of Sustainable Development, 2012). The cause was the detonation of between 20 and 120 tons of ammonium nitrate residue. Different investigating groups associated the ammonium nitrate residue to mixing of sodium dichlorocyanurate and ammonium nitrate spilled during warehousing activities at the plant. The actual cause of the detonation is not conclusively known.

In July 2006, a fire accident in a paint manufacturer's premises at Libra House, Kenya, resulted in over 10 casualties (Ministry of State for Special Programmes, 2009; & Lehtinen *et al.*, 2009). According to Lehtinen et al., poor safety management, lack of appropriate warehousing facilities and compromising of safety for security were the main contributing factors to the accident. Another 8 employees lost their lives in the

Kariobangi Light Industries' Picasso Chemicals factory fire accident in May 2011 (Ombati, 2011).

The September 2011 Kenya Pipeline Company (KPC) oil spill pipeline tragedy claimed an estimated 75 lives (Society for International Development, 2012). According to Kenya Alliance of Resident Associations (2011) and Mars Group Kenya (2012), the cause of the KPC oil spill was a ruptured gasket. Oil spilled into a nearby storm drain and heavy rains washed the oil into the Sinai village. The oil ignited and killed 75 persons and injured more than 120 others.

These statistics and others not mentioned here, indicate that accidents can occur due to several factors. Such factors include: human error of omission or commission, negligence, maintenance issues, natural cause, unprofessional operation of equipment, and use of unskilled labour.

The government of Kenya has made minor efforts to regulate the hazards and risks posed by paint manufacturers both to their workforce and product users (Ministry of Environment and Mineral Resources, 2011; Nganga, Clark & Weinberg, 2012). This necessitates research into how manufacturing safety levels can be raised in chemical industries and more so paint manufacturing firms in Kenya.

1.1.2 Key Performance Indicators

When an organization embarks on the implementation of a continuous improvement (CI) program, it must identify key performance indicators (KPIs) that will enable taking of measurements that have meaning to the program. A KPI is a performance target with a focus on an output, such as product quality, revenues, and profits, of an organization or part of the organization (Johnson, Whittington & Scholes, 2011). They are meant for comparison purposes, for instance, trends from one period to another or from one organization to the other.

KPIs are identified based on the objective that a CI program seeks to achieve (Raouf, 2004). This is usually so because a CI program seeks to close the gap between the status quo and the desired target. The next step is to identify opportunities for improvement and prioritize them based on return and criticality (Enoma & Allen, 2007). An action plan is then developed and implemented, and the results evaluated against the desired target. This becomes a cyclic process.

The most common KPI in health and safety has been accident and incident rate (Ansari & Modarress, 1997; Mearns & Håvold, 2003). Other key indicators are accident costs, investment in safety, levels of communication on health and safety issues, workforce involvement, health and safety policies, organizing for safety, management commitment to health and safety, testing of employee knowledge on health and safety issues, number of implemented corrective actions within agreed time scale and level of achievement in health and safety plans. Also important are sick leaves, absence due to injuries, and maintenance lag.

Manufacturing safety indicators can be broadly classified into two categories: leading indicators and lagging indicators (Mearns & Håvold, 2003). Lagging indicators show how an entity has performed to date in a certain area. Leading indicators predict how that entity will perform in the future. Program performance may not be adequately addressed by either indicator category alone. Lagging indicators are characterized by time delay and may provide information too late for the right action to be taken (Pojasek, 2009). The leading indicators may fail to link the expected outcomes to the right operational activities. Both lagging and leading indicators should be measurable and manageable. They should also hold the potential to show some improvement over a given period of time.

The intent of this research was to come up with a list of KPIs that can be applied to raise safety levels in paint manufacturing firms in Kenya. An initial list of KPIs was derived from existing literature and examination of risk factors in the manufacture of paint and allied products. This was then improved on during expert interviews and later validated using questionnaires.

1.2 Problem Statement

Industrial accidents in Kenyan paint manufacturing firms have led to loss of lives and impacted negatively on the national economy. In the last 10 years, industrial accidents in the paints industry have claimed at least 93 lives and injured more than 120 people. Causes of accidents are several: chemical explosions, poor maintenance, inappropriate material handling techniques, falling objects and poor safety management among other factors.

The management of health and safety in any organization requires the selection, measurement and management of the right indicators (Mearns & Håvold, 2003). The intention of this research was therefore to formulate and validate a set of key performance indicators that can be used in measuring manufacturing safety in this industry, and therefore form the basis of continuous improvement in manufacturing safety in the industry.

1.3 Objectives

To formulate a set of KPIs that can be used to measure manufacturing safety in the paints manufacturing industry and demonstrate their usability.

The above objective was to be achieved via the following specific objectives:

1) To formulate a set of key performance indicators for manufacturing safety.
2) To validate the KPIs so formulated.
3) Test the applicability of the KPI model based on the validated KPIs.

1.4 Research Questions

1) Which safety KPIs can be used to improve manufacturing safety in paint manufacturing industry?
2) How do the identified KPIs differ in importance in the measurement and reporting of safety in this industry?
3) How can these KPIs be applied in the measurement and reporting of manufacturing safety performance?

1.5 Justification of the study

Given the importance of a progressive economy and the need to protect workers from work-related hazards, there is need to promote creation of a safe working environment in Kenyan industries. Most organizations prefer compliance-oriented approach to manufacturing safety (Yu & Hunt, 2004), where they implement safety actions to meet the bare minimum required by the law. This makes it difficult for these organizations to improve on their safety levels once the minimum requirement has been met.

The government of Kenya, through the now defunct Ministry of Environment and Mineral Resources (MoEMR), and in partnership with United Nations Institute for Training and Research (UNITAR) implemented programs that were aimed at adopting the Strategic Approach to International Chemicals Management (SAICM) to ensure safe production, use and disposal of chemicals in Kenya (MoEMR, 2011). According to the ministry, this was aimed at reversing the negative effects of the trade liberalization policy which Kenya has been party to since 2004, and which had led to reduced monitoring and reporting on chemical production, use and disposal.

The Ministry of Labour’s Directorate of Occupational Safety and Health Services (DOSHS) has continued to make efforts to regulate the hazards and risks posed by paint manufacturers both to their workforce and product end user. However, the country continues to be exposed to paints with high levels of heavy metal (lead) with cases of up to 69,000 parts per million (ppm) being recorded in samples picked from Kenya against the recommended 90 ppm (Nganga, Clark & Weinberg, 2012). This means that it is not only the health and safety of the paint firms' workforce that is compromised, but the end user's as well.

An online search of the available literature showed there was lack of research on KPIs relating to health and safety in the paints and allied products industry in the chemical industry. Therefore, a solid safety measurement model consisting of validated key performance indicators is necessary for this industry. Paint manufacturers can then use this model to assess their performance in terms of safety, and implement the necessary actions that would lead to higher safety levels within their firms.

1.6 Thesis Layout

The first part of this thesis starts with an abstract highlighting the major elements of this study, and an introduction to the two important concepts, that is, manufacturing safety and key performance indicators. It then follows with an in-depth review of literature on paint manufacturing process and literature from empirical studies on KPIs in different industries. A methodology on sampling and data collection and analysis is then laid out.

The final part of the thesis looks at the research findings. It starts with analysis and discussion of the research findings and then makes conclusions and recommendations observed from the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to review both theoretical literature on paint manufacturing and also empirical literature on KPI formulation and use in different industries. The review is expected to guide the researcher in determining the kind of data that needs to be collected to answer the research questions. It is also expected to reveal clear gaps in the existing literature as well as the most used methods of collecting data on KPI formulation.

Organizations can be reactive or proactive when dealing with safety issues in the workplace (Waring, 1996). The reactive approach as a means of reducing accident losses has many shortcomings. The approach permits many fatalities and injuries to occur for evaluation of needs and priorities in safety measures (Yu & Hunt, 2004). Yu and Hunt (2004) propose the integration of the safety management system into the total quality management program of an organization.

Ansari and Modarress (1997) propose that organizations should use a more predictive strategy (proactive approach) that measures safety and health performance in advance of accidents. Continuous improvement (CI) unceasingly strives to improve the performance of production and service firms (Zangwill & Kantor, 1998). Performance improvement through CI has been witnessed at Motorola, General Electric, Honda, Honeywell and Sony among others (Bhuiyan & Baghel, 2005). The concept can be applied by organizations to raise their manufacturing safety levels as well.

The role of KPIs in improving performance is closely interrelated to risk management, performance management and benchmarking (Enoma & Allen, 2007). Risk management deals with risk perception, risk identification and risk audit. Performance measurement enables good planning, contributes to continuous improvement, and improves resource allocation (Sinclair & Zairi, 1995; Rose, 2006). Benchmarking enables comparison between an organization and the best in the industry. A benchmark serves as a standard against which relative performance can be measured, whether internal or external. KPIs are good in identifying the performance data required and also in pointing out the shortcomings in available data. They enable an organization to benchmark the right attributes of performance.

According to Hinks and McNay (1999), the practical use of KPIs involves industry-specific or organization-specific indicators. This may be so due to their specific context of application. A performance measurement system should contain not too many and not too few performance indicators. Too many indicators may lead to loss of focus while too few may provide poor judgement as to the true performance of an organization or a part of it.

Slater et al. (1997) suggest a set of between seven and twelve indicators, although other literature shows that this number depends on the industry (Hinks & McNay, 1999; Ugwu & Haupt, 2005; Bäckström, Kyster-Hansen, Swahn & Blinge, 2012). Once the main KPIs have been formulated, an organization can then define the sub-KPIs from which it can readily collect data for use in continuous improvement.

2.2 Paint Manufacturing Process

Products of the surface-coating (paints) are essential for the preservation of all types of architectural structures and manufactured goods from ordinary attacks of weather. Paints also increase attractiveness of manufactured goods, as well as the aesthetic appeal of both interiors and exteriors of architectural structures. They can also be used to provide information such as in traffic signs, road markings and information signs.

The paint industry is a branch of the chemical industries sector. Surface coatings (paints) have been divided into five product categories (Egyptian Environmental Affairs Agency [EEAA], 2002): solvent-based paints; water-based paints; varnishes and clear coatings; printing inks; and resins (used in manufacture of paints and varnishes). Thus a paint factory can have different production lines for each category. Paint manufacturing plants can have as few as one or two production lines or all five of them.

Identification of appropriate performance indicators for any process requires a good understanding of that process. This section describes the materials used in paint and allied products manufacturing, the paint manufacturing process.

2.2.1 Raw Materials and Utilities

2.2.1.1 Main Raw Materials

Liquid paint is a composite of finely divided pigment dispersed in a liquid composed of a resin or binder and a volatile solvent. Thus the main constituents in paints are pigments, binders and solvents (thinners), in addition to many other additives that give the paints specific properties for specific purposes or applications (Bassam, 2008). The liquid portion of the paints is known as the vehicle, which is composed of volatile and non-volatile parts. Non-volatile parts include oils, resins, celluloses, plasticizers, styrene-butadiene, polyvinyl acetate, acrylic and additives. Volatile parts include ketones, esters, alcohol, aromatics and aliphatics.

The pigment serves the optical function of providing colour, opacity and gloss; provides a protective function to the surface beneath; and reinforces the paint itself by helping the binder to stick (New Zealand Institute of Chemistry, 2002). Titanium dioxide is the most commonly used pigment. Other pigments include carbon black, iron oxides, zinc chromate, azurite, chromium oxides and lithopone.

Binders are the most important element in paint production and are used to hold the pigments together and enable them adhere to the surface being coated. Binders determine the application method, drying and hardening behaviour, mechanical properties and chemical resistance of the paint (Paulik, 2011). Printing inks use similar ingredients, that is, pigments, resins, solvents and additives (United States Environmental Protection Agency [EPA], 1992).

2.2.1.2 Main Additives

Additives give the paints specific properties for specific purposes or applications. There are several additives in the paint manufacturing process. They include driers, anti-settling agents, anti-skinning agents, plasticizers, wetting agents, dispersants, fire retarding, anti-floating and anti-foaming agents.

Driers are used to accelerate the drying of the paints. They include cobalt, lead, zinc, zirconium, manganese, calcium, barium and zirconium compounds. Anti-settling agents and dispersants are used to improve dispersion efficiency of the pigments into the vehicle, and to prevent settling of pigments during storage. Anti-skinning agents are added to the paints to prevent the solidification of paints surface during storage (Bassam, 2008).

Plasticizers (special types of oils, phthalate esters or chlorinated paraffins) are used to improve elasticity of paint films and to minimize the paint films tendency for cracking. They also improve the flow, flexibility and adhesion properties of paints. Wetting agents such as surfactants aid wetting of the pigment by binders. Anti-foaming agents such as fatty acid esters, mineral oils, waxes and silicon oils (BYK Additives and Instruments, 2009), are used to prevent foaming during paint production and application. Fire retardants such as borax and potassium bicarbonate (Polyakov, 2011) protect objects from high temperatures in the event of a fire. Anti-floating agents prevent horizontal and vertical segregation of pigments.

2.2.1.3 Utilities

a) Water

Water is a very essential utility in paint manufacturing. Water has several uses, the main ones being rinsing and cooling of equipment. The water is usually pre-treated to prevent scale formation especially where the main delivery line carries hard water.

b) Electricity

Electrical power is another essential utility, and used for lighting purposes as well as powering the various equipment used in paint manufacturing. These include mixers, mills and conveyor belts.

2.2.2 The Production Process

Paint manufacturing involves five major processes (Torrey Hills Technologies, 2012) as shown in as shown in Figure 2.1.

Figure 0.1: Steps in the paint manufacturing process

2.2.2.1 Mixing

Mixing is the first step after raw materials have been acquired and are ready for use. The raw materials can be delivered to mixers using conveyors, installed pipe networks or manually. Resin/ binder, pigment, and solvent are mixed together in large mixing tanks to produce an even mill base. There are different types of mixers: manual, automatic, kneaders, colloid mills, rotary churns, air streams mixing. Figure 2.2 shows an image of a mixer installed at a paint factory. The image on the left shows the upper part of the equipment where the pigment, binder and solvent are poured into the mixer.

(a) Upper section (b) Lower section

Figure 0.2: Main Ingredients Mixer

2.2.2.2 Grinding/ Milling

The even mill base (which is in form of a slurry) from the mixing stage is dispersed using mill equipment/ dispersants where pigment particles are finely dispersed. Common equipment in this process includes roller or ball mills, sand mills and dyno mills (which are mostly used in modern factories).

Although referred to as grinding or milling, the objective of this operation is to disperse rather than reduce the size of the individual particles of the pigment. Figure 2.3 shows examples of milling equipment used in pigment dispersion.

2.2.2.3 Blending

Additive agents are then added to the mill base in blending tanks, and the dispersion process completed. The colour phase is then adjusted using colour materials. Figure 2.4 shows blending tanks.

(a)

(b) (c)

(a) Ball mills; (b) Dyno mills; (c) High speed dispersant

Figure 0.3: Different types of mills

Figure 0.4: Blending tanks

2.2.2.4 Filtration

Blended and toned paint is then filtrated. This operation ensures that any particles larger than normal required size, non-dispersed pigments, foreign materials and any surface hardness are removed from the blended paint. The operation can be achieved through application of fine screens of sizes between 50 microns to 320 microns, filter press, centrifugal separators or normal settling (especially for purification of vanishes). The sludge from this process is treated and disposed. The filtration process is very critical in paint manufacturing. It determines the quality of the final product and productivity of the whole plant.

2.2.2.5 Packaging

This is the final operation where the filtered paint is packed into containers. It involves filling of the containers, sealing with air tight covers, palletizing and stacking appropriately in a warehouse ready for shipping.

2.3 Source of Health and Safety Risks

Paint manufacturing process involves materials and activities that contribute to health and safety hazards that put to risk the lives of the workers. These materials and activities include raw materials such as pigments and powder additives, volatile organic compounds, material handling activities, plant maintenance activities, and operation of equipment.

2.3.1 Pigments and Powder Additives

Materials in form of powder such as pigments and dryer agents have health complications whether they are toxic or not. Reactions to inhaled powder particles can range from mild conditions such as overproduction of mucus within the throat canal, to serious complications such as toxin poisoning. Powder pigments can also react with the skin and cause undesirable health conditions.

Control of pigments and powder additives is important for the health of the workers. Lead metal and its compounds, used as a drying agent, is poisonous and requires proper handling to minimise its effects on the health of workers. An alternative to lead metal as a drying agent is zirconium. Zirconium is a non-toxic transition metal. It is more expensive than lead and up to twice as much the amount is required in paint production.

2.3.2 Volatile Organic Compounds

Volatile organic compounds (VOCs) are unstable, carbon-containing compounds that readily vaporize in air at standard room temperature and pressure. Plasticizers such as phthalates, solvents, formaldehydes and fire retardants are some of the VOCs used in paint manufacturing. VOC emissions are affected by types of solvent used in the manufacturing process, the temperature at which the different raw materials are mixed, and the methods and materials used during cleanup operations (EPA, 1992). VOC content in grams per liter of coating can be determined using the following formula (Koleske, 1995):

$$VOC\ content = \frac{(W_v)(D_c)}{100\%-V_w-V_{es}} \quad (1)$$

where

W_v is the weight % of total volatiles less water less exempt solvent

D_c is the density of the coating

V_w is the volume % of water, and

V_{es} is the volume % of VOC exempt solvent[1]

According to European Commission (1999), VOC emissions occur as fugitive losses during manufacturing, filling and cleaning activities, mixing of preparations and storage of solvents. Short term exposure to VOCs can cause dizziness, nausea, eye irritation, coughing and shortness of breath. Long term exposure can lead to damage of the kidneys, liver, blood and nervous system and increased risks of asthma and other allergies (Ringling College, 2007). In excess release, VOCs react with oxides of nitrogen (NO_x) in the atmosphere to form ground level ozone (New Jersey Institute of Technology, 2002) which is a health hazard to the public.

2.3.3 Material Handling

Material handling is the movement, protection, storage and control of materials and products throughout manufacturing, storage, distribution, consumption and disposal. For the purposes of this study, the concern is on the handling of materials within the manufacturing plant.

[1] A list of VOC exempt solvents is shown in Appendix 4

There are different factors and considerations that determine the movement of material. These include the form of material, characteristics of the material, original position of the material, flow demands, final position, handling equipment available, in-transit conditions, integration with other systems and the degree of control required (Avallone, Baumeister & Sadegh, 2006). These factors will also determine the type of risks that can result during material handling.

The manufacturing environment in the paints and allied products industry involves different materials that require different handling methods for optimal safety. These materials include the solvents, the pigments and other additives used during the production process. Material handling can result to falling objects, materials slipping from material handling equipment (United States Department of Labour, 2002) and spilling, interruption of the production process, and related accidents.

In well established plants, solvents and other thinners are kept in sealed tanks and transported to points of use via installed pipe networks. This minimizes the level of VOCs within the plant and hence reduces health and safety risks involved. Dust extractors are used to control pigment dust and provide a working environment with low dust levels. Where these extractors are not installed, employees are exposed to air that has high levels of dust and is harmful to their health.

2.3.4 Plant Maintenance

Plant maintenance is an important factor in the manufacturing industry. It determines availability of equipment and how well a plant can process orders given the other production factors are held constant. It involves repairs of broken equipment, replacement of worn out parts, redesign of plant to ensure optimal performance and monitoring the production process to schedule maintenance works.

The maintenance activity requires knowledge of engineering principles and operation procedures of the equipment involved. Maintenance activities that may affect safety include unsafe operation of equipment during maintenance, incomplete installation of parts, incorrect assembly of parts incorrect tool usage and damaging of some parts during repair (Adebiyi & Charles-Owaba, 2009). Such mistakes not only pose a threat to the safety of the operators, but also increase the cost of maintenance as a result of poor equipment performance.

Plant maintenance also determines the duration of downtimes. Poor maintenance leads to more downtime and puts pressure on the production teams. Employees working to meet strict deadlines may overlook safety procedures and cause accidents, especially when there are time constraints. These safety procedures may include among others, the safety of working in heights, safe dismantling of equipment and appropriate use of personal protective equipment (PPE).

2.3.5 Operation of Equipment

Operation of the equipment used in paint manufacturing requires skilled labour. These equipment include the forklifts used in material handling, the mixers, millers, and filtration equipment. Using skilled labour minimises the number of omissions committed by the machine operator. Reduced omissions translate to reduced level of human-machine related incidences.

Even where skilled labour is used to operate equipment/ machines, other factors can contribute to acts of omissions by the operator. These include fatigue, illness, lack of concentration, strict work deadlines and inappropriate dressing. It is thus important to ensure that machine operation results in as minimal incidences of accidents as possible. This is usually achieved through addressing the above factors and through use of printed operating procedures against every piece of equipment within the plant. This should include the dos and the don’ts.

2.4 Empirical Literature

Health and safety at the workplace is mostly perceived as an operational management area, where costs exceed benefits. This is despite poor safety performance having been shown to significantly impact organization's profits (Fuller, 1999). As a result of this perception, many organizations implement safety programs with an intent of complying with regulatory requirements (Yu & Hunt, 2004). This approach to health and safety management does not promote continuous improvement.

Absence of accidents does not imply they will remain absent (Rose, 2006). A more proactive approach to health and safety management is necessary. This is so because any industrial accident or incident can lead to loss of lives, destruction of property and pollution to the environment; consequences, some of which cannot be costed to justify lack of appropriate measures to prevent such accidents.

Continuous improvement uses defined metrics and tools to measure, determine variance, and implement necessary programs with an aim to achieving particular targets. Once those targets have been achieved, new ones are determined and the process continues. Benchmarking enables organizations to compare their output results with results from the best in the industry. For comparison to be possible, and to enable objective collection and manipulation of performance data, the metrics used to measure the output must be clearly defined. KPIs enable objective collection and analysis of performance data. Appropriate performance data is then used by organizations to establish areas of poor performance in their operations, and thus find suitable ways to improve.

Studies have been done on the formulation of industry-specific KPIs, such as on safety and security in the aviation industry (Enoma & Allen, 2007), facilities management function (Hinks & McNay, 1999), transport and infrastructure management (Bäckström *et al.*, 2012), and infrastructure sustainability in the construction industry (Ugwu & Haupt, 2005).

These studies reflect how KPIs can be used in both private and public sector to enhance performance by application of relevant metrics in measurement of performance data.

Enoma and Allen (2007) did a case study to develop and test a list of KPIs that can be used for airport facility management with a focus on safety on security. They argue that performance indicators have been used to monitor past performance, and that there is need to find leading indicators that can be used to predict future performance in facilities. In that study, they were able to come up with five KPIs: breach of security; evacuation in the case of fire, bomb, or acts of terrorism; hysteria control; attack on airport facilities; and destructive or criminal behavior, either directed to passengers or cargo. Enoma *et al.* (2009) later used these KPIs to collect and analyse data from three Scottish airports and the Civil Aviation Agency. Their findings indicate that the KPIs have an effect on the design of the airports in order to effect safety and security.

In a study that sought to identify a set of appropriate KPIs that could be used by a premise's department to analyse their performance for their internal customers, Hinks and McNay (1999) came up with a set of 23 KPIs. This set was arrived at after an initial list of 172 proposed KPIs. In their findings, they observed that the definition of KPIs tended to be influenced by the business context. Hinks and McNay also argued that using KPIs made it possible to determine if performance was drifting from the intended course. However, they also noted that customers' interpretation of the KPIs was slightly different from that of the department. This highlights the need to incorporate both organizational views and those of the affected customers when formulating KPIs.

Bäckström *et al.* (2012) in their report on KPIs that could reflect sustainability issues in the Swedish transport and infrastructure, argued that there was need to include both operational and enabling KPIs if true performance was to be measured correctly. In that report, Bäckström *et al.* came up with a list of 13 KPIs: total goods volume, on time delivery, corridor ability and capacity, total energy used, green house gases emitted, engine standards, ISO 9001 dangerous goods, alternative fuels filling stations, ISO 31000, ISO 39000, common safety rating systems, safe parking, and fenced terminals. These, they argued, would lead to economy of scale, which is the core logic of transport logistics operation.

Another study on KPIs in infrastructure sustainability was carried out in the construction industry by Ugwu and Haupt (2005). The study was to ascertain perceptions and prioritization of KPIs for infrastructure sustainability from a cross section of industry stakeholders in Hong Kong and Republic of South Africa. In that study, a total of 55 KPIs were formulated from an extensive literature review. Their findings showed some agreement among the stakeholders on the indicators used. However, there was a slight difference on how the stakeholders prioritized the KPIs, which Ugwu and Haupt attributed to macro-level economics such as level of economic development in these two countries. This is in agreement with Hinks and McNay's (1999) observation that KPIs tend to be industry-specific and that their definition is influenced by the business context.

2.5 Research Approaches in Reviewed Literature

In this section, the main aim is to identify the research approach used in most studies involving KPI formulation, validation, prioritization and implementation. It will also identify the methods and instruments used in collecting the relevant research data, and finally the tools used for data analysis. In doing so the author intends to identify the most suitable research approach to use, the most appropriate data collection and analysis tools and instruments, and why some methods and instruments may not work for this study.

Case studies have been widely adopted by most research on KPIs (Enoma & Allen, 2007; Hinks & McNay, 1999; Enoma *et al.*, 2009; Bäckström *et al.*, 2012). The use of case studies in formulation and validation of KPIs is driven by the nature of effective KPIs, in the sense that they are industry-specific. Case studies offer an in-depth understanding of a particular subject. This is as opposed to statistical studies which are designed for breadth rather than depth (Cooper & Schindler, 2006).

There is also a particular trend on the methods and instruments used in these studies to collect data. For instance, Enoma and Allen (2007) used a combination of structured interviews involving key airport personnel, questionnaires, observation and workshops. Bäckström *et al.* (2012) used a combination of literature screening, interviews with experts and partners, questionnaires, statistics publications, and workshops. Ugwu and Haupt (2005) employed literature synthesis and screening, structured interviews with industry professionals, and questionnaires for validation of KPIs.

In the above studies, literature synthesis and screening was mainly used as the initial step to formulation of KPIs. Structured interviews and workshops were used to collect views and opinions from industry experts and professionals on the KPIs suggested after literature screening. This was also used to improve on the list of suggested KPIs since the literature may lack performance indicators that are important in the area under study. Use of opinions from experts is critical in formulation of KPIs since they tend to have a clear understanding of the field, industry, or generally, the business in context. Questionnaire-based surveys and workshops were used to validate the KPIs.

The Delphi technique was used by Hinks and McNay (1999) as their main instrument in the formulation and validation of KPIs. The Delphi technique is a methodological procedure that uses questionnaires, workshops and group discussions to collect data from a team of experts. The technique is designed to gather expert opinion in areas where there is lack of agreed knowledge. To analyse the data collected, more so on the validation of formulated KPIs, descriptive statistics such as mean and standard deviation are often used (Ugwu & Haupt, 2005).

2.6 Summary of Research Gaps

Manufacturing safety in man-machine systems is an important factor in the chemical industry. Presence of inflammable materials, possibility of liquid spillages, harmful uncontained chemical reactions and possible catastrophic consequences in the event of an accident makes this industry very sensitive to health and safety actions. Application of continuous improvement practices can improve the performance in health and safety in the chemical industry. This requires benchmarking of performance measures against set targets. A thorough understanding of these measures, their formulation and usage is important so that organizations measure what is relevant to their benchmarking process. These measures are derived from KPIs that are usually defined to aid learning in the company.

Research work on the formulation of industry-specific KPIs has been done in other areas such as aviation industry, health care/ medical industry, infrastructure sustainability, profitability and economics. An online search of the available literature shows there is lack of research in KPIs relating to health and safety in the paints and allied products industry in the chemicals industry. This is one of the clear gaps that are identified in the reviewed literature. A second identified gap is that there is no model that is based on such KPIs that can be used to measure and report manufacturing safety in this industry. Sectors of the chemical industry include: inorganic chemicals and organic chemicals, fertilizers, tanning, dyeing/ colouring pigments and extracts, paints and varnishes, essential oils and resinoids, soaps and wax related chemical products, explosives, and photographic goods. Each of these products are classified under different harmonized system (HS) codes; the paints and allied coating products lie under Chapter 32 of the HS codes (Kenya Bureau of Standards, 2012).

There is increased demand in construction chemicals, paints and coatings, with the growth seen in the infrastructure construction and repair projects, such as housing projects and highways (Deloitte, 2010). As this section of the chemical industry grows, industrial health and safety programs continue to be critical in prevention of both actual accidents and near-incidents. It was therefore imperative to conduct a study to come up with key performance indicators that would objectively be used to measure health and safety performance in this industry, with an aim of making improvements in the relevant operations. This study will enable paint manufacturers fully understand the different variables involved in maintaining the safety of its employees, and the paints industry will become a safer working environment for employees.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter examines the research design suitable for the study and evaluates the sampling procedure required to collect relevant data for the study. It also examines the data analysis tools that will adequately bring out the required picture created by the collected data. This is necessary to avoid collecting data that is not useful to this study and also to limit data analysis to the scope of this study thereby saving time and resources.

3.2 Research Design

A formal, communication type of study in form of a case study of the paint manufacturing industry was adopted. Expert interviews were conducted to enable formulate health and safety key performance indicators in this industry. Questionnaires were then distributed with the aim of collecting data that would enable validate the formulated key performance indicators. This design has been used by Hinks and McNay (2009) and Enoma and Allen (2007).

3.3 Research Framework

The study involved two steps as shown in Figure 3.1. Phase 1 of the study aimed to collect data on health and safety performance KPIs in the paint manufacturing industry. This data was then analyzed with the objective to come up with initial list of health and safety KPIs. Phase 2 involved validation and prioritization of the KPIs. Data collected during phase 2 was analyzed with the aim of producing the final list of the KPIs.

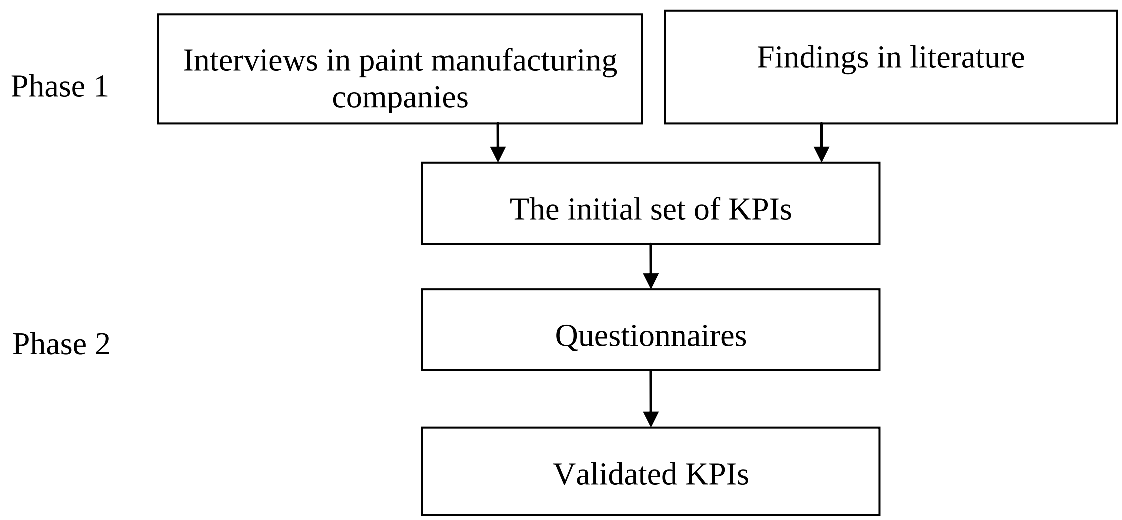

Figure 0.1: Research framework and methodology

3.4 Study Population

The population consisted of the production managers, safety professionals and other personnel directly involved in the planning for health and safety in paint and allied products manufacturing firms in Kenya. There are 23 paint and allied products manufacturing firms in Kenya (Kenya Postel Directories, 2013). The list is shown in Appendix 1.

Purposive sampling was used to select sample elements. Purposive sampling technique is a non-probability sampling that is used when one intends to study a certain phenomenon with knowledgeable experts within. It is fundamental to the quality of the data gathered in such studies. The objective of using this form of sampling therefore was to enable the researcher select those respondents who were experienced and knowledgeable enough in the handling of safety programs within their workplace so as to provide relevant data to this study. This type of sampling has been extensively employed in the reviewed literature as seen in the studies carried out by Enoma and Allen (2007), Ugwu and Haupt (2005) and Bäckström *et al.* (2012).

The sampling involved selection of all the elements from firms with established health and safety departments. This was necessary to ensure that most of the required data was captured as these firms have more safety infrastructure in place as compared to small firms. Based on the above criterion, a sample of 12 firms was selected, which included all the 5 large scale manufacturers and 7 small scale manufacturers; the 7 small scale manufacturers mostly had production managers who doubled as the health and safety manager. In the validation phase of the study, a census survey of the 23 firms was used since the number was relatively small for the researcher to administer questionnaires to all. In order to test the KPIs, one small scale manufacturer was selected.

The selection of a small scale firm was informed by two factors. First, the formulation of the KPIs was largely derived from data gathered from large scale manufacturers. The small scale manufacturers did not have established departments or units that focused on safety at the workplace. It would therefore be of interest to the researcher to see how they would perform based on the KPIs. Second, the size of a firm would determine the amount of time and funds required to gather data in such an exercise, due to the number of people to be interviewed and the records to be cross examined. There were limited funds and therefore a need to collect this data within reasonable costs.

3.5 Data Collection

Data was collected from the respondents using structured interviews and self-administered questionnaires. Structured interviews were used to collect data on different KPIs that formed the initial list. A total of 6 interviews were conducted from the sample of 12 respondents selected for the interviews. The other 6 respondents showed no willingness to participate in the interviews. Validation questionnaires were designed and used to validate the KPIs generated in the interview phase of the study. The initial mode of administration of the questionnaires was personal delivery. Using this approach, the researcher got a total of 6 responses. Another 5 responses were collected after the researcher chose to employ telephone based methods of data collection. This was a necessary attempt to increase the number of responses to a reasonable level. A sample of the interview questions is shown in Appendix 2. The validation questionnaire used for this study is shown as Appendix 3.

Literature synthesis and review of safety risks involved in the manufacturing of paints and allied products was used to supplement the data on KPIs that were collected using the structured interviews and questionnaires from the selected field experts. It was also a good guide to the researcher in establishing points of authority from the interviewees.

3.6 Data Preparation and Processing

Case analysis was used to analyze the responses collected during the interviews. Case analysis was carried out through an approach called summative content analysis. Summative content analysis involves counting and comparisons, usually of keywords or contents, and thereafter an interpretation of the underlying context (Hsieh & Shannon, 2005). The other two possible methods of content analysis are conventional and directed content analysis. Conventional approach is generally used with a study design whose aim is to describe a phenomenon especially when the existing literature on the phenomenon is limited. Where there is existing theory of the phenomenon, directed content analysis is used to provide further description of the phenomenon.

The purpose of analysis was to find the key words that describe measures of health and safety in paint manufacturing. From the three approaches described above, both conventional and directed content analysis would not have provided a summary of these key measures since they seek to develop or further existing description of a theory from the case study. Summative content analysis on the other hand seeks to establish keywords that describe a wider phenomenon, hence its selection for use in this study.

Processing of the returned questionnaires used during the validation stage involved sorting and coding of the responses. The variables were the KPIs that respondents were required to give a relative rating. The data was entered for processing using Microsoft Excel, SPSS and SAS JMP® software. Descriptive statistics such as mean and standard deviation were used to summarize the coded data. These values are important because they'll tell what the industry perceives to be the right approach in terms of handling health and safety within the paints and allied products manufacturing industry.

3.7 Testing of Safety Using KPIs

To show the practicality of the KPIs from this study, the KPIs were used to measure the level of safety in one of the factories in this industry. Data available in company records was used, and where the data was not available, information was obtained through interviews. The KPIs were measured using the sub-KPIs shown in Table 0-1. The data was then analyzed to provide a single measure for each KPI as shown in Appendix 5. A soft copy of the Ms Excel analysis worksheet has been attached.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the data collected in the two phases of this study. Firstly, the interview data is analyzed and used to derive the initial set of KPIs. Secondly, the data from the validation questionnaires is analyzed and discussed in depth. The results of the validation phase are then presented in a model that is then employed to measure the safety performance in one of the 23 firms.

4.2 Analysis of Interview Responses

A total of 6 structured interviews were conducted in the first phase of the study. This represents 50% of the initial target of 12 interviews. A response rate is meaningless if it is not further explained. To put it in perspective, the interview phase of this study sought data that was rich enough to provide a source for extracting relevant key performance indicators. To provide this kind of data, it would require the participant to be well knowledgeable in handling of health and safety in the manufacturing setup.

Five of the six firms that participated in the interviews had established departments handling health and safety. Only one firm did not have such a department, but nonetheless, had a production manager who doubled as the head of safety. The other six firms that declined the interview are all light companies operating within residential areas.

According to Bonde (2013), the homogeneity and degree of knowledge and expertise can be used to determine when saturation has been reached when interviews are the main source of data. Saturation is that point beyond which little or no more new data is being collected. The 23 firms are all homogeneous in that they share similar characteristics of belonging to the industry of paint manufacturers. The six firms had people quite knowledgeable and with more than three years of expertise in handling health and safety matters in this industry. This is as opposed to the other firms that did not participate, which did not have much expertise in health and safety matters. Where the interviewees have knowledge and are experts, saturation is reached early as was the case in this study. The six interviews can therefore be used to generalize the results of the study to cover the 23 firms.

The data collected during the interviews was then case analyzed using the method of summative content analysis described in the previous chapter. This was done with a view to extract health and safety key performance indicators for manufacturing safety in paint and allied products firms in Kenya. The method of extraction involved finding keywords from the interview responses; keywords that capture the entire scope of measuring manufacturing health and safety in the given environment. The researcher then listed all the keywords and defined them using existing literature and within the context of paint manufacturing. These keywords became the set of performance measures that needed to be validated in the second phase of the study.

A list of 21 key performance indicators was extracted from the 6 responses. These include: accident and incident rates, cost of accidents, management input, worker skill, worker commitment and integrity, plant air quality, noise exposure, spillage management, level of lighting, safety gear, waste disposal, maintenance function, fire safety, cooling water supply, warehousing and material handling function, space utilization, book keeping, risk response, communication, general health of workers and general cleanliness of premises.

The basic requirement of a key performance indicator is that it should be measurable. To show measurability characteristics of each key performance indicator, existing literature was used to obtain sub-KPIs that can be measured to document and report each of the KPIs. Table 4.1 shows these KPIs and their suggested sub-KPIs.

Table 0-1: Key Performance Indicators (from interview stage)

S/No	KPI	Sub-KPIs/ Direct measures
1	Accident and incident rates	Number of accidents/ incidents within a given period; recorded near misses in a particular period
2	Cost of accidents	Amount of money spend on compensation of victims of accidents; annual healthcare costs; first aid costs
3	Management input	Number of meetings held by senior management on issues of health and safety; average time taken to implement different policies on health and safety; percent of budget allocated to Health, Safety and Environment (HSE) activities; Number of HSE seminars (or employee HSE training hours) conducted within a given period
4	Worker skill	Hours of in-the-job training; number of hours of job practice; education level
5	Worker commitment and integrity	Hours absent from work; Worker productivity; number of work related initiatives from an employee; number of tasks completed within agreed time
6	Plant Air quality (Air Analysis)	Level of pollutant (lead, ammonia and VOCs) concentration in atmospheric air per cubic unit measured annually (NEMA) or at shorter internally agreed periods
7	Noise exposure (Sound analysis)	Number of decibels emitted from source object conducted annually (NEMA) or at shorter internally agreed periods
8	Spillage management	Frequency of spill drills; response time by target group to contain spills; number of (un)controlled spills
9	Level of lighting	Level of lighting in lux or foot-candles
10	Safety gear	Percentage of employees with proper personal protective equipments (ppes); percentages based on working condition of the ppes; inspection intervals for ppes; commitment to using the gear by workers
11	Waste disposal	Amount of waste generated per ton of paint produced; percentage of waste recycled; amount and percentage of treatable waste; number of complaints received due to mishandled waste

Table 4.1 Continued…

12	Maintenance function	Lost machine hours due to downtimes; mean time between failures (mtbf); Lost production volume during downtime; lost man hours during (un)scheduled downtimes; skill of people doing the evaluation of the failure; maintenance cost; Overall Equipment Effectiveness (OEE)
13	Fire safety	Clarity of guidelines on fire safety; number and frequency of fire incidences/ near misses; amount of extinguisher medium per square unit of working space; number of fire drills in a year
14	Cooling Water supply	Number of dry tap hours within given period (dry tap defined as flow below levels required to maintain operations)
15	Warehousing/ material handling function	Accidents and incidents from falling objects; percentage of properly sealed containers; percentage of leaking containers; percentage of materials and chemicals with missing, incomplete or worn out material safety data sheets (MSDSs); percentage loss of raw materials (difference in materials in and materials out)
16	Space utilization	Percentage of space occupied by machines and other equipment; per employee utilisation
17	Book keeping	Percentage of general HSE audits (NEMA) completed in time (quarterly); Percentage of missing HSE related activity records
18	Risk response	Amount of time taken to contain an incident; policies in place with regard to risk mitigation and handling
19	Communication	Level of communication of activities affecting neighbours; percentage of external complaints handled effectively; average response time (ART) to different situations such as accidents, alien intrusion recognition; average communication cycle time
20	General health of workers	The frequency of certain illnesses among workers; man hours lost due to minor ailments; man hours lost due to minor accidents
21	General cleanliness of premises	Frequency of premises cleanups; the efficiency of material handling function; per cent of times when floors are wet

4.3 Analysis of Questionnaires

A total of 23 questionnaires were distributed to all paint and allied products manufacturing firms in Kenya.

4.3.1 Response Rate

A total of 11 duly filled questionnaires were collected. This represents a response rate of 47.8%. The respondents included some of those firms that had participated in the interview stage as well as those who did not. This was necessary to ensure validity of the data being sought for. The percentage of 47.8% is representative of the entire population since all the population is involved in the manufacture of the same products and the processes involved are the same across the industry. This enabled the researcher to generalize the findings of the study to the entire 23 firms.

4.3.2 Descriptive Statistics

Table 4.2 shows the computed Mean and Standard Deviation, SD, for each KPI. The KPIs are arranged in the order of the highest Mean. The Standard Deviation values define the amount of variation in a set of data values. A further statistic, standard error, SE, was calculated to ascertain how far the mean is from the true mean of the population. The values obtained at 95% confidence interval show relatively low values of SE, that is, 0.091 to 0.944, and these indicate that the true mean is less than 1 unit away from the calculated means.

4.3.3 Nomenclature of the Key Performance Indicators

Respondents to the validation questionnaires were asked to suggest a different name for each KPI depending on the actual names used in the industry, HSE audit requirements, and professional expertise, where applicable. Four out of the eleven respondents indicated that the *Book Keeping* KPI should be renamed *Record of Past Incidences, Register Keeping*, *Health*, *Safety and Environmental Audits* or *Documentation*. Out of the 4 suggested names for the KPI, *Documentation* was seen to fully define the measure in question and was therefore adopted. The other reason for adopting this new nomenclature for the KPI was that the respondents indicated that, as it was, *Book Keeping* could easily be confused with the book keeping function in accounting.

Table 0-2: Mean and Standard Deviation of Different KPIs

Key Performance Indicator	Mean	SD	SE
Fire safety	9.91	.302	0.091
Waste disposal	9.82	.405	0.122
Space utilization	9.73	.905	0.273
Plant Air quality (Air Analysis)	9.55	.934	0.282
Spillage management	9.55	.522	0.157
Safety gear	9.55	.934	0.282
General health of workers	9.55	.820	0.247
Worker skill	9.45	1.214	0.366
Warehousing/ material handling function	9.45	.820	0.247
Risk response	9.45	1.293	0.390
Communication	9.45	1.036	0.312
Noise exposure (Sound analysis)	9.36	.809	0.244
Maintenance function	9.36	2.111	0.636
Accident and incident rates	9.18	2.089	0.630
General cleanliness of premises	9.09	1.921	0.579
Worker commitment and integrity	9.00	1.732	0.522
Level of lighting	8.91	1.640	0.495
Cost of accidents	8.73	2.284	0.689
Management input	8.73	2.687	0.810
Documentation	8.09	2.256	0.680
Water Supply	8.00	3.130	0.944

Two out of the 11 respondents indicated that the *Cooling Water Supply* KPI should be renamed *Water Supply* or *Cooling Systems*. The *Water Supply* suggestion was adopted since the argument was that both cooling and cleaning depend on water supply. This implies that water supply should be adequate for both functions which independently influence safety.

One respondent indicated that *Safety Gear*, *Risk Response* and *Communication* KPIs should be renamed to *Personal Protective Equipments*, *Emergency Response* and *Internal and External Communication* respectively. *Risk Response* was retained since the KPI involved both emergencies occurring within the premises and the policies in place to mitigate incidents, which may not adequately be covered under the nomenclature of *Emergency Response*. The other 2 suggestions, that is, *Personal Protective Equipments* and *Internal and External Communication* were also not adopted since a majority of 10 out of 11 respondents indicated that the initial nomenclature assigned by the researcher was satisfactory. The results are summarized in Table 4.3.

Table 0-3: Adjusting of KPI Nomenclature

S. No.	Initial Nomenclature	Suggested Nomenclature[2]	Adopted Nomenclature
1.	Book Keeping	Record of Past Incidences; Register Keeping; Health, Safety & Environmental Audits; Documentation	Documentation
2.	Cooling Water Supply	Water Supply; Cooling Systems	Water Supply
3.	Safety Gear	Personal Protective Equipments	Safety Gear
4.	Risk Response	Emergency Response	Risk Response
5.	Communication	Internal & External Communication	Communication

[2] The frequency of the suggested alternative names was 1 in all cases.

The respondents unanimously considered all the other 16 KPIs to have been appropriately named. This new nomenclature of the 2 KPIs was adopted for the final list of KPIs as shown in Table 4.4.

4.3.4 Additional Key Performance Indicators

The respondents were also asked to suggest other key performance indicators that may not have been listed in the validation questionnaire. Out of the 11 respondents, only 1 respondent indicated that *training*, *first aid* and *conformity to legal requirements and other bodies* should have been among the suggested KPIs. *Training* had been covered under *Management Input* as training relating to health, safety and environmental activities, and also under *Worker Skill* as training relating to the profession of the worker. It was therefore not included in the final list of KPIs as a standalone KPI.

First Aid is an event that takes place in response to an accident or an incident, to stop the worsening of a condition as the victim awaits medical attention, or as remedy to minor mishaps. The cost of offering first aid can be measured, making first aid measurable in the sense of cost. However, the researcher had bundled this cost among other costs as a sub-KPI (annual healthcare costs) under *Cost of Accidents*. To emphasize its importance in the management of safety in this industry, first aid cost was separated from the sub-KPI of "annual healthcare costs and listed as a sub-KPI on its own as "first aid costs".

Conformity to legal requirements and other bodies by an operational unit is an element that reflects the basic minimum requirements that have to be met to ensure continued operation of business and avoid related penalties. The intent of this research was to provide a model from which paint and allied product firms can design safety activities with the aim of achieving "*zero defects*", that is, zero incidents in the management of health and safety. Conformity to legal requirements and other bodies will only ensure that the basic minimum requirement is achieved and does not necessarily promote continuous improvement. Moreover, conforming to legal requirements is not optional; it is mandatory. According to Roubtsova and Michell (2013), key performance indicators should be oriented towards improvement and not to conformance. *Conformity* was therefore not included in the final list of KPIs.

Table 0-4: Nomenclature of the 21 Key Performance Indicators

Serial No.	Key Performance Indicator
1	Accident and incident rates
2	Cost of accidents
3	Management input
4	Worker skill
5	Worker commitment and integrity
6	Plant Air quality (Air Analysis)
7	Noise exposure (Sound analysis)
8	Spillage management
9	Level of lighting
10	Safety gear
11	Waste disposal
12	Maintenance function
13	Fire safety
14	Water supply
15	Warehousing/ material handling function
16	Space utilization
17	Documentation
18	Risk response
19	Communication
20	General health of workers
21	General cleanliness of premises

4.4 Key Performance Indicators Model

4.4.1 Introduction

There exists several approaches to formulation and validation of area specific key performance indicators (Roubtsova & Michell, 2013). The approach used in this study was that of using existing research, expert knowledge and other available documents in the formulation and validation of KPIs. This approach is summarized in figure 4.1.

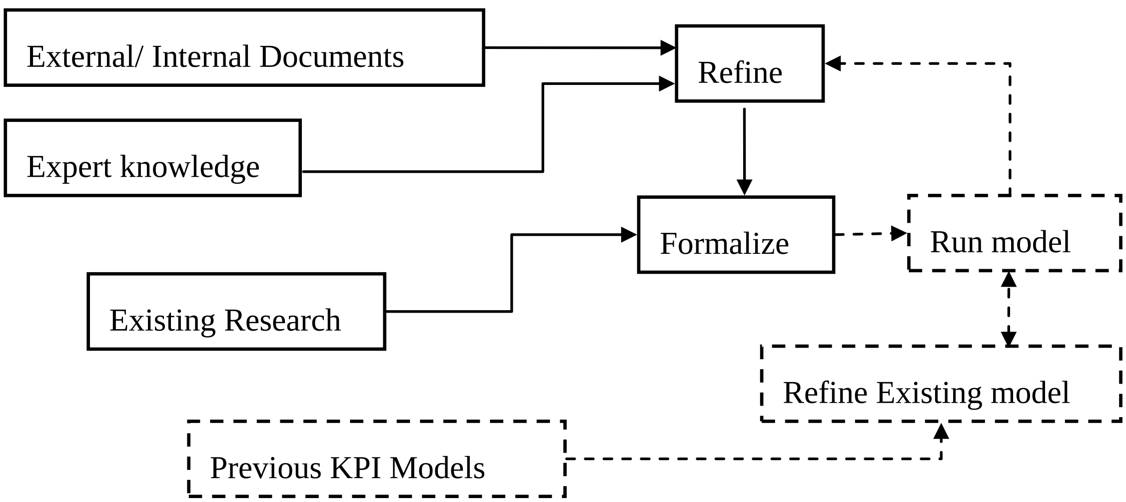

Figure 0.1: KPI Design Model

The solid line items indicate the steps that were completed during this study. However, the design of key performance indicators is an iterative process which takes place over time, as new systems replace old ones and some measures become obsolete. For this reason, the dashed line items were included to indicate the subsequent steps that would be included in the initial KPI design model to ensure that the initial KPIs are improved upon over time.

The findings of this study included a list of 21 key performance indicators that are relevant in the measurement and management of manufacturing safety within paint manufacturing industry in Kenya. Indeed, the management of safety begins with identifying the sources of the risks involved, understanding the metrics that would adequately report on the risks, identifying key action initiatives to manage those risks and, reviewing and continual improvement of safety programs. During this study, five major sources of risks were identified. These include pigments and powder additives, volatile organic compounds, material handling activities, plant maintenance activities, and operation of equipment.

4.4.2 The Key Performance Indicators Model

The results from the validation stage showed that all the 21 KPIs were highly relevant in the measurement and management of health and safety within the paint manufacturing industry. The KPI with the least mean was *Water Supply* with a mean value of 8.00 and standard deviation value of 3.13. Since the respondents were asked to score each KPI on a range of 1 to 10 points, a mean value of 8.00 would indicate highly relevant. *Fire Safety* was ranked the first with a mean value of 9.91 and standard deviation value of 0.302.

The identified final 21 "parent" KPIs are discussed in the order of their relevance to management of manufacturing safety in the paint manufacturing industry. The possible sub-KPIs or "child" KPIs under each parent KPI are highlighted in table 4.1.

a. Fire safety

Fire safety refers to the precautions or measures that are taken to prevent or reduce the probability of the occurrence of a fire that can result in death, injury or property damage. Such measures could include training, equipment, and worker behaviour. The objective of fire safety is to reduce the risk to life and property to very low levels acceptable by the owners of the organization as well as by the society (Ramachandran, 1999).

Fire can be caused by different sources within the paint manufacturing setup. Flammable substances account for most fires. Other sources include faulty electrical machines such as motors, human error and behavior such as smoking, and faulty wire installations.

b. Waste disposal

According to the European Communities (2004), no official definition of industrial waste exists. In this study, industrial waste is defined as the waste from the paint manufacturing process. This waste includes wash-solvent, wash-water, wash-solids, VOCs, off-specification products, pigment dust, filters, pallets, drums, and rags. Waste management can be done through four Rs, that is, Reduce, Reuse, Recycle and Recover.

c. Space utilization

Space utilization in this context is defined as the way in which workspace has been planned for and used to achieve the manufacturing objective. This planning and use includes facilities layout, size of the premises and capacity to adequately accommodate all necessary equipment, and worker density (number of workers per unit floor area).

Space utilization affects the way in which materials are moved within the working environment, the manner in which workers respond to different incidents and the number of casualties that arise from accidents such as fire accident. According to Stringer (2013), high worker density can induce psychological stress among workers and lead to poor concentration. This can result to incidents that endanger human life. Crowded space can also make it difficult to maneuver material moving equipment such as forklifts. Low maneuverability of forklifts can lead to human injuries, collisions with stationary machines and falling objects.

d. Plant Air quality (Air Analysis)

Air quality is a critical factor in health and safety within any working environment (Springer, 2013; Ajala, 2012). Air quality within the paint manufacturing environment can be affected by presence of solid airborne pigment particles and VOCs. These pollutants cause irritation to the breathing system, toxicity in the human body, decreased brain function, kidney damage, and in some cases, nerve damage (WorkSafeBC, 2011). Ajala (2012) noted that a work environment with a well-designed and efficient ventilation system reduces exposure to such airborne hazardous substances, and prevents work-related illnesses, absenteeism and employee turnover.

e. Spillage management

Spillage of paints occurs occasionally within the paint manufacturing environment. Spilled paint can cause employees to slide and fall, expose them to harmful VOCs and above all, lead to extra hours of production in order to meet production targets. The handling of spilled paint or other liquids within the factory is very important, and may reduce the risk of fires in some cases.

f. Safety gear

Personal protective equipment, or in general terms, safety gear, protects the worker against extreme exposure to hazardous substances as well as harmful activities. Gas masks, hand gloves, safety boots, ear plugs, goggles, overalls, and other PPEs should be made available to workers and be in good working condition all the time.

g. General health of workers

Exposure of employees to different harmful pollutants and accident-causing equipment has a big orientation on the general health of the individual worker. Unhealthy workers are more likely to show high levels of absenteeism, high turnover and lead to high costs of health insurance.

h. Worker skill

Worker skill affects an employee's understanding of how to correctly operate machines and equipment. This has a direct impact on their safety and that of others since it influences the probability of the worker performing unsafe operation procedures.

i. Warehousing/ material handling function

Materials handling procedures and practices have a potential to cause major accidents or incidents within the paint manufacturing environment. Transportation and warehousing of pigment dust, handling of VOC containing liquids and movement of pallets, among other related activities within the factory have a bearing on the level of health and safety within the factory. The operation of material handling equipment such as forklifts also has an impact on the safety of workers. Forklifts have specific load limits, speeds and operating procedures. Violation of such limits when operating forklifts can lead to accidents. Workers should also be trained on proper inspection of material handling equipment before and after use.

j. Risk response

Risk is an inherent characteristic within any manufacturing setup, paint manufacturing included. Risks in a paint manufacturing factory include fire, spillage, moving parts, tripping, falling and exposure to hazardous airborne substances, among other risks. The procedures in place to assist the workers appropriately respond to such risks, when they occur, influences the level of damage to property and/ or impact on human life. These procedures are anticipative and prepare the workers to respond appropriately in the event of an emergency.

k. Communication

Communication is a key factor in any work place. It enables information to flow from one person or group to another, setting different activities into motion. In handling manufacturing safety, communication plays a key role of ensuring that relevant information such as on alerts, safety procedures and related policies is communicated appropriately and in a timely manner. Communication can be internal or external.

Internal communication refers to communication activities within the working environment, the factory. This entails use of warnings, markings and signs, incident reporting, equipment operating procedures, schedule of important factory activities and results of safety activities within a given period among other activities. The speed and accuracy of information flow affects the timeliness of worker’s response to different situations and thereby their level of safety.

External communication entails flow of information to and from the outside environment of the manufacturing plant. A paint manufacturing plant can engage in activities that affect the outside environment. These activities and their anticipated effects must be communicated to those who will be affected within the immediate environment. The outside environment also relays information to the manufacturing plant, such as on government policies and regulations that relate to the paint manufacturing activities. All communication must be done effectively and accurately convey the necessary message.

l. Noise exposure

Noise has a negative impact on employee comfort and reduces their productivity (Naharuddin & Sadegi, 2013). Noise also prevents quick response to sound signals, such as from cranes and forklifts, and this may lead to injuries. Employees working in areas with noise levels above 85 db should be provided with necessary PPEs (Adebiyi & Charles-Owaba, 2009). Those areas with noise levels exceeding 135 db should be guarded and workers should be prohibited from using the areas. It is therefore important to perform sound analysis of different sections within the manufacturing plant.

m. Maintenance function

Maintenance plays a key role in improving the overall equipment effectiveness (OEE) of any manufacturing plant. This has an impact on how well a plant is able to process orders without straining the system. Maintenance activities that may affect safety include unsafe operation of equipment during maintenance, incomplete installation of parts, incorrect assembly of parts incorrect tool usage and damaging of some parts during repair (Adebiyi & Charles-Owaba, 2009).

n. Accident and incident rates

These are simply those incidents or accidents that occur within the plant as a result of negligence, malfunction of equipment, or terrorism related activities. An environment prone to such incidents causes tension among workers and has a potential of increasing the probability of the occurrence.

o. General cleanliness of premises

Wet floors, littered space and contaminated breathing air can be a source of accidents or incidents. Workers can slip and fall on wet floors, thereby injuring themselves. Littered space can also lead to slips and injuries through lacerations by unattended sharp objects.

p. Worker commitment and integrity

Worker commitment and integrity are two elements of safety that are difficult to measure yet critical in management of health and safety. A committed employee is likely to report malfunctioning equipment, take safety related initiatives, and warn other employees of accident and incident prone areas known to them.

q. Level of lighting

Sufficient lighting helps prevent workplace accidents through improved eye-hand coordination, reduced fatigue and eyestrain to the worker (Ajala, 2012). Besides these direct effects, Sehgal (2012) states that lighting can also affect our brain activity on sleep and wakefulness, causing changes in alertness levels. An equipment operator who is not fully alert can easily cause an accident either to themselves of their colleague workers. The right levels of light intensity should therefore be maintained within the factory.

r. Cost of accidents

Accident costs arise as a result of need for treatment of injured persons, replacement of first aid consumables, repair and replacement of affected equipment and facilities, and worker compensation and related costs. The reporting of such costs in annual records can show how safe a manufacturing factory is for its workers. These costs can also be indirect, not necessarily as mentioned. Indirect accident costs include overtime to offset the absence of an employee, resources spend in investigating an incident, damaged reputation and employee morale (Eitzman, 2011).

s. Management input

The management of a firm has the greatest responsibility of ensuring a safe working environment for its employees. Certain activities may indicate the management' support in creating a near-zero accident environment. These include health and safety budget items in the firm's budget, elaborate policies put in place regarding the training of personnel on safety, response to any possible risks that may occur within the factory, and whether the style of management encourages employees to report safety related practices.

t. Documentation

Documented data provides a wide view of how different aspects of a certain activity have evolved over the time. Documenting health and safety data will provide a means of reference to those concerned with implementation of continuous improvement practices.

u. Water supply

Water is an essential utility in paint manufacturing. Besides being used in water-based paints, water is useful in the equipment that requires cooling. This resource is also important in maintaining a clean working environment.

4.4.3 Testing the KPI Model

The design of any engineering model follows an iterative process. The KPI model suggested above is an initial guide into what should be measured to objectively report on health and safety within the paint manufacturing industry. The model can be formalized by integrating it into a firm's wider performance management system (PMS) and using collected results to refine it over the life of the firm, as shown in Figure 4.1.

The results obtained from the micro enterprise dealing with paints manufacturing showed the level of safety was at 4.84, with the least score being on lead exposure at 1.85 and the highest being fire safety at 6.97. A score of 4.84 out of 10 is too low and shows an unsafe working environment. These results show the areas where much improvement is required in order to safeguard the lives of the workers. Table 0-5 shows the scores of the 21 KPIs, based on the data collected.

Appendix 5 shows the KPI model as used and includes the raw data that was fed to generate the findings in Table 4-5. Excel equations and formulae were used to compound the effect of each sub-KPI on the 21 parent KPIs. A soft copy of the Ms Excel file is attached to this report.

Table 0-5: Results of the KPIs Model Testing

Key Performance Indicator	Mean
Fire safety	6.97
Waste disposal	4.61
Space utilization	5.60
Plant Air quality (Air Analysis)	1.85
Spillage management	2.19
Safety gear	5.70
General health of workers	6.00
Worker skill	4.50
Warehousing/ material handling function	3.04
Risk response	2.58
Communication	5.22
Noise exposure (Sound analysis)	6.20
Maintenance function	3.83
Accident and incident rates	6.12
General cleanliness of premises	5.85
Worker commitment and integrity	4.65
Level of lighting	5.96
Cost of accidents	3.18
Management input	4.06
Documentation	5.73
Water Supply	7.90
Average	**4.84**

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Manufacturing safety plays a critical role in the success of any manufacturing entity. A good safety climate improves worker productivity, reduces liabilities to the company and creates a high level of goodwill in the society the organization interacts with. To control the parameters that bring about a safe working environment, some form of measurement is required: to determine the difference between the current situation and the desired result. This implies the need for performance indicators, or simply metrics, which can be used to collect and assess a situation statistically. Such metrics ought to be measurable and show some level of improvement over time.

The use of key performance indicators in any process enables benchmarking of the process to the best-in-class practices, as practiced by world class manufacturing firms. This is so because benchmarking promotes a culture that seeks to find ways of achieving new targets of quality. This study focused on manufacturing safety as one of the most important areas in manufacturing.

The results of this research showed that 21 KPIs were necessary in the measurement and reporting of manufacturing safety within paint manufacturing firms. The results also showed that fire safety is the most important KPI, having a Mean value of 9.91. This can be attributed to the presence of highly inflammable liquids within the factory and the need to protect workers from fire risk.

The 21 KPIs consisted of 17 leading KPIs and 4 lagging KPIs. The 4 lagging KPIs, that is, general health of workers, accident and incident rates, cost of accidents, and documentation, appeared among the least relevant KPIs. This implies the acceptance by this particular industry that leading indicators, which promote proactive behavior towards manufacturing safety, are quite important as compared to lagging indicators. Moreover, the test results from one of the medium enterprise dealing with paint manufacturing showed that the level of safety in these factories can be determined using these KPIs.

5.2 Recommendations

The measurement of manufacturing safety and health identifies the gaps where resources can be deployed appropriately to improve on the outcome of the measurement. The improved outcome can then be used to set new targets and this becomes a cyclic process, making near zero defects an achievable target.

Based on the results of this research, the researcher has the following two recommendations:

i. The paint and allied products manufacturing industry should implement the 21 KPI model developed in this study, in their assessment of manufacturing safety within their firms.
ii. The KPI model presented here should be revised regularly through an organized implement-and-refine process, possibly by the leaders in the paints manufacturing industry in coordination with bodies such as Kenya Association of Manufacturers (KAM). This is necessary since critical success factors (CSFs) are likely to change over time as firms adopt new manufacturing technologies, and thus the KPIs themselves. KAM can also come up with standards relating to paint manufacturing that would then be adopted by all paint manufacturers.

5.3 Further Work

Research is a continuous process through which theories are developed, tested, refined and adopted in mainstream literature. Further work should be carried out to develop literature on the following related issues:

i. The challenges that are likely to be encountered by various firms in the implementation of the 21 KPI model
ii. The ability of firms to integrate the measurement model into the overall company measurement models such as the Kaplan and Norton's Balanced Score Card (BSC). This is necessary because a single report on the overall performance of an organization provides data that can easily be interrogated by interested parties such as the management, government regulatory authorities and occasionally, the public.
iii. Development of KPIs in other industries
iv. Development of university or department performance ranking metrics using a similar approach as used in this study.

REFERENCES

Adebiyi, K. A., & Charles-Owaba, O. E. (2009). Towards setting a sustainable manufacturing safety programme in Nigeria. *Disaster Prevention and Management*, *18*(4), 388-96.

Adler, P. A., & Adler, P. (1987). Membership Roles in Field Research. Newbury Park, CA: Sage.

Ajala, E. M. (2012). The influence of workplace environment on workers' welfare, performance and productivity. *The African Symbosium*, *12*(1), 141-49.

Ansari, A., & Modarress, B. (1997). World-class strategies for safety: a Boeing approach. *International Journal of Operations & Production Management*, *17*(4), 389-98.

Avallone, E. A., Baumeister III, T., & Sadegh, A. M. (eds.) (2006). *Marks' Standard Handbook for Mechanical Engineers* (11th ed.). New York: Mc-Graw Hill.

Bäckström, S., Kyster-Hansen, H., Swahn, M. & Blinge, M. (2012). *Green Corridor Manual – Key Performance Indicators (KPIs) and policy measures in green transport corridor establishment.* Karlshamn: NetPort.Karshamn.

Bassam, M. E. (2008). *Chapter 7: Paints, Pigments, and Industrial Coatings*. Retrieved from http://faculty.kfupm.edu.sa/chem/belali/chem%20456/Chapter%207/CHAPTER%207_PAINTS,%20PIGMENTS,%20AND%20INDUSTRIAL%20COATINGS.pdf

Bhuiyan, N. & Baghel, A. (2005). An overview of continuous improvement: from the past to the present. *Management Decision*, *43*(5), 761-71.

Bonde, D. (2013). *Qualitative interviews: When enough is enough* [White Paper]. Retrieved from http://www.researchbydesign.com.au/media/RBD-WhitePaper-Margin-of-Error.pdf

BYK Additives & Instruments. (2009). Paint Additives. *Paint & Coatings Industry Magazine*. Retrieved from http://www.pcimag.com/ext/resources/PCI/Home/Files/PDFs/Virtual_Supplier_Brochures/BYK_Additives.pdf?1372100853

Clark, M. D. T. (2002). Paints and Pigments. *New Zealand Institute of Chemistry.* Retrieved from http://nzic.org.nz/ChemProcesses/polymers/10D.pdf

Clarke, S. (2006). Safety climate in an automobile manufacturing plant: The effects of work environment, job communication and safety attitudes on accidents and unsafe behavior. *Personnel Review, 35*(4), 413-30.

Cooper, D. R. & Schindler, P. S. (2006). *Business Research Methods* (9th ed.). New Delhi: Tata McGraw Hill Education Private Limited.

De Marchi, B., Funtowicz, S., & Ravetz, J. (1997). *4 Seveso: A paradoxical classic disaster*. United Nations University. Retrieved from http://archive.unu.edu/unupress/unupbooks/uu21le/uu21le09.htm

Deloitte. (2010). *The decade ahead: Preparing for unpredictable future in the global chemical industry.* Retrieved from http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Manufacturing/thedecadeahead_final_lowres_v3.pdf

D'Silva, T. (2006). *The Black Box of Bhopal: A Closer Look at the World's Deadliest Industrial Disaster*. Victoria, B. C.: Trafford Publishing.

Dubey, A. K. (2010). *Bhopal Gas Tragedy: 92% injuries termed "minor".* Retrieved from http://www.first14.com/bhopal-gas-tragedy-92-injuries-termed-minor-822.html

Egyptian Environmental Affairs Agency. (2002). Paints *Industry – Self-Monitoring Manual.* Retrieved from http://www.imc-egypt.org/studies/FullReport/Paints%20and%20Coating%20Development%20Strategy_AR.pdf

Eitzman, M. (2011). *The business case for safety in manufacturing: Higher productivity linked to safer technology and better risk management* [White paper]. Retrieved from http://www.inaco.com.au/wp-content/uploads/2013/05/The_business_Case_for_Safety_Manufacturing1.pdf

Enoma, A., & Allen, S. (2007). Developing key performance indicators for airport safety and security. *Facilities, 25*(7), 296-315.

Enoma, A., Enoma, A. & Allen, S. (2009). Airport redesign for safety and security: Case studies of three Scottish airports. *International Journal of Strategic Property Management, 13*, 103-116.

European Communities. (2004). *Hazardous and industrial waste management in accession countries*. Project Report. Retrieved from http://www.uni-mannheim.de/edz/pdf/eurostat/03/KS-54-03-954-EN.pdf

European Commission. (1999). *Paints Manufacturing*. Retrieved from http://ec.europa.eu/environment/air/pollutants/stationary/solvents/activities/pdf/84_en.pdf

Fadier, E., and De La Garza, C. (2006). Safety design: towards a new philosophy. *Safety Science, 44,* 55-73.

French Ministry of Sustainable Development. (2012). *Explosion in the AZF fertilizer plant.* Retrieved from http://www.aria.developpement-durable.gouv.fr/ressources/fd_21329_toulouse_dp_gb_01012012_vf.pdf

Fuller, C. W. (1997). Key performance indicators for benchmarking health and safety management in intra- and inter-company comparisons. *Benchmarking for Quality Management & Technology, 4*(3), 165-74.

Fuller, C. (1999). Benchmarking health and safety performance through company safety competitions. *Benchmarking: An International Journal, 6*(4), 325-37.

Gerber, J., Jensen, E. L. & Kubena, J. L. (eds.) (2007). Seveso Dioxin Disaster. *Encyclopedia of White-Collar Crime.* London: Greenwood Press.

Hämäläinen, P., Saarela, K. L., & Takala, J. (2009). Global trend according to estimated number of occupational accidents and fatal work-related diseases at region and country level. *Journal of Safety Research, 40,* 125-39.

Health and Safety Executive. (1975). Flixborough Nypro (UK) Explosion 1 June 1974: *Accident summary.* Retrieved from http://www.hse.gov.uk/comah/sragtech/caseflixboroug74.htm

Hinks, J., & McNay, P. (1999). The creation of a management-by-variance tool for facilities management performance assessment. *Facilities, 17*(1/2), 31-53.

Hsieh, H.-F., & Shannon, S.E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research, 15*(9), 1277-1288.

Johnson, G., Whittington, R. & Scholes, K. (2011). *Exploring Strategy: Text and Cases* (9th ed.). Harlow: Financial Times Prentice Hall.

Kalelkar, A. S. & Little, A. D. (May 1988). *Investigation of large-magnitude incidents: Bhopal as a case study*. Paper presented at The Institution of Chemical Engineers Conference: Preventing Major Chemical Accidents, London, England. Retrieved from http://www.bhopal.com/~/media/Files/Bhopal/casestdy.pdf

Katz-Navon, T., Naveh, E., & Stern, Z. (2007). Safety self-efficacy and safety performance: Potential antecedents and the moderation effect of standardization. *International Journal of Health Care Quality Assurance, 20*(7), 572-84.

Kenya Alliance of Resident Associations. (2011). Disasters: The elusive quest for disaster prevention and management. *Neighbourhood, 18.* Retrieved from http://kara.or.ke/resources/KARA%20OCTOBER%202011%20ISSUE.pdf

Kenya Bureau of Standards. (2012). *Pre-Export Verification of Conformity to Standards.* Retrieved from http://www.intertek.com/uploadedFiles/Intertek/Divisions/Oil_Chemical_and_Agri/Media/pdfs/Appendix%20C%20%20Products%20Subject%20to%20Kenya%20PVoC%20Programme%20(Covered)%20(2).pdf

Kenya Postel Directories. (2013). *Paints – Wholesale and manufacturers.* Retrieved from http://www.yellowpageskenya.com/search/?business=Paint-Wholesale+%26+Manufacturers&locality=&category=PaintWholesale+%26+Manufacturers&sorta=&start=0&page=1

Koleske, J. V. (ed). (1995). Paint and Coating Testing Manual: *Fourteenth Edition of the Gardner-Sward Handbook*. Michigan: ASTM International.

Le Coze, J.-C. (2012). Outlines of a sensitising model for industrial safety assessment. *Safety Science, 51,* 187-201.

Lehtinen, S., Joronen, M. & Hinkkanen, S. S. (eds). (2009). Accident prevention – A safe workplace. *African Newsletter on Occupational Health and Safety, 19*(1). Retrieved from http://www.ttl.fi/en/publications/electronic_journals/african_newsletter/Documents/african_newsletter1_2009.pdf

Mars Group Kenya. (2012). *Kenya Pipeline Company – Sinai fire disaster report callous to the extreme*. Retrieved from http://blog.marsgroupkenya.org/?p=2843

McCann, M. (1984). *Paint and coating manufacture*. Retrieved from http://www.ilo.org/safework_bookshelf/english?content&nd= 857170955

Mearns, K. & Håvold, J. I. (2003). Occupational health and safety and the balanced scorecard. *The TQM Magazine, 15*(6), 408-23.

Ministry of Environment and Mineral Resources. (2011). *Kenya national profile to assess the chemicals management.* Retrieved from http://www.environment.go.ke/saicm/wp-content/uploads/2011/10/Kenya-Natiional-Chemicals-Final1.pdf

Ministry of State for Special Programmes. (2009). *Draft national policy for disaster management in Kenya.* Retrieved from http://www.ifrc.org/docs/idrl/765EN.pdf

Naharuddin, N. M., & Sadegi, M. (2013). Factors of workplace environment that affect employees performance: A case study of Miyazu Malaysia. *International Journal of Independent Research and Studies, 2*(2), 66-78.

New Jersey Institute of Technology. (2002). *Paint Pollution*. Retrieved from http://njcmr.njit.edu/distils/lab/paint_html/ptimeline.htm

Nganga, C., Clark, S. & Weinberg, J. (2012). *Lead in Kenyan household paint*. Retrieved from http://ipen.org/iccm3/wp-content/uploads/2012/09/Lead-in-Kenyan-Household-Paint.pdf

Ombati, C. (2011). Eight workers die in chemical factory fire. *ICT Fire & Rescue.* Retrieved from http://ictfire.com/news/?p=253

Paulik, C. (2011). *Chemical Technology of Organic Materials II*. Retrieved from http://www.jku.at/cto/content/e34502/e116152/e129411/OT2paint_ger.pdf

Pojasek, R. B. (2009). Using leading indicators to drive sustainability performance. *Environmental Quality Management.* Retrieved from http://isites.harvard.edu/fs/docs/icb.topic746473.files/Supplemental%20Reading%20Folder/Leading%20Indicators%20Final.pdf

Plyakov, D. L. (2011). Up in Smoke: The effects of additives on the fire resistance of paint. Retrieved from http://www.usc.edu/CSSF/History/2011/Projects/S0616.pdf

Ramachandran, D. (1999). Fire safety management and risk assessment. *Facilities, 17*(9/10), 363-76.

Raouf, A. S. I. (2004). Productivity enhancement using safety and maintenance integration: an Overview. *Kybernets*, *33*(7), 1116-26.

Ringling College. (2007). *Safe use and disposal of paints and solvents*. Retrieved from http://www.ringling.edu/fileadmin/content/ehs/pdf/Safe_use_and_disposal_of_paints_and_solvents.pdf

Rose, A. (2006). Measuring operational safety in aviation. *Aircraft Engineering and Aerospace Technology: An International Journal*, *78*(1), 26-31.

Roubtsova, E. & Michell, V. (2013). Modelling and Validation of KPIs. Retrieved from http://portal.ou.nl/documents/114964/20294245/TouW_symposium_20131123_elr_2.pdf

Sehgal, S. (2012). Relationship between work environment and productivity. *International Journal of Engineering Research and Applications, 2*(4), 1992-95.

Sinclair, D. & Zairi, M. (1995). Effective process management through performance management. *Business Process Re-Engineering and Management Journal, 19*, 46-51.

Slater, S. F., Olson, E. M. & Reddy, V. K. (1997). Strategy based performance measurement. *Business Horizons, 40*(4), 37-44.

Society for International Development. (2012). Disaster preparedness in the GHEA: Taking a leaking ship to the high seas? *Greater Horn of East Africa (GHEA) Outlook, 24*. Retrieved from http://www.sidint.net/docs/RF24.pdf

Stringer, L. (2013). Workplace strategies that enhance human performance, health and wellness. Retrieved from http://www.hok.com/uploads/2013/02/15/hok--workplace-design-productivity.pdf

Torrey Hills Technologies, LLC. (2012). *Paints and Coatings* [White paper]. Retrieved from http://www.threerollmill.com/documents/Paints_coatings.pdf

Ugwu, O. O. & Haupt, T. C. (2005). Key Performance Indicators for infrastructure sustainability – A comparative study between Hong Kong and South Africa. *Journal of Engineering, Design and Technology, 3*(1), 30-43.

United States Department of Health and Human Services. (1984). Recommendations for control of occupational safety and health hazards: Manufacture of paint and allied coating products. *DHHS Publication No. 84-115*. Retrieved from http://www.cdc.gov/niosh/docs/84-115/84-115.pdf

United states Department of Labour. (2002). Materials Handling and Storing. *Occupational Safety and Health Administration No. 2236*. Retrieved from https://www.osha.gov/Publications/osha2236.pdf

United States Environmental Protection Agency. (1992). Control of VOC emissions from ink and paint manufacturing processes. *Control Technology Center – EPA-450/3-92-013*. Retrieved from http://www.epa.gov/ttn/catc/dir1/ink_paint.pdf

Varma, R. & Varma, D. R. (2005). The Bhopal Disaster of 1984. *Bulletin of Science, Technology and Society*.

Waring, A. (1996). Corporate health and safety strategy. *Facilities, 14*(3/4), 52-55.

WorkSafeBC. (2011). Lead-containing paints and coatings: Preventing exposure in the construction industry. Retrieved from www.worksafebc.com

Yu, S. C.-K., & Hunt, B. (2004). A fresh approach to safety management systems in Hong Kong. *The TQM Magazine, 16*(3), 210-15.

Zangwill, W. I. & Kantor, P. B. (1998). Toward a theory of continuous improvement and the learning curve. *Management Science, 44*(7), 910-20.

Zohar, D. (1980). Safety climate in industrial organizations: theoretical and applied implications. *Journal of Applied Psychology, 65,* 96-102.

APPENDICES

Appendix 1: Paint Manufacturing Firms in Kenya

S. No.	Name	Location	Other Branches
1	Crown Paints (K) Ltd	Nairobi	Westlands, Kisumu, Mombasa
2	Sadolin Paints (EA) Ltd	Nairobi	Mombasa, Kisumu, Nakuru
3	Basco Products (K) Ltd	Nairobi	Mombasa, Kisumu,
4	Alfa Coate Industries	Nairobi	
5	Apex Coating EA Ltd	Nairobi	
6	Beaver Industries	Nairobi	
7	East Africa Paints and Mining Ltd	Nairobi	
8	Flamingo Paints Ltd	Nakuru	
9	Galaxy Paints & Coatings Ltd	Nairobi	Mombasa
10	Grand Paints Ltd	Nairobi	Kisumu, Mombasa
11	Ideal Manufacturing Co. Ltd	Nairobi	
12	Kasol Paints Ltd	Nairobi	
13	Kenind Paints Ltd	Nairobi	
14	Maroo Polymers Ltd	Nairobi	
15	Nairobi Ramtrade Ltd	Nairobi	
16	Nasib Industrial Products Ltd	Nairobi	
17	Nayan Products (K) Ltd	Nairobi	
18	Pinnacle Paints Ltd	Nairobi	
19	Prime Coatings Ltd	Nairobi	
20	Rally Paints Investments 2000	Nairobi	
21	Sajco Kenya Ltd	Mombasa	
22	Smart Paint Ltd	Nairobi	
23	Solai Paints Ltd	Nairobi	

Appendix 2: Structured Interview Questions

Questions to be asked in chronological order.

1. What are the most critical health and safety risks in the paints and allied products manufacturing industry?
2. What are the procedures for managing these risks?
   a. Risk management procedures,
   b. Automated detection and response systems,
   c. Performance measurement
3. How will the management know if the management of these risks begins to fail?
   a. Performance management system
4. Which Key Performance Indicators can we monitor to ensure that the management of these risks does not fail?

a) Accident and incident rate

b) Exposure levels

- Noise levels e.g. from dispersants, mixers and mills
- Heavy metals such as lead
- Hazardous gases such as ammonia
- Volatile organic compounds (VOCs)

c) Cost of accidents

- Days absent from work due to injury
- Compensation cost
- Healthcare cost
- Lost man-hours

d) Shop-floor performance

- Spillages/ leakages from equipment & chemical containers
- Occupancy

e) Illumination

- Lighting intensity
- Speed of repairs on lighting

f) Maintenance function

- Ventilation performance
- Unscheduled downtime

g) Material handling

- Warehousing of raw materials – spillages etc
- Transportation of materials

h) Worker skill

- Worker training and experience
- Level of education

i) Information flow

- Speed of communication and information flow
- Response time
- Labeling of chemical containers
- Other forms of warning

j) Supply chain management (could be used for terrorism acts)

- Approved supplier list
- Review of supply contents e.g. in labs
- Outsourced labour

k) Waste disposal (amounts and content)

- Equipment cleaning wastes e.g. rinsewater, waste solvent
- Off-spec paint
- Obsolete paints
- Pigment dusts
- Accidental spills and discharges
- Emissions and leakages

5. Any other comments you may want to add regarding health and safety in this industry?

Appendix 3: Validation Questionnaire

Dear Sir,

This is a validation questionnaire of a study that seeks to derive a set of safety key performance indicators (KPIs) in the paint manufacturing industry in Kenya. An appendix is attached on page 4 and 5 to show the specific sub-KPIs to be measured under each suggested KPI. Your expertise and knowledge will contribute greatly to this process. The questionnaire consists of 5 questions. Data collected from this questionnaire will be treated with utmost confidentiality. Results of the study will be made available to you upon request.

Question 1: Kindly rate the variables below in terms of their relevance in measurement and reporting of health and safety within your premises, based on a scale of 1 – 10, where 1 implies "Not relevant" and 10 implies "Extremely relevant." Tick the rating that applies.

S. No	KPI	Score									
		1	2	3	4	5	6	7	8	9	10
1	Accident and incident rates										
2	Cost of accidents										
3	Management input										
4	Worker skill										
5	Worker commitment and integrity										
6	Plant Air quality (Air Analysis)										
7	Noise exposure (Sound analysis)										
8	Spillage management										
9	Level of lighting										
10	Safety gear										
11	Waste disposal										
12	Maintenance function										

13	Fire safety										
14	Cooling Water supply										
15	Warehousing/ material handling function										
16	Space utilization										
17	Book keeping										
18	Risk response										
19	Communication										
20	General health of workers										
21	General cleanliness of premises										

Question 2: In the list of 21 variables listed, are there any that you'd suggest to be renamed? Please indicate against the respective variable in the table below.

S.No.	KPI	Suggested different name
1	Accident and incident rates	
2	Cost of accidents	
3	Management input	
4	Worker skill	
5	Worker commitment and integrity	
6	Plant Air quality (Air Analysis)	
7	Noise exposure (Sound analysis)	
8	Spillage management	
9	Level of lighting	
10	Safety gear	
11	Waste disposal	
12	Maintenance function	

13	Fire safety	
14	Cooling Water supply	
15	Warehousing/ material handling function	
16	Space utilization	
17	Book keeping	
18	Risk response	
19	Communication	
20	General health of workers	
21	General cleanliness of premises	

Question 3: Based on your experience, is the list of health and safety performance indicators shown in question 1 exhaustive? (**Yes [ ]** or **No [ ]**) If Yes, skip to question 5. If No, go to question 4.

Question 4: In your opinion, what are other performance indicators that should be included in the list in question 1 to objectively and exhaustively measure health and safety within the paint manufacturing industry? Please list and make a short description of each.

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Question 5: Any other general comments?

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Thank you for your patience and assistance.

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[Sub-]Appendix: Specific Sub-KPIs:

S.No.	KPI	Sub-KPIs/ Direct measures
1	Accident and incident rates	Number of accidents/ incidents within a given period; recorded near misses in a particular period
2	Cost of accidents	Amount of money spend on compensation of victims of accidents; annual healthcare costs
3	Management input	Number of meetings held by senior management on issues of health and safety; average time taken to implement different policies on health and safety; percent of budget allocated to Health, Safety and Environment (HSE) activities; Number of HSE seminars (or employee HSE training hours) conducted within a given period
4	Worker skill	Hours of in-the-job training; number of hours of job practice; education level
5	Worker commitment and integrity	Hours absent from work; Worker productivity; number of work related initiatives from an employee; number of tasks completed within agreed time
6	Plant Air quality (Air Analysis)	Level of pollutant (lead, ammonia and VOCs) concentration in atmospheric air per cubic unit measured annually (NEMA) or at shorter internally agreed periods
7	Noise exposure (Sound analysis)	Number of decibels emitted from source object conducted annually (NEMA) or at shorter internally agreed periods
8	Spillage management	Frequency of spill drills; response time by target group to contain spills; number of (un)controlled spills
9	Level of lighting	Level of lighting in lux or foot-candles

10	Safety gear	Percentage of employees with proper personal protective equipments (ppes); percentages based on working condition of the ppes; inspection intervals for ppes; commitment to using the gear by workers
11	Waste disposal	Amount of waste generated per ton of paint produced; percentage of waste recycled; amount and percentage of treatable waste; number of complaints received due to mishandled waste
12	Maintenance function	Lost machine hours due to downtimes; mtbf; Lost production volume during downtime; lost man hours during (un)scheduled downtimes; skill of people doing the evaluation of the failure; maintenance cost
13	Fire safety	Clarity of guidelines on fire safety; number and frequency of fire incidences/ near misses; amount of extinguisher medium per square unit of working space; number of fire drills in a year
14	Cooling Water supply	Number of dry tap hours within given period (dry tap defined as flow below levels required to maintain operations)
15	Warehousing/ material handling function	Accidents and incidents from falling objects; percentage of properly sealed containers; percentage of leaking containers; percentage of materials and chemicals with missing, incomplete or worn out material safety data sheets (MSDSs); percentage loss of raw materials (difference in materials in and materials out)
16	Space utilization	Percentage of space occupied by machines and other equipment; per employee utilisation
17	Book keeping	Percentage of general HSE audits (NEMA) completed in time (quarterly); Percentage of missing HSE related activity records
18	Risk response	Amount of time taken to contain an incident; policies in place with regard to risk mitigation and handling

19	Communication	Level of communication of activities affecting neighbours; percentage of external complaints handled effectively; average response time (ART) to different situations such as accidents, alien intrusion recognition; average communication cycle time
20	General health of workers	The frequency of certain illnesses among workers; man hours lost due to minor ailments; man hours lost due to minor accidents
21	General cleanliness of premises	Frequency of premises cleanups; the efficiency of material handling function; per cent of times when floors are wet

End.

Appendix 4: VOC Exempt Chemicals

Volatile organic compounds (VOC) means any compound of carbon excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions. This includes any such organic compounds other than the following, which have been determined to have negligible photochemical reactivity:

- Methane
- Ethane
- Methylene chloride (dichloromethane)
- 1,1,1-trichloroethane (methyl chloroform)
- 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113)
- Trichlorofluoromethane (CFC-11)
- Dichlorodifluoromethane (CFC-12)
- Chlorodifluoromethane (HCFC-22)
- Trifluoromethane (HFC-23)
- 1,2-dichloro 1,1,2,2-tetrafluoroethane (CFC-114)
- Chloropentafluoroethane (CFC-115)
- 1,1,1-trifluoro 2,2-dichloroethane (HCFC-123)
- 1,1,1,2-tetrafluoroethane (HCFC-134a)
- 1,1-dichloro-1-fluoroethane (HCFC-141b)
- 1-chloro-1,1-difluoroethane (HCFC-142b)
- 2-chloro-1,1,1,2-tetrafluoroethane (HCFC-124)
- Pentafluoroethane (HFC-125)
- 1,1,2,2-tetrafluoroethane (HFC-134)
- 1,1,1-trifluuoroethane (HFC-143a)
- 1,1-difluoroethane (HFC-152a)

— Parachlorobenzotrifluoride (PCBTF)
— Cyclic, branched, or linear completely methylated siloxanes
— Acetone
— Perchloroethylene (tetrachloroethylene)
— 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca)
— 1,3-dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb)
— 1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC-43-10mee)
— Difluoromethane (HFC-32)
— Ethylfluoride (HFC-161)
— 1,1,1,3,3,3-hexafluoropropane (HFC-236fa)
— 1,1,2,2,3-pentafluoropropane (HFC-245ca)
— 1,1,2,3,3-pentafluoropropane (HFC-245ea)
— 1,1,1,2,3-pentafluoropropane (HFC-245eb)
— 1,1,1,3,3-pentafluoropropane (HFC-245fa)
— 1,1,1,2,3,3-hexafluoropropane (HFC-236ea)
— 1,1,1,3,3-pentafluorobutane (HFC-365-mfc)
— Chlorofluoromethane (HCFC-31)
— 1-chloro-1-fluoroethane (HCFC-151a)
— 1,2-dichloro-1,1,2-trifluoroethane (HCFC-123a)
— 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane (C4F9OCH3)
— 2-(difluoromethoxymethyl)-1,1,1,2,3,3,3-heptafluoropropane ((CF3)2CFCF2OCH3)
— 1-ethoxy-1,1,2,2,3,3,4,4,4-nonafluorobutane (C4F9OC2H5)
— 2-(ethoxydifluoromethyl)-1,1,1,2,3,3,3-heptafluoropropane ((CF3)2CFCF2OC2H5)
— Methyl acetate and
— Perfluorocarbon compounds which fall into these classes:

(i) Cyclic, branched, or linear, completely fluorinated alkanes

(ii) Cyclic, branched, or linear, completely fluorinated ethers with no unsaturations

(iii) Cyclic, branched, or linear, completely fluorinated tertiary amines with no unsaturations

(iv) Sulfur containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluourine

A chemical is classified as VOC exempt if it:

i) Has a vapour pressure of less than 0.1 millimetres of mercury (at 20ºC); or if the vapour pressure is unknown

ii) Consists of more than 12 carbon atoms,

iii) Has a melting point higher than 20ºC, and does not sublime.

Appendix 5: The KPI Modeling and Measurement Tool

HEALTH AND SAFETY ASSESSMENT (Paint Manufacturing)

NB: FORM DATA SHOULD BE FOR A PERIOD OF ONE TRADING YEAR.

S.No.	KPI	No.	Sub-KPIs/ Direct measures	Amount[3]	KPI Score[4]
1	Accident and incident rates	a)	Number of accidents/ incidents	1	**6.12**
		b)	Recorded near misses	8	
2	Cost of accidents	a)	Amount of money spend on compensation of victims of accidents (Kshs.)	0	**3.18**
		b)	Healthcare costs (Kshs.)	1,104,000.00	
		c)	First aid costs (Kshs.)	42,000.00	
		d)	Total operating budget for the year (Kshs.)	16,400,000.00	
3	Management input	a)	Number of meetings held by senior management on issues of health and safety	4	**4.06**
		b)	Average time taken to implement different policies on health and safety (weeks)	2	
		c)	Percent of budget allocated to Health, Safety and Environment (HSE) activities	5.34	
		d)	Average Number of employee HSE training hours	19	

[3] The values in this column represent the actual data collected from the firm used to test this KPI model.
[4] The values in this column represent the averaged scores for each KPI. The equations and formulae used can be found in the attached soft copy.

Appendix 5 continued...

4	Worker skill	a)	Average amount of experience on the job (hours)	9000	**4.50**
		b)	Highest level of Education in the field (10 - Phd; 9 - Masters; 8 - Undergraduate; 7 - Bacallaurete/ Associate degree; 6 - Higher Diploma; 5 - Diploma; 4 - A Level; 3 - O Level; 2 - Tertiary training; 1 - Primary School; 0 - None.)	5	
5	Worker commitment and integrity	a)	Percentage of the time employees are absent from work	18	**4.65**
		b)	Worker productivity	0.63	
		c)	Number of work related initiatives from employees	50	
		d)	Percentage of tasks completed within agreed time	90	
6	Plant Air quality (Air Analysis)	a)	Maximum hourly exposure of lead measured and recorded annually (NEMA) ($\mu g/m^3$)	39.8	**1.85**
		b)	Hourly exposure to VOCs measured annually (NEMA) (ppm)	19	

Appendix 5 continued...

7	Noise exposure (Sound analysis)	a)	Highest number of decibels emitted from source object conducted annually (NEMA)	68.5	**6.20**
8	Spillage management	a)	Frequency of spill drills (per year)	3	**2.19**
		b)	Response time by target group to contain spills (minutes)	7	
		c)	Percentage of controlled spills	93	
		d)	Percentage of uncontrolled spills	7	
9	Level of lighting	a)	Level of lighting in lux	1788	**5.96**
		b)	Single or three phase	3	
10	Safety gear	a)	Percentage of employees with proper personal protective equipments (ppes)	72	**5.70**
		b)	Percentage of working ppes	86	
		c)	Commitment to using the gear by workers	92	
11	Waste disposal	a)	Average amount of waste generated per ton of paint produced (kgs)	20	**4.61**
		b)	Percentage of waste recycled and treated	60	
		d)	Percentage of complaints relating to waste disposal successfully handled within 5 days	96	

Appendix 5 continued...

12	Maintenance function	a)	Mean time between failures (mtbf) (hours)	240	3.83
		b)	Lost production volume during downtime (tons)	5.1	
		c)	Lost man hours during scheduled downtimes	91	
		d)	Lost man hours during unscheduled downtimes	156	
		e)	Skill of people doing the evaluation of the failure 5 - Very skilled; 4 - Average skill; 3 - moderately skilled; 2- Least skilled 1 - Not skilled.	4	
		f)	Maintenance cost (Kshs.)	2,010,000.00	
		g)	Overall Equipment Effectiveness (OEE)	0.56	
13	Fire safety	a)	Clarity of guidelines on fire safety 5 - Very Clear; 4 - Clear; 3 - Moderately Clear; 2 - Not clear 1 - Do not exist	4	6.97
		b)	Number of fire incidences	0	
		c)	Amount of extinguisher medium per square unit of working space (kg/m^2)	10.89	
		d)	Classes of fire extinguishers available, A, B, C: (1 - All three; 2 - Only 2; 3 - Only 1)	1	
		e)	Number of fire drills in a year	6	
14	Water supply	a)	Number of dry tap weeks within given period (dry tap defined as water flow below levels required to maintain operations)	1.266	**7.90**

Appendix 5 continued...

15	Warehousing/ material handling function	a)	Number of accidents and incidents from falling objects	6	**3.04**
		b)	Percentage of properly sealed containers	95	
		c)	Percentage of leaking containers	2.6	
		d)	Percentage of materials and chemicals with missing, incomplete or worn out material safety data sheets (MSDSs)	4.3	
		e)	Percentage loss of raw materials (difference in materials in and materials out)	14.2	
16	Space utilization	a)	Percentage of space occupied by machines and other equipment	60	**5.60**
		b)	Per employee utilisation (m^2)	5.6	
17	Documentation	a)	Percentage of general HSE audits (NEMA) completed in time (quarterly)	75	**5.73**
		b)	Percentage of missing HSE related activity records	23.6	
18	Risk response	a)	Average amount of time taken to contain an incident (minutes)	33.9	**2.58**
		b)	Adequacy of policies in place with regard to risk handling and mitigation. 5 - Quite adequate; 4 - Adequate; 3 - Moderately adequate; 2 - Not adequate; 1 - I don't know	4	

Appendix 5 continued...

19	Communication	a)	Level of communication of activities affecting neighbours (per cent times)	83	**5.22**
		b)	Percentage of external complaints handled effectively	91	
		c)	Average response time (ART) to alien intrusion (mins)	7	
		d)	Average communication cycle time (hours)	6.5	
20	General health of workers	a)	Frequency of ENT illnesses among workers (per cent of workers)	32	**6.00**
		b)	Man hours lost due to minor ailments and accidents	117	
21	General cleanliness of premises	a)	Frequency of premises cleanup. 10 - Thrice a day; 9 - Twice a day; 8 - Once a day; 7 - Thrice a week; 6 - Twice a week; 5 - Once a week; 4 - More than thrice a day; 3 - Twice a month; 2 - Once a month; 1 - Less than once a month.	8	**5.85**
		b)	Efficiency of material handling function	85.8	
		c)	Per cent of times when floors are wet	14.7	

End.