# MANAGING CHEMICALS AT THE UNIVERSITY OF LIMPOPO: A SAFETY PERSPECTIVE

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# DECLARATION

I declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Business Administration (MBA) has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all materials herein had been duly acknowledged.

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## ABSTRACT

Chemicals are found to be enormously dangerous on the health and safety criteria. In academic laboratories, chemical safety has always been a major concern. Safety risks are either not perceived at all, or perceived to be less dangerous than what they actually are. The climate of safety in any organization consists of employees' attitudes towards, and perceptions of safety behaviour. In academic departments, safety is influenced by factors such as the organisational environment, management attitude and commitment, the nature of the job or task, and the personal attributes of the individual. This study is concerned with safety climate and chemical management practices in academic departments. More specifically, it investigates the safety perceptions, attitudes, and chemical management behaviours of university employees. It represents the empirical results of a questionnaire survey administered in a university department and direct observations of safe and unsafe chemical management behaviours, targeting employees who work with chemicals.

Based upon the survey analysis results, this study demonstrates that employees in the academic departments under study have a good degree of risk awareness and a relatively high degree of safety consciousness. The results also reveal employees' intentional unsafe chemical management behaviours. Further, it was found, empirically, that overall employees' intentional unsafe behaviours seem to be best explained by employees' perceptions of management attitude and commitment to safety, social and physical work environment, priority for safety, as well as their perception of the risk they are generally exposed to in their work environment. The study, thus, establishes that perceptions of management attitudes and actions have a direct effect on employees' behaviour. There is a positive correlation between workers' safety climate and chemical management safe behaviour in academic departments.

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# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# CHAPTER 1

# BACKGROUND AND RESEARCH OVERVIEW

## 1.1 INTRODUCTION

The use of chemicals has brought immense benefits to humankind, and at the same time it has had negative impacts on human health and safety, particularly for the poorest and youngest people, on the integrity of terrestrial and marine ecosystems, and on air and water quality. The unsound management and use of chemicals poses threats to human well-being at many levels: it threatens the sustainability of the environment which provides essential goods-and-services for livelihoods, it undermines human health, it threatens physical security, and it reduces the ability of communities to care for themselves and, especially, for children. Basic attitudes, philosophy, knowledge, and misinformation compete with “academic freedom” when related to the prevention of accidents and health impairment in laboratories (Fawcett, 1972).

In her speech, the Deputy Minister of Environmental Affairs and Tourism (DEAT), Mabudafhasi (2006) said: *“Let us recall our commitment that we made in Johannesburg in 2002 during the World Summit on Sustainable Development. We committed ourselves to sound management of chemicals for sustainable development as well as the protection of human health and the environment.”* By this statement, the South African community is encouraged to ensure that chemicals are used and produced in ways that are not detrimental to human health and the environment.

Chemicals have a central place in science and safe chemical practices are the most basic and fundamental parts of any lesson (Sarquis, 2003). In the case of university departments, chemicals are the raw materials that support the delivery of laboratory services (Pipitone, 1991), and they are critical to student learning and research that can facilitate new technologies and efficiencies in the 21st century. It is thus necessary to identify the factors which motivate employees at all levels to address chemical safety, for example, employees working as academic laboratories operators may exhibit a specific approach to safety. University departments must invest in safety culture initiatives development of safety management systems that address the organizational measures needed to achieve the goal of influencing individual attitudes to safety. Explicit efforts should be made to encourage safety principles to be carried beyond the workplace to all aspects of daily life.

Today's best practice demonstrates that chemicals can be used widely in a cost-effective manner and with a high degree of safety. However, a great deal remains to be done to ensure the environmentally sound management of toxic chemicals, within the principles of sustainable development and improved quality of life for humankind. Management of chemicals brings into play controls such as inventory, storage of chemicals, and disposal of chemical wastes. Working with chemicals takes into account such aspects as minimizing exposure, housekeeping, transport, disposal, and responding to accidents and emergencies (National Research Council, 1995). Organizational safety culture may influence employees' safety attitudes which can have a significant impact on how chemicals are managed within an organization.

There is a fundamental need for a safe and healthy learning and working environment in university departments and other educational establishments. Employees and managers in the university departments need guidance on dealing with hazards and risks and on good safety and health management. There is a need to explore the relationship between organizational safety culture and chemical management practices within a university department, and the means and influences which can be used to reduce risk.

## 1.2 BACKGROUND TO THE RESEARCH PROBLEM

Research and teaching laboratories use chemicals and produce a variety of waste chemicals that may be subject to regulatory management standard. If improperly managed, those chemicals could pose a risk to human health and the environment. Laboratory chemicals are regulated by the Department of Labour (DoL) and various other national and provincial departments. The university community and its management are tasked with ensuring that all laboratories understand and comply with these regulations. Employees' attitude towards safety and lack of knowledge and awareness of the importance and effectiveness of proper chemical management in meeting the requirements for health and safety of people and the environment is the main issue.

Recently, enforcement activities undertaken by the DoL after an explosion incident that occurred at a University in Limpopo had shown that the concerned Department had inadequate levels of chemicals management. The Department did not have systems in place for managing chemicals; the hazardous substances that the department procures, stores and uses were not monitored; and there were no inventory records, which are essential for proper management as required by the law. The DoL warned the Department about their non-compliance with the Safety, Health and Environmental (SHE) regulations and threatened to close it down.

It is the author's aspiration to act in response to this matter by exploring the influence that safety attitudes have on chemical management practices within university departments and to develop guidelines for sound management of chemical and make recommendations for developing a positive organizational safety culture that would ensure compliance with relevant legislative requirements and regulations. As Hill (2003) stated, "*responsibility, in its true sense, is an entirely voluntary act … response to the needs … of another human being*".

## 1.3 PURPOSE OF THE STUDY

The purpose of this study is to explore employees' chemical safety attitudes and perceptions, and their contribution to employees' chemical management practices. A qualitative methodology will be used to understand these issues and ensure all data collection contributes to high quality conclusions and recommendations. Questionnaires will be used to collect primary data on employees' safety attitudes and secondary data will be obtained from literature. At the same time, the management of chemicals will be explored using qualitative observations with employees.

This study focuses on the identification of effective approaches to better manage chemicals. It will evaluate current chemical management practices and identify areas where improvements are necessary in provision for the health and safety of employees, students and the environment. The study will serve as a basis for the establishment and implementation of a chemical management system that will ensure compliance with the regulatory and legal requirement associated with laboratory chemicals.

## 1.4 PROBLEM STATEMENT

Poor management of chemicals poses a health and safety risk towards people and the environment. Institutions risk bad publicity, heavy fines or sometimes even closure due to non-compliance with the regulatory requirement caused by poor management of chemicals. Everyone using chemicals has the responsibility for managing and handling them safely and must consider their part in the life cycle of the chemicals and their safe use and disposal. Most academic department and many other facilities experience frequent incidents/accidents where people sustain injuries (minor or major) and even die, due to poor management of chemical and lack of safety considerations in chemical operations (Peplow & Marris, 2006; Pope, 2004; SAPA, 2006). Academic laboratories are more dangerous than those in industry, with more relaxed approach to safety. The accident rate in universities is 10 to 50 times greater than in the chemical industry (Peplow & Marris, 2006).

Safety is a condition in which risk or hazard is controlled to an acceptable degree and this is critical for the welfare of the workforce and the organization. Unfortunately in most cases people are not aware of the hazards associated with chemical substances that they use and they often do not understand the potential risks of mismanagement/misuse of a chemical. Safety refers to a state in which people may efficiently and effectively complete their tasks in a healthy and comfortable environment. Employees must have knowledge and skills in safety, and a strong safety ethic to work in a safe manner (Hill, 2005). This requires a change in attitude towards safety among many of today's employees. Safety attitudes are therefore indicative of organization's safety culture. Employees with positive attitudes towards safety will be more reflective about their actions, the importance of their safety, and about their responsibilities towards other people, and thereby prevent accidents.

## 1.4 RESEARCH QUESTIONS

Creswell (2003) contends that qualitative research is exploratory and is useful when the researcher does not know the important variables to examine. This type of approach is needed because the topic is new and has never been addressed with a sample or group under study. Some departments within academic institutions use chemicals as part of training and learning. Although working with chemicals is fascinating, there are dangers involved, especially when safety and risk assessment is not considered an important objective of the work being carried out. Every individual needs to be aware of safety issues, and to take the necessary precautions and/or actions with regard to risk assessment and safety concerns relating to chemical substances and processes.

Cox and Cox (1991) states that safety cultures reflect the attitudes, beliefs, perceptions and values that employees share in relation to safety. Unsafe work practices (chemical management) in academic departments are a trend in most university institutions, and employees and students suffer injuries related to these unsafe practices. This has prompted the researcher to perceive that negative safety culture within university departments may contribute towards poor chemical management practices. Therefore, the main problem addressed in this study is the inevitability of a positive safety culture on the sound management of chemicals within academic departments.

In a qualitative study, inquirers state research questions, not objectives (i.e., specific goals for the research) or hypothesis (i.e., predictions that involve variables and statistical tests) (Creswell, 2003). These research questions assume two forms: a central question and associated sub-questions. The central question is a statement of the question being examined in the study in its most general form. The question format lends itself more to descriptive and inductive research, while the hypothesis is more appropriate for explanatory and deductive research (Welman *et al*, 2005). The main problem stated in the above paragraph can be rephrased in a research question: *How do employees' safety attitudes contribute to the management of chemicals within an academic department?*

Creswell (2003) recommends that a researcher ask one or two questions followed by no more than five to seven sub-questions. Several sub-questions follow each general central question, and the sub-question narrow the focus of the study but leave open the questioning. These questions, in turn, become topics specifically explored in interviews, observations and the documents and archival material. The central research question for this study asks:

- What are the perceptions and attitudes of employees on chemical safety within a university department?
- How do employees manage chemicals used within the department?
- How do employees' safety attitudes contribute to chemical management practices?

## 1.5 RESEARCH AIM AND OBJECTIVES

The main aim of this study is to explore safety attitudes and perceptions, and their contribution to the management of chemical operations within a university department. The conception of employees' safety attitudes is based on Pidgeon's conception of safety culture (Pidgeon, 1991). Pidgeon distinguished three main aspects of safety culture: (a) norms and rules for handling hazards which define what is and is not a significant risk and what response is appropriate, (b) attitudes towards safety which refers to individual and collective beliefs about hazards and the importance of safety and also motivation to act upon these beliefs, (c) reflexivity on safety practice as a learning process and searching for new meanings in the face of uncertainty and ambiguity about risk. Positive safety attitudes towards the improvement of the chemical management operations inevitability within a university department

The research questions outlined in section 1.4 (Research Question) will be answered by looking at the following objectives:

- Identify prudent/sound management of chemicals
- Evaluate current chemical management practices, identify shortcomings of the strategies followed, and make recommendations on the management systems and control measures for minimizing health and safety risks.
- Identify and describe employees' perceptions and attitudes towards chemical safety, and their awareness of the hazards and risks associated with chemicals used in the workplace
- Identify the factors affecting employees' perception and attitudes of chemical safety
- Establish whether these perceptions and attitudes are congruent with chemical management practices in the workplace.

## 1.6 ETHICAL CONSIDERATIONS

The research is conducted within the dictates of social scientific ethical requirements. Ethical issues to be considered include informed consent and other related key issues such as confidentiality and anonymity. The research is conducted with the informed consent of the University of Limpopo and other stakeholders encountered during data collection because deceptive and covert practices are not in keeping with ethical practice. The names of respondents under study are kept confidential and anonymous.

## 1.7 CLARIFICATION OF CONCEPTS

There are certain terms and concepts that form the root of this research and are used throughout the report. Without proper understanding of the meanings of those terms and concepts, it will be extremely difficult to grasp certain ideas and important arguments on safety and chemical management presented in this research. These concepts are explained in alphabetical order:

**Chemical**

The name chemical refers to any substance used in or resulting from a reaction involving changes to atoms or molecules.

**Chemical management**

Chemical management refers to a number of practical measures that organizations can undertake on their own to improve their productivity, obtain cost savings and improve organizational procedures as well as workplace safety and environmental performance. Thus, it is a management tool for cost management, environmental and occupational hygiene management, and organizational change. When these areas are adequately taken into consideration, a ‘triple win’ can be achieved and a successful process of continuous improvement in the company can be established

**Chemical safety**

Chemical safety refers to the management principles and systems applied to the identification, understanding, and control of hazards involved in the manufacture or use of chemicals to prevent injuries and incidents. It is achieved by undertaking all activities involving chemicals in such a way as to ensure the safety of human health and the environment. It covers all chemicals, natural and manufactured, and the full range of exposure situations from the natural presence of chemicals in the environment to their extraction or synthesis, industrial production, transport use and disposal.

**University Department**

A university is an institution of higher education and research, which grants academic degrees at all levels (bachelor, master, and doctorate) in a variety of subjects. A university provides both tertiary and quaternary education. The word *university* is derived from the Latin *universitas magistrorum et scholarium*, roughly meaning "community of teachers and scholars". A university department is a separate part, division, or branch, of a university.

## 1.9 DEMARCATION AND SCOPE OF THE STUDY

The research is conducted in the Limpopo Province where there are two universities. The two universities (University of Limpopo in Polokwane and University of Venda in Thulamela) are situated about 200 Km away from each other. Due to the primary interest of evaluating all university departments using chemicals in their operations, the research focuses on the science faculties/schools. This research only includes the university situated in the Polokwane Local Municipality. The university situated in the Thulamela Local Municipality is totally excluded from this research.

The research focuses on safety and chemical management practices of university departments using purposive sampling. How many departments there should be under study depends on the exhaustion of either diversity or shared school environment management patterns. Therefore, it is important to note that the number of departments is unimportant and that the size of the sample should not be predetermined. This study identifies and establishes best practices for regulating and managing chemicals in academic institutions, and provides guidelines and recommendations on the chemical management practices and programs. It focuses on conducting chemical safety survey, which will provide a basis for action by stimulating the initiation, maintenance, review and assessment of records that describe and define current safety policies, practices, and attitudes. The results of the survey will be used to plan and guide chemical safety management standards, to guide or evaluate administrative policy, to find ways to better manage chemical inventories, to identify better ways to control chemical hazards, to find ways to improve compliance with government policies, laws and regulations associated with hazardous chemicals.

## 1.10 PLAN OF STUDY

This work is divided into chapters. These chapters are organized and follow each other sequentially as described below. The project report will contain six chapters. The purpose of this layout is to give an overview of the major phases involved during the undertaking of the project, from its planning and initiation stages to completion. Below is the report layout:

### Chapter 1: Introduction

This chapter provides an introduction to the area of research. It gives an overview of the research project including the background to the research. It identifies the research problem, hypothesis, aims and objectives, project scope and project schedule of the research.

## Chapter 2: Literature Review

This chapter gives brief explanations on topics researched and studies that are relevant to this project.  It is a combination between literature search and literature review.  Among the discussed topics are chemical safety, chemical storage and chemical inventory management including purchasing, handling, use and disposal, and legal framework on chemical management.  It includes a review of sound chemical management practices that will be used as a benchmark for identify good practices for managing chemical in the department

## Chapter 3: Research Design and Methodology

This chapter emphasizes on the justification of the chosen project design and methodology.  It also discusses information gathering techniques and explanations about the approaches used to analyse data.

## Chapter 4: Research Results and Discussions

This chapter outlines the findings of the research.  Results will be displayed in tables, graphs, diagrams, and photos.  It will also explain the results, findings and test of hypothesis.  It discusses the results in relation to other findings, especially the information from the literature review.

## Chapter 5: Recommendations

This chapter also outlines a set of recommendations that will be made to the Management of the University of Limpopo.  Recommendations will be made based on the research findings.

## Chapter 6: Conclusions

This chapter concludes the research and outlines possible areas of future research.  It summarizes the research progress, findings, recommendations and future prospects on the subject under investigation.

## 1.11 SUMMARY

This chapter dealt mainly with orientation of this research. The chapter was introduced and a background and context of the research provided. The following section was a statement of the problem. The section thereafter provided the aims of the research. This was immediately followed by a brief discussion of the research design and method that provided the various important methodological aspects of the research, namely, the research method used, sampling, methods for data collection, and methods for data analysis, validity and reliability as well as ethical considerations. A theoretical framework of the research was provided in the next section. Basic concepts used in the research were also clarified. The next section demarcated the study and provided the area where the research ought to be conducted. A plan of study that clearly demonstrated the division of this work in chapters was also outlined.

As mentioned earlier, the next chapter discusses the theoretical framework of this research substantially. In so doing, the chapter provides a literature review that elucidates natural environment management, organizational change management and policy-making with the purpose of providing the foundation for the assessment of those external school environments.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

Consider the following scenario: "*A chemical storage room at your plant is burning; the result of an explosion. Your manager wants to know why this happened. You review all the regulatory programs you have in place, and none seem to address this specific chemical and this specific situation. What do you say to your company?*" (Langerman, 2003). There is some good science behind the incident that is worth explaining and emphasizing to prevent a similar incident at other facilities. Facilities using hazardous substances are required to comply with programs that aim to reduce the frequency of accidents and the severity of consequences in the event of an accident (Batterman & Kovacs, 2003).

Although useful, chemicals have the potential to cause considerable health and environmental problems throughout their life cycle, from production through to disposal (National profiles on chemicals management, 1998), especially if they are not handled or stored properly. The prudent management of hazardous materials, from their procurement to their proper disposal as chemical waste, is a critical element of a laboratory safety program. A successful management program includes standard operating procedures (SOPs) to ensure the safe handling, storage, and transport of chemicals and the proper disposal of chemical waste (Foster, 2005).

Laboratories in academic departments use and store many chemicals to which exposures are intermittent. It is important to recognize that these chemicals, even in relatively small quantities handled on a short-term basis, can present a hazard to the health and safety of employees, students and the environment (Fawcett, 992). The hazards associated with the storage, handling, and use of laboratory chemicals have significant consequences (Pipitone, 1991) entailing special requirements to avoid. An increasing number of regulations and standards involving chemicals have been passed to protect the personnel, the public and the environment from hazards of chemicals (Fawcett, 1992).

These regulations make it mandatory that all personnel involved in chemical laboratory operations be aware of the implications of their actions and work. Failure to comply with the regulatory requirements exposes an organization to the legal liabilities of fines, penalties, and even criminal prosecution (Pipitone, 1991). Safety and environmental compliance are not the exclusive responsibilities of any one individual, department or office. All employees must take all reasonable care for their own health and safety and that of others who may be affected by their conduct at the workplace (Stricoff & Walters, 1995).

"*Management of chemicals involves both ethical and legal issues, as well as overlying technical considerations*", (ACS task force, 1994). From an ethical standpoint, organizations need to provide a safe environment for employees and students to work and study. Further, an organization must take steps to reduce or eliminate the impact that hazardous materials used at the facility could have on the surrounding community and environment. Legally, an organization must be aware that government regulatory agencies have an obligation to enforce relevant laws and can impose severe financial penalties or force closure of operations for those who violate those laws (ACS task force, 1994).

Every person handling or using chemicals should have a safety ethic, which will include the following: "*I value safety, work safely, prevent at-risk behaviour, promote safety, and accept responsibility for safety*" (Hill, 2003). If this ethic is adopted by all, the world would indeed be safer. Prudent Practices in the Laboratory offers a succinct definition of a safety culture as "*encompassing a group of people who voluntarily and willingly think about potential hazards and* *seek out and use resources that help ensure the maximum safe use of materials and procedures*" (Sarquis, 2003).

## 2.2 CHEMICAL TOXICOLOGY, HAZARDS AND RISKS

*"What is there that is not a poison? All things are poison and nothing [is] without poison. Solely the dose determines that a thing is not a poison*." Paumgartten, 1993). "*All substances are poisons; the difference is in the dose*", (Pantry, 2003). The above aphorism is attributed to the Swiss alchemist and physician Phillippus Aureolus Paracelus, known as the father of toxicology (Walters, 2003). It illustrates that the potential for harm is widespread and all chemicals could be toxic but the degree of harm that a chemical can inflict on a human or any other living being depends on the dose or the degree of exposure as well as on other factors (Paumgartten, 1993). In other words the risk from a toxic hazard depends on the exposure.

Hazards in laboratories using chemicals arise from the chemicals themselves—reactivity, flammability, corrosivity, and toxicity – and from other hazards (Bulloff, 1991). Though there is no chemical, which does not have the capacity to cause harmful effects, even the most toxic chemicals can be used harmlessly (Magos, 1992). A complete literature search of the reaction and its components, and care in handling, using and disposing of excessive chemicals and waste products, along with proper and adequate protective clothing, adequate venting, and the following of the good house keeping and personal hygiene, will reduce greatly the probability and severity of injuries (Fawcett, 1992).

### 2.2.1 Toxic Effects of Chemicals

The toxic effects, or toxicity of a chemical can be defined as the potential of that chemical to poison the body – of the person exposed, of an unborn baby (if the exposed person is pregnant), of a future offspring of the exposed person or even of an offspring of the exposed person's offspring. The potential that a chemical substance has for causing negative health effects depends principally on the toxicity of the chemical and the degree of exposure. The toxicity is a property of the chemical itself, while the exposure depends on how the is used; for example, whether it is heated, sprayed or otherwise released into the workplace environment. Another important concept in evaluating harm, however, is the individual susceptibility of exposed persons. There can be marked differences in reactions between workers who are exposed to the same chemical, at the same worksite and in similar concentrations.

Virtually all chemical substances may cause adverse health effects, depending on the dose and conditions under which individuals are exposed to them (Pantry, 2003). The toxicity (poisonous nature) of any substance is inversely related to the amount (dose) required to cause harm; the more that is required, the lower the toxicity. Toxicology is the study of harmful effects of chemicals on living organisms (Springer, 1991). Substances which can cause harm following exposure to very small amounts are said to be extremely toxic. Substances which require exposure to many grams before harm results are said to have low toxicity (Jaffery, 2002).

#### 2.2.1.1 Local and Systemic effects

Chemicals can have local or systemic effects. Local toxicity refers to the direct action of chemicals at the point of contact (Springer, 1991). Local effect is when the effect is limited to a specific area of the body, usually the point of contact; solvents, acids and strong alkalis are examples. Systemic toxicity occurs when the chemical agent is absorbed into the bloodstream and distributed throughout the body, affecting one or more organs (Kenneth & Fivizzani, 2005). Systemic applies to chemicals that affect the organs of the body such as the liver, kidneys and the brain (Springer, 1991). Examples would be lead, mercury and certain solvents such as alcohol. Systematic effects may have organ specific names, for example: hepatotoxic (damaging the liver); nephrotoxic (damaging the kidneys); neurotoxic (damaging the nervous system); cardiotoxic (damaging the heart); and immunotoxic (damaging the immune system) (Duffus & Worth, 2001).

#### 2.2.1.2 Acute and Chronic effect

Some materials present acute hazards that can have a detrimental effect relatively quickly, even during a single exposure. An acid burn is a good example of an acute hazard. Acute effects generally involve short-term high concentrations and immediate results (Springer, 1991). An example would be an acid or ammonia, where one contact has an obvious result. Chronic hazards may take years of repeated exposures to produce a harmful effect. Carcinogenic materials usually work as chronic hazards, taking many exposures over an extended period of time (Kenneth & Fivizzani, 2005). Chronic effects develop slowly with ultimate development of a disease (Springer, 1991). Examples are lead, asbestos and certain solvents and certain chemicals known as *sensitizers.*

#### 2.2.1.3 Sensitizers and other effects

Some substances fall into one or more of the above categories. An example of a chemical which can exhibit all of these four types of toxicity is phenol. It burns the skin immediately at the point of contact and so its effect is acute and local. It is absorbed into the body and affects the liver and kidneys and so its effect is therefore also chronic and systemic. Sensitizers are those substances that can produce an allergic type response from the body after one, or sometimes repeated, contact. This can affect the skin, the breathing or both (Jacobs *et al*, 2004). Exposure to these substances can mean that a person can become sensitised and a minimum exposure can give an immediate response. Some epoxy compounds and other chemicals such as amines and the isocyanates are examples.

### 2.2.2 Exposure

Chemicals are found everywhere, not only in the workplace but also in the general environment (in the air, water and soil). The heaviest exposures to some chemicals often occur during industrial or agricultural activities. But significant exposure can also occur through contact with naturally occurring ores and the surrounding soil, from vehicle exhaust emissions, from building and insulating materials and from various foods. What must be remembered is that that for a chemical to exert an effect, there must first be an exposure. Not even the most toxic chemical will cause harm to an organism, including humans, if there is no exposure (WHO, 1996)

The probability that the toxic chemical will produce injury depends not only on its toxicity but also on the conditions of exposure (Magos, 1992). The concept of exposure demonstrates that the same chemical can be both harmful and harmless. There are three aspects of exposure: dose (how much), duration and frequency (how long and how often), and route (how the victim is exposed). Changing any one of these aspects can change the effect. Severity of toxicity is dependent on the dose and time (duration and frequency) of exposure. Chemicals can take different routes to enter the body including ingestion, absorption, inhalation, and trans-placental transfer or a combination of these routes (Springer, 1991).

#### 2.2.2.1 Dermal Contact

One of the most frequent exposures to chemicals is by contact with the skin. Spills and splash can result in overt contamination of the skin. A common result of skin contact is localized irritation or dermatitis (Magos, 1992). However, a number of materials are absorbed through the skin to produce systemic poisoning. The main portals of entry for chemicals through the skin are the hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the outer layers of the skin. The follicles and the glands are supplied with blood vessels, which facilitate the absorption of chemicals into the body. Chemicals can also gain entrance into the body when contaminated hands touch the mouth, nose, eyes, sores or cuts (Furr, 1995).

#### 2.2.2.2 Inhalation

Most chemicals found in the workplace have the potential to be dispersed into the air as dust, in droplets (as mist, i.e. an aerosol) or as gas or vapour and then inhaled. Inhalation of toxic vapours, mists, gases, or dusts can produce poisoning by absorption through the mucous membrane of the mouth, throat and lungs and can seriously damage these tissues by local action. Inhaled gases or vapours may pass rapidly through the capillaries of the lungs and be carried into the circulatory system. The degree of injury resulting from inhalation of toxic substances depends on the toxicity of the material, its solubility in tissue fluids, its concentration and the duration of exposure. Inhalation hazards are often associated with gases and volatile chemicals, but solids and non-volatile liquids can also present an inhalation hazard for laboratory personnel (Furr, 1995).

#### 2.2.2.3 Ingestion

Ingestion of toxic materials in the laboratory can also occur when contaminated hands come in contact with the mouth or with food items which are placed in the mouth (Furr, 1995). Food items and utensils themselves can become contaminated when stored in the laboratory. The practice of mouth pipetting can result in aspiration of toxic materials.

#### 2.2.2.4 Injection

Accidents involving needles and syringes can result in injection of contamination through the skin. The needle and syringe is one of the most hazardous items used in the laboratory, especially when combined with the task of inoculating an uncooperative animal. Also, containers of toxic chemicals may break resulting in hazard from contact with broken, contaminated glass.

#### 2.2.2.5 Ocular exposure

The eyes are of particular concern, because they are so sensitive to irritants. Ocular exposure can occur via splash or when contaminated hands rub the eyes. Few substances are innocuous in contact with the eyes and a considerable number are capable of causing burns and loss of vision. The eyes are very vascular and provide for rapid absorption of many chemicals.

### 2.2.3 Dose

Increasing levels of exposure to or dose of a chemical will generally lead to more severe effects. For instance, higher concentrations of carbon monoxide in the air will progressively reduce the capacity of an exposed person’s blood to carry oxygen. The resultant lack of oxygen in the blood leads initially to headaches. As the oxygen levels decline further, the symptom worsen (nausea, unconsciousness and eventually death occur. This progression in severity of effect as the dose increases is called the "dose-effect relationship".

In the case of a population or a group of workers, increasing exposure levels will also lead to an increasing proportion of the group manifesting a specific effect. For example, increasing exposure to benzidine dyes will result in a higher incidence of bladder cancers among the exposed population. Similarly, increasing exposure to lead will be reflected in a greater proportion of workers who undergo blood changes. This frequency of affected people in an exposed population is called "the response". The increase in response with increasing exposure level or dose is known as the "dose-response relationship".

Another important concept is "threshold dose" or the "no-observed-effect-level" (NOEL). This means that at low levels of exposure to a chemical, the severity of the effect and the response decrease, and that at a certain point there is no effect on health. Usually this level is determined by exposing animals to lower and lower concentrations of a chemical until a level is found at which no effect on the animal is observed.

Evaluation of chemical hazard is based on two relationships, one is the dose-effect relationship and the other is the dose-response relationship. In general, the larger the dose, the shorter the time it takes for an injury to occur. Conversely, it usually takes longer for injury to result from smaller doses. Also as dose increases, the severity of the injury increases until a dose is reached that causes immediate systemic reactions which can be so severe that death results. On the other hand, the dose may be so small that immediate local and systemic injury is not noticed but longer term problems are created. The dose at which a chemical begins to be harmful is referred to as threshold.

#### 2.2.3.1 Dose-effect relationship

Listing effects against the corresponding dose gives the dose-effect relationship. The relationship between dose and effect is very different from one chemical to another. If one effect, like anaemia or loss of nerve function, can be measured on a graded scale of severity, the gradation of this effect in relation to dose is used also as a dose-effect relationship. The frequency of dosing may alter the effect. In some cases a frequent, low dose exposure may provide a more severe effect than a less frequent but higher dose (Magos, 1992).

#### 2.2.3.2 Dose-response relationship

The characteristics of exposure to a chemical and the spectrum of effects caused by the chemical come together in a correlative relationship that toxicologists call the dose-response relationship. This relationship is the most fundamental and pervasive concept in toxicology. To understand the potential hazard of a specific chemical, toxicologists must know both the type of effect it produces and the amount, or dose, required to produce that effect (Magos, 1992).

#### 2.2.3.3 Threshold

An important aspect of dose-response relationships is the concept of **threshold**. For most types of toxic responses, there is a dose, called a threshold, below which there are no adverse effects from exposure to the chemical. Some of the most commonly used measures of toxicity are the $ED_{50}$ and the $LD_{50}$. One can calculate the dose that is able to produce a response in 50% of the population and this is called $ED_{50}$ (ED = effective dose). If the response is death the dose that killed 50% of the population is called $LD_{50}$ (LD = lethal dose) (Magos, 1992).

### 2.2.4 Occupational Exposure limits

The correlation between the atmospheric concentration of a toxicant and its health effects is the basis of exposure limits. The first comprehensive list of exposure limits, called the Threshold Limit Values (TLVs) are promulgated by the American Conference of Governmental Industrial Hygienists (ACGIH) in the USA. TLVs set the pattern for other exposure limits, like Permissible Exposure Limits (PEL) promulgated by the OSHA, Maximum Allowable Concentrations (MAC) formulated by Dutch authorities, and in the UK Maximum Exposure Limits (MEL) and Occupational Exposure Standards (OES) (Furr, 1995). These standards are all 8-hour Time Weighted Average (TWA) concentrations and expected to prevent adverse effects in nearly all individuals exposed daily (a normal working day of 8 hours in a 40-hour week) during the whole working life (Furr, 1995).

Tau (2005:49) indicates that “the threshold limit values in UK and South Africa (SA) have now been replaced by occupational exposure limits (OELs)”. In United Kingdom a HSE Guideline Note EH 40, which forms part of the Control Of Substances Hazardous to Health (COSHH) Regulations of 1988 gives details of occupational exposure limits (OELs) that should be used to determine the adequacy of control of exposure by inhalation to substances hazardous to health (Furr, 1995). In SA this guideline note is adopted and reproduced as part of the Regulations for Hazardous Chemical Substances, 1995 (Tau, 2005).

The law requires that when hazardous substances are to be used, the working environment must be monitored at regular intervals to ascertain that the exposure levels are below the prescribed limits (Furr, 1995). Exposure levels can be controlled by use of good working practices and by engineering control measures (e.g. ensuring that dust and/or vapour emissions are contained, and adequate ventilation is provided). Personal protection must be made available to cater for periods of high concentrations and at such times the relevant area must be demarcated with the correct sign.

### 2.2.5 Chemical Hazards and Risks

In a general sense, the toxicity of a substance can be defined as the substance's capacity to harm a living organism. A highly toxic substance will harm an organism even if only very small amounts are present in the body. Conversely, a substance of low toxicity will not produce an effect unless the amount present in the body is very large. The main factors that must be considered when assessing the toxicity of a substance include:

- the quantity of the substance absorbed (the dose) by the person exposed to that chemical;
- the route via which exposure to the chemical occurs (e.g. inhalation, ingestion, or absorption through the skin);

- the duration of exposure to the chemical and how often that exposure occurs;
- the type and severity of the injury caused by exposure to the chemical; and
- whether or not that injury is permanent or reversible, e.g. cancer is irreversible, although sometimes treatable.

Three other terms are commonly used when the toxicity of a chemical is discussed: hazard, risk and safety. The words hazard and risk have special meanings in regulations and guidance about substances at work and the difference between them is important for a correct understanding of the control of hazardous substances. Hazard refers to the intrinsic properties of a chemical (the potential of a substance to cause damage) whereas risk refers to the chance or probability that a chemical will cause an adverse health effect under defined conditions of exposure to that chemical (WHO, 2006). If there can be no exposure to a chemical, no matter how dangerous (hazardous) it may be there is no risk of harm.

Chemicals which pose only a small hazard but to which there is frequent or excessive exposure may pose as much risk as chemicals which have a high degree of hazard but to which only limited exposure occurs. However, even if the risk of some health effect is low, the chemical in question is still a hazard. Depending on the circumstances, a "low risk" may be acceptable to the people exposed. Determining the "acceptable risk" is part of the process for setting safety standards. It is important to understand that the effects of chemicals may not be immediately obvious. On the other hand the more unpleasant ones are not necessarily the most dangerous (Fawcett, 1992).

Safety is even more difficult to define than risk or hazard. The safety of a chemical, in the context of human health, is the extent to which a chemical may be used in the amount necessary for the intended purpose, with a minimum risk of adverse health effects. It can also be defined as a "socially acceptable" level of risk. But it is usually unclear which part of society is judging the risk. Workers that are exposed to the risk are likely to be more concerned about the safety of a chemical than others. Therefore, it is very important to question statements such as "this chemical is safe" or "there is a high level of safety when using this chemical". Safety is a subjective concept.

Substances with which laboratory personnel work may be toxic, flammable, explosive, carcinogenic, pathogenic, or radioactive to mention a few unpleasant possibilities (Furr, 1995). The variety of chemicals commonly present in a laboratory poses the potential for accidental hazardous chemical reactions, fires or explosions. An explosion results when a material undergoes rapid reaction that results in a violent release of energy. Such reactions can occur spontaneously or be initiated and can produce pressures, gases, and fumes that are hazardous. Highly reactive and explosive materials used in the laboratory require appropriate procedures. In this section, techniques for identifying and handling potentially explosive materials are discussed (National Research Council, 1995)

A hazardous reaction occurs when two or more incompatible chemicals combine to result in an undesirable or uncontrolled reaction with adverse consequences. Such reactions may result when incompatible chemicals are accidentally spilled, when they are inadvertently mixed as chemical waste, or when they are unwittingly combined during experimental procedures. Many of the underlying causes of incidents and accidents in laboratories which have involved unexpected violent chemical reactions are related to the effects of physicochemical factors upon the kinetics of a practical reaction system, these factors include those governing the rate of reaction with concentration, and with the rise in temperature during the reaction. It follows from the law of mass action that concentration of each reactant will directly influence the velocity of reaction and the rate of heat release. It is, therefore, important not to use too-concentrated solutions of reagents (Bretherick, 1992).

Flammable substances are among the most common of the hazardous materials found in laboratories. The potential risk arises from the presence of combustible solids, liquids, or gases in conjunction with ignition sources (Warwicker & Sheldon, 1992). However, the ability of a material to vaporize, ignite or explode varies with the type or class of substance. Prevention of fire and explosion requires knowledge of the flammability characteristics of combustible materials likely to be encountered. Many common laboratory solvents and chemicals have flash points that are lower than room temperature (Bretherick, 1992). Personnel should be thoroughly instructed and trained in nature of the hazards and the proper steps to avoid them. This should include emergency procedures, operation of equipment, safety advices, knowledge of the properties of materials used, and PPE required (Furr, 1995).

### 2.2.6 Toxicological Risk Assessment and Management

According to Penker and Elston (2003), safety and accident prevention must be part of a proactive philosophy, policy, and practice that is modelled on a daily basis. Handling chemicals safely means learning how to conduct a risk assessment and hazard evaluation, learning how to minimize risk and to control hazards, and learning how to identify safe procedures (Hill, 2003). The risks associated with a potential for harm due to exposure to chemicals have to be identified, assessed and managed appropriately. Managerial decisions should aim to minimize risk (probability of exposure) associated with chemical use by handling appropriate to the toxicity and other hazardous properties.

The distinction between assessment and management of risks is a key issue. Risk assessment procedure is designed to evaluate, usually quantitatively, the nature and magnitude of a potential risk. Reducing risk is based on reducing exposure. The function of risk management is to decide whether a level of risk is acceptable, and if not, to translate the information into policies and actions designed to, for example, control exposure, to reduce risk through national legislative action, or to reduce risk in a variety of other ways.

Risk assessment provides the rational basis for public health decisions and actions aimed at reducing or eliminating the risk concerned (Dybing *et al*, 2002). This assessment allows health administrators to weigh the risks to human health and the costs of reducing those risks, against the benefits arising from the use of the chemical substance in question. Thus, risk management does not merely involve reaching conclusions on the basis of risk assessment; it also includes developing alternatives to a chemical agent, and comparing the available options, as well as taking due account of any ethical, political and socioeconomic considerations that may be relevant (Paumgartten, 1993). The risk assessment process consists of four elements (NAS, 1983), which are: hazard identification, exposure assessment, dose-response assessment, and risk characterization.

#### 2.2.6.1 Risk Assessment

Risk assessment involves identification of the hazard (the chemical of concern, for instance, and its adverse effects, target populations and conditions of exposure); characterizing the risk; assessing exposure (by measuring and monitoring); and estimating the risk. Thus, it consists of identification and quantification of the risk resulting from a specific use or occurrence of a chemical, taking into account the possible harmful effects on individuals of using the chemical in the manner and amount proposed, and all possible routes of exposure.

The first stage of a risk assessment, hazard identification, is primarily a question of identifying the effects that are considered as adverse, irrespective of the dose needed or the specific mechanism involved to elicit this effect (Dybing *et al*, 2002). Hazard identification should eventually provide an answer to the question: Does exposure to the chemical agent cause adverse health effects? (Paumgartten, 1993). The next step, assessment of exposure, is concerned with estimating the amount of a substance that is taken up or absorbed by human beings following exposure (actual or anticipated) by different routes (portals of entry). Assessment of exposure should be carried out in such way as to answer the following question: What levels of exposure are currently being experienced by individuals, or can be anticipated for those individuals, under different conditions?

Exposure assessment is centred on the quantification of these effects, so that the dose–response relationships identified at this stage of the risk assessment can be compared with the potential for exposure (risk characterization) (Dybing *et al*, 2002). Dose–response assessment involves evaluation of the relationship between the dose of the chemical substance and the anticipated incidence of the adverse effect in the exposed population (Paumgartten, 1993). During this phase of risk assessment, the question to be answered is: what is the relationship between the dose and the incidence of the adverse reaction in humans?

The last stage of a risk assessment, risk characterization, stands on the three previous stages and constitutes the outcome of the risk assessment process as a whole. Data gathered and analysed in the three earlier stages are assembled, integrated and summarized, and conclusions on the risk of adverse health effects are drawn (Paumgartten, 1993). The general question to be answered at this final stage is: What is the estimated incidence of adverse health effects in a given population, under specific conditions of exposure?

#### 2.2.6.2 Risk Management

Risk management covers the whole range of actions taken to prevent, minimize or otherwise control specific risks posed by a certain chemical or situation. It is based on concepts of safety and therefore contains elements of policy relating to political, social and economic factors, as well as engineering and process control. If the result of risk assessment indicates that the risk is too high, risk management must be undertaken with the aim of risk reduction. Risk management is that process of making management decisions about the risks that have been identified and analysed.

A risk can be reduced by making major changes to the way an experiment is done, or the hazard can be totally eliminated by not doing the experiment. There is one other way one can get rid of risks. That is by transferring the risk (Singley, 2004). Key decision factors such as the size of the population, the resources, costs of meeting targets and the scientific quality of risk assessment and subsequent managerial decisions vary enormously from one decision context to another. Risk management does not merely involve reaching conclusions on the basis of risk assessment; it also includes developing alternatives to a chemical agent, and comparing the available options, as well as taking due account of any ethical, political and socioeconomic considerations that may be relevant (Paumgartten, 1993).

### 2.2.7 Common Types of Chemicals That Cause Health Risks

***Dusts and Fumes:*** All particles may be harmful: the effect depends on size of particles and amount and nature of substance: particles less than 10 μm (PM10 fraction) can be breathed deep in the lungs and those less than 2.5 μm (PM2.5 fraction) may be particularly dangerous. Dusts containing crystalline silica or asbestos may cause incurable lung damage leading to cancer, especially in smokers: metal fumes may cause “metal fume fever” (Duffus & Worth, 2001).

***Gases – Phosgene:*** Gases such as sulphur oxides, nitrogen oxides, chlorine and ammonia are corrosive and irritating to the lungs and nose. Phosgene is formed when solvents containing chlorine, such as 1,1,1-trichloroethane, trichloroethylene, or carbon tetrachloride come into contact with hot surfaces or flames – Phosgene can kill before its smell is detectable: phosgene is produced in cigarettes in the presence of chlorinated solvents in the surrounding atmosphere (Duffus & Worth, 2001).

***Carbon Monoxide:*** Carbon monoxide is an odourless colourless gas formed by incomplete burning of carbon compounds: Carbon monoxide gradually blocks oxygen supply to the nervous system, making your brain function less effectively before it causes death; it reacts with haemoglobin stopping it carrying oxygen in the blood (Duffus & Worth, 2001).

***Hydrogen Cyanide:*** Hydrogen cyanide gas can pass through the skin as well as the lungs and kills by depriving your brain and heart of oxygen; it reacts with the final electron carrier of the cytochrome system to block cell respiration (Duffus & Worth, 2001).

***Solvents:*** Apart from water, most solvents are liquid organic chemicals and many evaporate rapidly at room temperature. Organic solvents are often flammable: organic solvent vapours may be inhaled or the liquid absorbed through the skin. Many organic solvents cause dizziness, headache, reduced brain activity, and tiredness. They may irritate the skin, eyes, nose and lungs. They may damage the liver, kidneys, bone marrow and nervous system. Benzene, carbon tetrachloride and carbon disulfide are particularly dangerous. Benzene can cause leukaemia, a cancer of the white blood cells, Carbon tetrachloride can cause severe liver damage, and Carbon disulfide affects the brain and nervous system causing character change and unpredictable behaviour (Duffus & Worth, 2001).

***Metals:*** Metals can enter the body as dust, fumes or through the skin; alkyl derivatives may be particularly dangerous because their fat solubility enables them to enter the body readily, for example methyl-mercury. Cadmium poisons the liver and the kidney. Chromium compounds cause dermatitis and some chromates may cause lung cancer. Lead causes anaemia and harms brain and nerve function. Mercury, breathed in as elemental vapour, or absorbed as methyl-mercury from the skin or gut, damages the nervous system and kills at quite low exposures. Nickel metal causes dermatitis: some nickel compounds may cause lung and nose cancer (Duffus & Worth, 2001).

***Arsenic:*** Arsenic is a semi-metal (metalloid) which may be present with metals in the form of arsenides, arsenites, and arsenates; chronic arsenic poisoning can start with irritation of the lungs, the eyes or the skin and lead to damage to the nervous system and to cancer, especially of the skin (Duffus & Worth, 2001).

***Acids and Bases:*** Strong acids and bases are corrosive to human tissue: stirring may create mists which can be breathed in and attack the nose and lungs. Mixing strong acids and bases or adding water to them produces heat which can cause them to splash up. When diluting, strong acids should always be added to water; water should never be added to strong acids. Some acids are explosive in contact with organic material like sawdust. Reaction of acid with pieces of metal can release flammable hydrogen gas as well as acid mist. Phosphoric acid in contact with hot surfaces releases very poisonous phosphorus oxide gases. Strong bases like ammonium, sodium and potassium hydroxides are corrosive to human tissue: some time may pass before the person affected feels the damage. Bases penetrate the skin and cause deep sores: even dilute base solutions cause tissue irritation (Duffus & Worth, 2001).

***Pesticides:*** Pesticides are used to destroy pests of all kinds including weeds (herbicides). Many, including herbicides such as paraquat, are poisonous to people. The World Health Organization (WHO) has classified them into groups according to the danger they might pose to people and the environment. The WHO classification is as follows: extremely hazardous, highly hazardous, moderately hazardous, *and* slightly hazardous (Duffus & Worth, 2001).

## 2.3 CHEMICAL INCIDENTS

An increase in the number of accidents in the chemical industries and growing environmental concerns have caused many governments to ask industries to study worst-case scenarios, to control the risk of accidents and to handle hazardous wastes and gases produced (Shah *et al*, 2003). In a study issued in 2002, the US Chemical Safety Board reported that more than half of 167 "serious incidents" occurring between 1980 and 2001 that it had uncovered in a literature search were due to reactive chemicals (Grossel, 2003). The board found that 108 workers lost their lives in 48 of these incidents. These series of serious events had increased the need and demand for stronger approaches towards regulation and legislation.

Major disasters involving hazardous chemicals include industrial accidents, such as the 1974 explosion in Flixborough, England; the 1976 run-away reaction in Seveso, Italy; the 1994 Ammonium nitrate explosion in Port Neal, Iowa; the 1998 Yellow Dye # 96 explosion in Patterson, New Jersey; the 1999 Hydroxylamine explosion in Allentown, Pennsylvania; the 2001 Ammonium nitrate explosion in Toulouse, France; the Mississauga explosion in Canada due to collision of train loads of chlorine and propane; the Somerville Massachusetts incident involving the spill of phosphorus trichloride, the 1994 Ammonium nitrate explosion in Port Neal, Iowa; and the worst in the history of chemical technology, the 1984 Bhopal disaster (Langerman, 2003; Krishna Murti, 2000, Batterman & Kovacs, 2004).

In South Africa, Sasol has had a series of explosions recently, a gas explosion at a Sasol's Secunda plant in Sasolburg claimed the lives of 10 people and injured scores of others in September 2004, another explosion at Sasol's Natref plant in Sasolburg injured 14 workers in January 2005, four people were injured in yet another explosion in Sasol's Sasolburg plant in August 2005 (Sapa, 2005; Dinga Sikwebu, 2004; Solidarity, 2005, SABC News, 2006). Thor Chemicals is notorious worldwide for giving mercury poisoning to its workers and for widespread mercury contamination of the surrounding land and streams. Thousands of tons of mercury waste were imported from the USA and European countries to the Thor Chemicals Cato Ridge plant during the 1980s and 1990s. Three workers have died from Mercury poisoning and numerous others have been left ill from exposure to this waste (Groundwork, 2003).

Chemicals accidents like these have punctuated efforts to enhance chemical safety (Grossel, 2003). Chemical health and safety, once considered a hindrance or deterrent to laboratory work, is now slowly being recognized and observed as an essential part of the operation. It is becoming commonplace practice for the legal system to assume that those who routinely work with chemicals in laboratories have knowledge of the regulations related to their work. Chemical safety should be an inherent value of every chemist, to protect the laboratory employees and students from exposure to hazardous materials and unsafe work practices (Foster, 2003). The employee or student and the employer or instructor must ensure that proper orientation, understanding, and application of this (physical and health hazards of chemical materials) knowledge is carried out (Fawcet, 1992; Fivizzani, 2005).

The known hazards of any commercial materials are described in the Material Safety Data Sheet (MSDS). The Occupational Health and Safety Administration's (OSHA's) hazard communication standard, 29 CFR 1910.1200, formalized employee's "right to know" about the hazards of the chemicals with which they work, and OSHA mandates training for several chemicals that have specific regulations. It requires employers who use hazardous chemicals to train employees in chemical hazards and personal protection. The standard also requires that employers prepare a written hazard communication program and maintain MSDSs on hazardous chemicals present in the workplace.

In recent years, there has been increasing emphasis placed on the health effects of chemical exposures (Furr, 1995). As stated by Fivizzani (2005), people need to understand how chemicals get into the body. They need to appreciate whether specific hazardous materials are inhalation, absorption, or ingestion hazards. Some materials present acute hazards that can have a detrimental effect relatively quickly, even during a single exposure (e.g., an acid burn). Chronic hazards may take years of repeated exposures to produce a harmful effect. Carcinogenic materials usually work as chronic hazards, taking many exposures over an extended period of time. Exposure dose is a function of the concentration and the time of exposure (Furr, 1995). Reducing either the concentration or the time lowers the actual dose.

## 2.4 CHEMICAL MANAGEMENT

Chemical management is a critical aspect of any teaching or research laboratory safety program. The chemical management program should include sections on all aspects of Chemical Management, including procurement, storage, handling, inventory, transportation, and chemical waste disposal (Foster, 2004). Virtually every stage in the chemical life cycle has undergone dramatic change during the past 15 years as the new culture of laboratory safety has become established. Necessarily, the new ways that chemicals are acquired, tracked through an institution, stored and delivered to the laboratory must be considered in contemporary experiment planning along with the detailed conduct of the experiment and the follow-up stages of handling all products and waste.

The prudent handling of chemicals requires reducing the volume of every component to the minimum necessary to achieve the goals for which it was acquired. Any excess should be disposed of quickly and legally, unless there is a justifiable use of it. The ACS booklet "Less Is Better" (1993) emphasizes the safety and financial reasons for buying chemicals in small packages: reduced risk of breakage, reduced risk of exposure following an accident, reduced storage cost, reduced waste from decomposition during prolonged storage in partially empty bottles, and reduced disposal cost for small containers of unused materials. Managers must consider the possible impact of raw materials, transport, processing, use, and disposal of waste after the chemical has been used. After manufacture, the majority of chemicals are used outside the chemical industry, in other industries, in agriculture, in the home, and in laboratories for research, analysis and for the teaching of students. Thus all of us have a responsibility for handling chemicals safely and must consider our part in the "life cycle" of a chemical and its safe use and disposal.

### 2.4.1 Chemical Management Responsibilities

Safety is a shared responsibility. Programmes for handling chemicals and chemical wastes in any quantity must receive support and guidance from all levels of an organization (ACS task force, 1994). Safety programs are rarely successful without the support of the departmental administration and the dedication of the Safety Leaders (Foster, 2004). Leadership is critical for any organization, large or small, to effectively accomplish the requirement and expectations of hazardous chemicals and waste management. Management must show a commitment to chemicals and waste management programs by defining goals, developing and enforcing policies, and setting priorities. To accomplish this, management must allocate recourses for personnel, space and equipment, training and any other requirements that will allow the program and employees to operate effectively (Foster, 2004).

Proper laboratory management is the responsibility of at least all line management on an organizational chart, beginning at the top with the CEO. In academic institutions this group would include presidents, provosts, departmental chairpersons, professors, and other members of the supervisory academic staff. Laboratory management also may include staff positions like laboratory manager, waste manager, waste handlers, etc. However, the reality is that if one works in the laboratory facility, you are responsible in one way or another for proper laboratory chemicals and waste management (ACS task force on laboratory waste management, 1994).

### 2.4.2 Chemical Procurement

Planning for purchasing is essential for the operation of any facility that uses chemicals as a result of the increased cost of chemicals, the necessity of safety in the storage and handling of chemicals, and the ever-increasing regulations and cost of disposal of these items (Bequette, 1991). The real cost of a chemical includes its initial purchase price plus the ultimate disposal costs. From the viewpoint of purchasing, the quantity actually used relative to the quantity purchased governs the unit purchasing cost. Personnel often check the price of the next larger quantity of chemical and realizing that the price per gram decreases with larger purchases, they buy the larger volume thinking that such a strategy saves money because someone will eventually use the surplus material (Fivizzani, 2005).

The perceived economy of purchasing chemicals in large quantity containers may be deceptive. The key to minimizing the amount of wasted money is good planning based on accurate information, such as previous usage rates, projected future usage rates, available storage space for different types of chemicals, safety regulations concerning storage of hazardous chemicals, ability of personnel to handle certain size containers of different chemicals, the economic feasibility of purchasing in large quantities, and the method and time required to replenish in-house stocks (Bequette, 1992).

Planning should begin with management or administration defining clear-cut areas of responsibilities and purchasing procedures. Strict enforcement in these areas will eliminate delays in ordering and deliveries, duplicate shipments, wrong addresses on shipments, and confusion in accounting areas. Methods of procurement, receipt, and distribution of hazardous chemicals may vary widely among different laboratory facilities and may be highly dependant on the size and complexity of the organization, as well as the degree to which its procurement systems are formalized. However, each laboratory should establish a means by which chemical purchases and deliveries can be reviewed and approved (Stricoff & Walters, 1992). A purchase review, for example, can be used to evaluate new hazards introduced by procurement of a chemical not previously used at the facility. A purchase review can also be used to minimize the quantities of chemicals purchased, thereby reducing the magnitude of risk.

Foster (2004) suggested that when preparing to purchase a chemical, there are several questions that one should ask, including:

- Do I really need to order this chemical? Check the departmental chemical inventory to determine if the chemical is listed on the inventory for another laboratory.
- How much do I really need to order to perform my experiment? (*Less is always best*.) Order the least amount of chemicals that will be needed to save storage space and money.
- What personal protective equipment (PPE) is required when handling this chemical? Is the proper PPE available in the laboratory?
- What is the level of training that is required to use this chemical?
- Are there special handling precautions?
- Does the laboratory have the proper storage facilities?
- Does the laboratory chemical hood provide proper ventilation?
- Are there special containment considerations in the event of a spill, fire, or flood?

- Will the institution provide disposal of this chemical? Are there additional costs related to the disposal of this chemical?

### 2.4.3 Chemical Storage

Every organization that uses chemicals needs an ongoing system for the safe storage of those chemicals. The complexity of the system and its major elements (environment, procedures, people, and information) depend on the type and amount of chemicals stored. The key to an effective and safe storage system is the analysis of your storage needs, both in depositing and supplying chemicals to your laboratories. As a system, safe storage is an ongoing process, a continuous cycle of planning, implementation, and monitoring strategies. Safe storage requires regular attention and management. The accumulation of excess chemicals can be avoided by purchasing the minimum quantities necessary for a research project. All containers of chemicals should be labelled properly. Any special hazards should be indicated on the label (National Research Council, 1995).

Chemical storage should be protected to preclude leaks, spills, and other forms of physical damage. In the event of a chemical spill or fire, incompatible chemicals that are stored in close proximity can mix and create fires, toxic fumes, and explosions. For this reason, storage on bench tops and in hoods should be avoided, and spill trays, spill- and shatter-proof containers, secondary containers, and proper receptacles should be used as needed (Foster, 2004). In the event of an accident, container breakage, a spill, violent weather events, or a fire incompatibility of stored chemicals is a serious concern (Cournoyer, 2005). To protect personnel, chemicals must be separated and stored according to hazard category and compatibility (Foster, 2005). Compatibility information can be found on the label and in the MSDS. The five main chemical classes to segregate are: oxidizers, corrosives, flammables, toxins, and reactives.

To ensure that chemicals do not deteriorate while stored and to avoid accidents and potentially costly fines from regulatory agencies chemical containers should be labelled; and labels should contain the following information: Chemical Name; Hazard Warning; Name of Manufacturer; Date of receipt, opening, and expiration (Stricoff and Walters, 1995). Proper labelling is a simple and powerful way to reduce many of the environmental hazards and costs associated with chemicals used in the laboratory. Proper labelling of containers also decreases the risk of injuries and accidents, and aids in complying with regulatory requirements such as hazard communication.

### 2.4.4 Chemical Handling and Use

Laboratory personnel work in a potentially extremely hazardous and unforgiving environment (Furr, 1995). The risk of working with a hazardous material is a function of the inherent hazard of the material and the worker's exposure to that material. Staff and students should learn the appropriate ways to minimize personal exposure to hazardous chemicals. Using Personal Protective Equipment (PPE), including a chemical hood or glove box, will reduce exposure significantly. Scientists must understand that exposure levels can be monitored to ensure that excessive exposure does not occur. In addition, there are some medical tests that can measure any detrimental effect due to excessive exposure. Examples of such tests are pulmonary function tests and tests for blood levels of lead or mercury. When applicable, occupational health monitoring is an appropriate part of a research project (Fivizzani, 2005).

In some chemistry courses, hazardous chemicals are being replaced with non-hazardous reactants whenever possible. When the use of hazardous materials cannot be avoided, many experiments can be carried out on a very small scale, thereby limiting exposure levels and the quantity of hazardous waste produced. Such minor micro-scale experiment developed for safety purposes have the added advantage of teaching good laboratory techniques. Every professional chemist should have some knowledge and experience in designing safe experiments with hazardous chemicals, including the use of engineering controls, personal protective equipment, and replacing hazardous materials with non-hazardous substitutes where appropriate (Elston, 2000; Fivizzani, 2003).

### 2.4.5 Chemical Inventory

Managing chemical inventories at colleges and universities has often been identified by environmental health and safety (EH&S) directors as one of the major safety and compliance management challenges for higher education institutions. The complex organizational structure at colleges and universities combined with the extent and diversity of chemical use activities has made resolving this issue most difficult (Gibbs, 2005).

The prudent management of hazardous materials, from their procurement to their proper disposal as chemical waste, is a critical element of a departmental laboratory safety program. A successful chemical management program includes standard operating procedures to ensure the safe handling, storage, and transport of chemicals and the proper disposal of chemical waste (Foster, 2005). The chemical tracking system should be designed to track chemicals from the time they are purchased through the time when they are used, and ultimately disposed, “from cradle to grave”. The cradle-to-grave tracking system should also provide information on who uses chemicals and where chemicals are kept (Foster, 2005).

In an academic department, the chemical inventory process is also a critical element of chemical management. There is no better tool for determining teaching or research chemical needs, identifying chemical hazards, submitting chemicals for proper disposal, providing information to emergency personnel, and training laboratory personnel on their specific laboratory chemical hazards than producing a hazardous chemical inventory for your department (Foster, 2004). The amounts of hazardous materials should be carefully monitored in the laboratory. A physical chemical inventory should be performed at least annually, or as requested by the Chemical Hygiene Officer. A thorough inventory will ultimately facilitate the elimination of unneeded or outdated chemicals and provide more efficient use of laboratory storage space (Foster, 2005).

An up-to-date chemical inventory is an important component of the departmental Chemical Inventory Management System. According to *Prudent Practices in the Laboratory*, a chemical inventory "is a database that tabulates the chemicals in the laboratory, along with information essential for their proper management." (Prudent practices in the laboratory). The OSHA Laboratory Standard, *Occupational Exposure to Hazardous Chemicals in Laboratories*; 29CFR; Part 1910.1450, Appendix A, Section D.2.b (*Chemical Procurement, Distribution, and Storage*), states that "*Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity*." (OSHA, 1990; Foster, 2005). Additionally, Appendix A, Section D.2.d (*Chemical Procurement, Distribution, and Storage*) states that "*Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom*." The ACS Joint Board-Council Committee on Chemical Safety publication, *Safety in Academic Chemistry Laboratories*, encourages laboratory supervisors to "maintain a detailed and current inventory of chemicals" (Foster, 2005).

Tracking chemical inventories is necessary for safety management as well as regulatory compliance. This task however, is especially challenging for diverse and decentralized research and laboratory organizations. Safety and compliance, waste minimization, emergency preparedness, and facility planning design all benefit from knowing what chemicals exist at a facility, who has responsibility for them, and where they are located (Gibbs, 2005; Foster, 2005). To protect employees and students from exposure to hazardous materials, the amounts of hazardous materials that are stored in the laboratories and prep rooms should be carefully monitored. Chemical inventory can be maintained on software that varies from a searchable spreadsheet to any of the various commercially available software packages that have been developed exclusively for chemical inventory management and to address hazardous materials issues during chemical operations (Cournoyer, 2005).

The benefits of performing annual chemical inventory updates may include the following: Ensures that chemicals are stored according to compatibility tables, Eliminates unneeded or outdated chemicals, Allows the ability to share chemicals in emergency situations, Allows for checking of expiration dates for chemicals, Allows for checking of the integrity of the shelving and storage cabinets, Allows for the repair/replace of container labels and caps, Ensure compliance with all regulations, and Reduces the risk of exposure to hazardous materials and ensure a clean and healthy laboratory environment. Without an inventory of chemicals stored in a particular location, many questions pertinent to chemical operations can be time-consuming to answer. On the other hand, a well-managed system can address hazard identification, storage incompatibility, hazard minimization, and safety concerns before they become issues.

### 2.4.6 Chemical Waste Strategies

Waste is generally defined as excess, unneeded, or unwanted material. All laboratory work with chemicals eventually produces chemical waste. Everyone involved in the laboratory activities shares the legal and moral responsibility to minimize the amount of waste produced and to dispose of chemical waste in a way that has the least impact on the environment. Depending on what is contained in the waste, some waste must be professionally incinerated or deposited in designated landfills, while other waste can be neutralized or discharged in normal streams (ACS task force, 1994). Hazardous waste should be identified clearly so that its origin can be traced. Chemical waste should be accumulated at a central site where it can be sorted, stored temporarily, and prepared for disposal by commingling or allowable on-site treatment for hazard-reduction or perhaps, recycling (Foster, 2004).

In academic institutions, waste disposal issues rarely get the attention they deserve (Fivizzani, 2005). Concern about the fate of used or unwanted products of chemical reactions has not been a significant part of the traditional culture of laboratory workers. Chemists should have a basic comprehension of how waste materials are handled in their organization. Planning new products or programs must consider environmental issues. Will raw materials, by-products, or final reaction products create any environmental concerns? Do the use of these materials result in detrimental water or air emissions? Will outdated, spoiled, or reacted products become hazardous or non-hazardous waste that requires funding for proper disposal? (Fivizzani, 2005).

Increasing environmental awareness and the current growth in the number and complexity of laws and regulations governing waste disposal have made reduction of wastes a critical part of laboratory operations (ACS task force, 1994). Whenever a scientist plans an experiment involving chemicals, he/she should ask these questions:

(1) Is this chemical hazardous to me, my co-workers, or the end users of a potential product?

(2) Will any hazardous by-products form during the manufacture or use of this material?

(3) What is required for proper disposal of surplus or returned materials?

A number of laws and regulations now require waste minimization planning and reporting (Fivizzani, 2005). The benefits of reducing waste generation are significant. The dangers of accidents and personnel exposure are minimized, and the liability and negative publicity associated with such incidents are reduced. Substantial cost savings are a clear incentive for waste minimization.

## 2.5 SAFETY MANAGEMENT

Safety management is one of the management activities of an organization. Different organizations have different management practices, and also different ways to control safety hazards. The term safety has been in use for a long time. Safety implies an acceptable level of risk, relative freedom from harm, and low probability of harm. Summarizing different opinions in earlier studies, Manuele (1993) defined safety as a state for which the risks are judged to be acceptable. Gloss and Wardle (1984) contended, however, that safety is a relative condition, and there is no such thing as absolute safety under any conditions.

Liu (1995) maintained that safety refers to an existing condition, which shields people from external hazards and a protective function, which provides people with healthy, comfortable, and highly efficient working conditions. Song (1997) defined safety as a state where people feel stable and comfortable and enjoy physical and mental health, while the work environment is kept in good order and tidy in the production process. Huang (1995) suggested that safety is a complex combination of mental, physiological, and physical conditions which are related to the knowledge, capability, experience, and working habits of people. In other words, injury or danger can be reduced when those conditions match people's knowledge and skill levels.

Effective management of laboratory safety requires the preparation and implementation of a written plan, the chemical hygiene plan (CHP), that documents information and provides training to ensure employee's awareness on the hazards of chemicals present in their work areas. In addition, all laboratories should have a written health and safety plan. The CHP complies with the Occupational Health and Safety Administration (OSHA) laboratory standard, 29 CFR 1910.1450. The OSHA's Laboratory Standard (29 CFR Part 1910.1450), officially called Occupational Exposure to Hazardous Chemicals in Laboratories, applies to all employers engaged in the laboratory use of hazardous chemicals.

The standard is intended to protect laboratory employees from the health hazards of hazardous chemicals and to ensure that exposures do not reach or exceed exposure limits (Keith Furr, 1995; Stricoff & Walters, 1995).

There is a general recognition that while the importance of engineered safeguards and formal management systems to control risks is essential, it is equally important to win the commitment of the workforce to treat safety as a priority through a genuine corporate commitment to achieve high levels of safety (INSAG-15, 2002). Employees and students should know and understand the physical and health hazards of the materials that they use. Every person who uses chemicals should be aware of what chemicals are used and stored, and their toxic properties and routes of absorption (Smith, 1992). This may appear a daunting task, but in most cases information is readily available from suppliers, in published literature, and in Government publications. It must be the aim of everyone involved to ensure that all chemicals are handled safely without either immediate or long-term dangers (Luxon, 1992). A clean, healthy general working environment must be provided and individuals encouraged to become safety conscious.

### 2.5.1 Safety Culture

The concept of safety culture was largely popularized as a result of the nuclear plant disaster that occurred at Chernobyl in 1986 (Merritt & Helmreich, 1996; Meshkati, 1997), although several years earlier Zohar (1980) researched the climate for safety by measuring employee perceptions based on a questionnaire completed by 400 employees. Zohar (1980) used eight dimensions to measure these perceptions. His concern was individual performers and how their perceptions related to ratings of safety inspector. Since its inception, the concept of safety culture has been a key topic in discussions of safety across many industries. Whilst there are differing perspectives within the broad definition of Safety Culture there appears to be general agreement, however when it comes to decomposing culture to its sub components there appears to be a moderate divergence of opinion.

Most definitions of safety culture encapsulate beliefs, values, and attitudes that are shared by a group. As human behaviours (and thus at an individual level, safe or unsafe behaviours) are partly guided by personal beliefs, values, and attitudes (Fazio, 1986; Kleinke, 1984), continued workplace safety may have its base in individually, and organizationally constructed shared beliefs that safety is important. A related theme evident in the definitions of safety culture offered is that of individual norms. Ostrom, Wilhelmsen and Kaplan (1993) argue that a culture is comprised of social norms, which are unspoken rules of behaviour that, if not followed, result in sanctions. An example of a positive safety norm may be that the workforce reports all procedural irregularities. Reason (1997) argues that this norm will only develop under the conditions he calls a 'reporting culture' – a culture in which workers feel free to report their errors and near misses to management without unjust punishment. Understanding the safety culture of an organization, work site or work-group as a whole may be difficult but identifying and understanding the dominant safety norms may be a more manageable method of attending to specific issues.

Reason (1997) asserts that safety culture comprises interacting elements that enhance safety health as a natural by-product. Safety culture concerns the basic values, norms and attitudes concerning safety that exist in an organization (Turner *et al*, 1989). An efficient and successful safety management depends largely on the attitudes and the commitment to safety that exist in the organization especially on the management level. McCormack (1999) highlights that a safety culture is one in which everyone willingly become involved for the prevention of accidents. Similar to the broad definition offered by Turner *et al* (1989), Pidgeon and O'Leary (1995) define safety culture as the set of beliefs, norms, attitudes, roles, and social and technical practices within an organization which are concerned with minimizing the exposure of individuals, both within and outside an organization, to conditions considered to be dangerous.

The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine commitment to, and the style and proficiency of, an organization's health and safety management (Pidgeon, 1991). Furthermore, organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficiency of preventative measures. A positive culture in a workplace exists when safety and health is understood to be, and is accepted as, a high priority. The existing safety culture within an organization very much affects how proactive the approach to safety management will be. An efficient safety management probably demands integration with the general management of the organization, but also as far as possible coordination with the areas of quality, health and environment. A good safety culture manages to create motive powers for safety within the organization itself.

Cooper (1999) believes that Safety Culture is a super-ordinate goal that is achieved by dividing the task into a series of sub-goals that are intended to direct people's attention towards the management of Safety. Cooper (1999) then notes that there are three major components of Safety Culture in line with Bandura's 1977 and 1986 work on reciprocal determinism. Reciprocal determinism identifying that people are neither deterministically controlled by their environments nor entirely self-determining. These 3 major components are the person, situation and behaviour; of which 'person' and 'behaviour' featured in the discussion on the definition of culture above where the psychological and behaviour elements were aligned with the intrinsic and extrinsic elements.
Further expansion of Cooper's (1999) work leads to his proposed model which has been replicated Figure 2.1 Below.

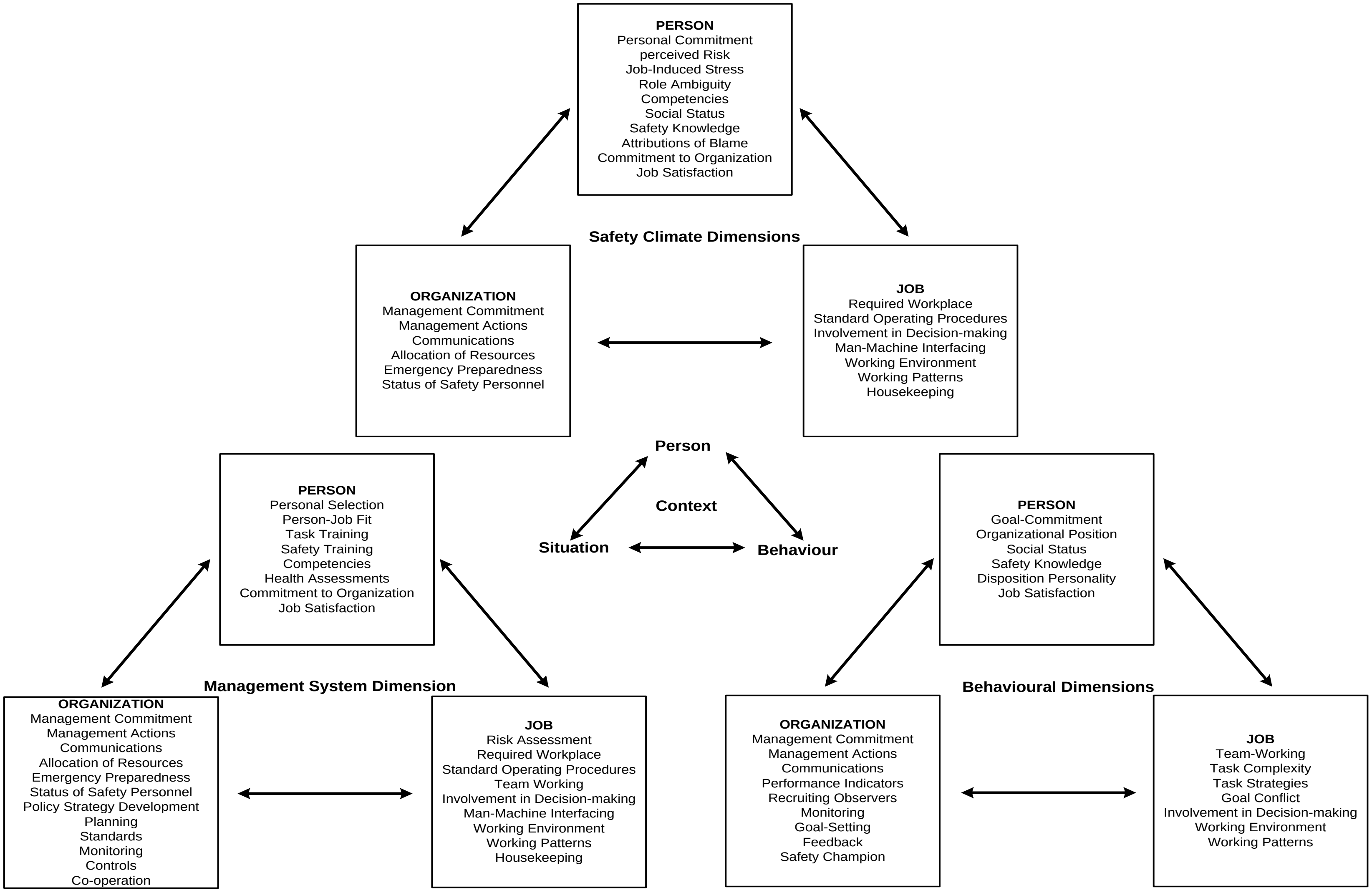


**Figure 2.1: Reciprocal Model of Safety Culture (Cooper, 1999).**

Cooper (1999) has combined the research of many people to develop the model as shown and as can be seen in Figure 2.1, the model is multi layered with the person, job and organization being replicated for the three main dimensions of Safety Management Systems, Safety Climate and Behaviour. The Cooper model seems to have significant credibility as it follows the UK Health and Safety Guide (Flannery, 2001).

Cooper's (1999) model has some attractive features in that it combines Zohar's Safety Climate dimension in addition to commonly used Safety Management Systems and Behavioural Dimensions, all of which can be measured to various degrees. Mearns (1998) articulates the distinction drawn by Cooper (1999) between the 3 dimensions when discussing offshore installations and suggests that senior management within individual companies try to create a particular 'culture' with respect to health and safety, but that the context of the operating environment and the particular activities which the installation is engaged in, determines the prevailing 'Safety Climate' which is of far more relevance to the offshore worker.

Importantly Mearns (1998) also argues that organizations should pay more attention to how their 'Safety Culture', in the form of norms, values, assumptions and philosophies map into their rules, policies, procedures and how these, in turn, are perceived and enacted by the workforce in a particular environmental context. Mearns (1998) appears to be noting that culture is homogenous but captured within context. Using this notion it appears reasonable to conclude that a change in context will lead to a change in culture. Additionally, Mearns' statement accords with Coopers (1999) model in that 'norms values, assumptions and philosophies' equate to the psychological elements, enacted by the workforce equates to the behavioural element and the environment context' equates to the Safety Management Systems element.

Chemical safety in the workplace is imperative for the welfare of the workforce and the organization. Employers and employees must have knowledge and skills in safety, and a strong safety ethic to work in a safe manner. University laboratories should provide protective conditions, be assessed for occupational hazards and have their safety quality evaluated in relation to governmental regulations, and employer and labour requirements. An organization's safety culture can be observed in the beliefs and behaviours of its staff members regarding the importance of eliminating or minimizing workplace hazards. Safety culture encompasses elements such as conducting work safely and responsibly; protecting the health, safety, and welfare of the general public; and protecting the environment

Cox and Cox (1991) argued that employee attitudes are one of the most important indices of safety climate, since these attitudes are often framed as a result of all other contributory features of the working environment. Donald and Canter (1993) proposed using the attitudinal approach, particularly with respect to safety attitudes and climate. This attitudinal approach starts from a basic premise: ‘a large number of accidents are under the control of those involved in them. The people involved may not intend to have an accident, but the behaviour that leads them to the accident is intentional, and they are aware of what they are doing. This is in contrast to the idea that an accident happens because of some momentary lapse of concentration or slip. They then developed a Safety Attitude Questionnaire (SAQ) to measure attitude, which comprises sixteen scales. The rationale is that surveying workers’ safety attitudes, using questionnaires as measurement instruments, may appear to be similar to management safety audits.

Attitudes, both personal and organizational, affect the development of a safety culture in a workplace. The environment in which people work and the systems and processes in an organization also influence the safety culture. Each organization needs to consider all of these aspects in developing and nurturing a safety culture that suits the organization and the individuals within it. A useful framework distinguishes between three interrelated aspects of safety culture, specifically psychological aspects (often referred to as 'safety climate'), behavioural (or organizational) aspects and situational (or 'corporate') aspects. This approach is summarized in Figure 2.2, produced based on the theory of Cooper (2000). The connecting arrows reflect the view that the three aspects of safety culture are interrelated and are therefore not mutually exclusive.

The psychological aspect of safety culture refers to how people feel about safety and safety management system. This encompasses the beliefs, attitudes, values and perceptions of individuals and groups at all levels of the organization, which are often referred to as the safety climate of the organization. This can be measured objectively through the use of safety climate questionnaires which aim to uncover the workforce's norms, values attitudes and perceptions of safety at a given point in time.

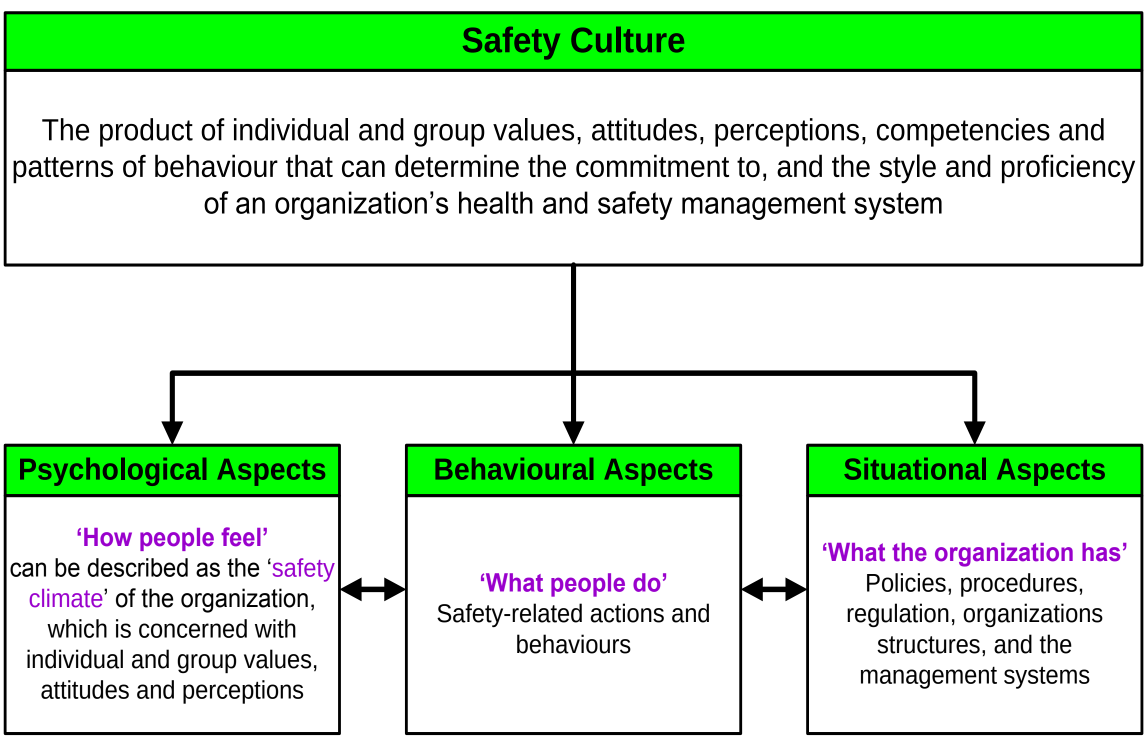


**Figure 2.2: A three aspect approach to safety culture (Adopted from Cooper, 2000)**

Behavioural aspects are concerned with what people do within the organization, which includes the safety-related activities, actions and behaviours exhibited by employees. These aspects can also be described as organizational factors. Behavioural components can be measured through self-report measures, outcome measures and observations. The situational aspects of safety culture describe what the organization has. This is reflected in the organization's policies, operating procedures, management systems, control systems, communication flows and workflow systems. These aspects can also be described as corporate factors.

### 2.5.2 Safety Climate

The term safety climate was coined by Zohar (1980) in an empirical investigation of safety attitudes in Israeli manufacturing. He defined it as a summary of molar perceptions that employees share about their work environments'. More recent definitions resonance this, for example, Niskanen (1994) defines safety climate as a set of attributes that can be perceived about particular work organizations and which may be induced by the policies and practices that organizations impose upon their workers.

Brown and Holmes (1986) deemed that safety climate is a set of perceptions or beliefs held by an individual or group about a particular entity. In addition, many authors (Coyle, Sleeman, & Adams, 1995; Dedobbeleer & Beland, 1991; Williamson, Feyer, Cairns, & Biancotti, 1997) portrayed that the climate was focused on the members' perception, attitude or belief regarding safety issues in the organization. These issues are related to the working environment or the organizational characteristics.

Furthermore, Glennon (1982) claimed that safety climate is employees' perceptions of the many characteristics of their organization that have a direct impact upon their behaviour to reduce or eliminate danger. Diaz and Cabrera

(1997) considered that safety climate is a set of molar perceptions, shared by individuals with their work environment, which are valid as references for guiding behaviour in the execution of tasks during day-to-day eventualities. Additionally, Cabrera, Isla and Vilela (1997) conceptualise safety climate as organizational members' shared perceptions about their work environments and organizational safety policies.

Cooper (1998) proclaimed safety climate is a perceived image that is mostly concerned with labours' perceptions of the importance of safety and how it is enforced within the organization. Safety climate is defined as a set of molar perceptions of safety culture, shared by individuals, which is affected by organizational factors and personal factors, and influences the safety behaviours of employees. Safety climate is generally acknowledged to be the perception of safety culture.

The definitions of safety climate are clearly related to those of safety culture. For example, Guldenmund (2000) points out that shared aspects are stressed in both sets of definitions. The main differences in the definitions are that whereas safety culture is characterised by shared underlying beliefs, values, and attitudes towards work and the organization in general, safety climate appears to be closer to operations, and is characterised by day-to-day perceptions towards the working environment, working practices, organizational policies, and management. Thus, safety culture and safety climate appear to operate on different levels and this reflects the origin of the concepts in the organizational psychology literature of the 1980's and earlier social and behavioural psychology.

As many of the definitions of safety culture and safety climate have common elements, safety climate may reflect the underlying culture of the work-group or organization, although its focus is actually much narrower than safety culture. More specifically, safety culture is seen as a sub-facet of organizational culture (Cooper, 2000) and exists at a higher level of abstraction than safety climate

(Reichers & Schneider, 1990). It seems plausible that safety culture and safety climate are not reflective of a unitary concept, rather, they are complementary independent concepts.

Of particularly significance in any discussion on the issue is Zohar's (1980) observations that any given organization creates a number of different climates, and that James and Jones (1994) distinguished between measures of organisational climate that are based on (a) structural properties such as size, structure, systems complexity, leadership style and goal directions and (b) perceptions held by employees about aspects of their organisational environment summarized over individual employees.

The concept of Safety Climate used by Zohar focuses only on employee perceptions. Additionally Zohar (1980) makes the assumption that perceptions translate into behaviours which is one of the three dimensions of Coopers (1999) work. Zohar states that it is assumed that these perceptions have a psychological utility in serving as a frame of reference for guiding appropriate and adaptive task behaviours. Based on a variety of cues present in their work environment, employees develop coherent sets of perceptions and expectations regarding behaviour-outcome contingencies and behave accordingly.

The similarities between Zohar's (2000) work and Cooper's (1999) model can easily be identified and have been tabled below (Table 1) for easy reference. It is worthy of note that certain authors have a position regarding Safety Cultures dependent on their particular focus. By way of example, Krispin and Hantula (2001) focus solely on behavioural safety interventions as does McSween and Matthews (2001), however, Cooper's (1999) model appears to broadly consider all positions including behavioural, perceptual (climate) and situational (Safety Management Systems) dimensions perhaps not to the depth of the single focus but with the whole in mind.

**Table 2.1: Comparison of Cooper (1999) and Zohar (2000) regarding the 3 major component of safety culture (Flannery, 2001)**

| Cooper (1999) | | Zohar (2000) |
|---|---|---|
| Safety Climate | ⟺ | Safety Climate |
| Behaviours | ⟺ | Assumptions that the perceptions translate into behaviour |
| Safety Management Systems | ⟺ | Acknowledged in the paper noting the work by James and Jones (1994) but not the focus of the paper |

The Safety Climate espoused by Zohar (1980) can be viewed as the discrete element of Safety Climate in Cooper's (1999) model and is confirmed by Cooper's acknowledgement and reference to his work. Similarly Zohar (1980) appears to share Cooper's (1999) assertion of reciprocal determinism when he indicates perceptions and therefore behaviours are based on work environmental cues. Even though comprising only one third of the Cooper (1999) model, Safety Climate appears to be the most discussed, recognized and measured dimension.

Support for the importance of perceptions in Safety Cultures is also noted by Williamson, Feyer, Cairns, & Biancotti (1997) where they state that in understanding the safety climate or culture of a workplace, the perceptions and attitudes of the workforce are important factors in assessing safety needs. The structure and systems as part of climate (James & Jones 1994) fit into the dimension of Safety Management Systems in the Cooper (1999) model.

Pizzi, Goldfarb and Nash (2001) appear to concur with the importance of Safety Climate measurement when they stated that the aspect of organizational Safety Culture that may be visible or measurable is sometimes referred to as the safety climate, which includes management systems, safety systems, and individual attitudes and perceptions. Interestingly this statement uses both parts of the James and Jones (1994) climate definition; structure/systems and perception.

Also in agreement with the measurement of climate was the Ladbroke Grove Rail Inquiry (2000), which concluded that a distinction can be drawn between culture and climate and further indicated that climate is the observable, tangible part of culture and that culture is the understanding of people's fundamental values with respect to say, risk and Safety. In light of the preceding discussions it appears reasonable to conclude that Safety Climate is a distinct dimension of Safety Culture that lends itself to measurement of safety perceptions within the organisation.

### 2.5.3 Safety Climate Measures

Safety climate measures have been widely researched and tend to be used as substitute measures of safety culture. Over the years a number of questionnaires have been developed by various researchers (e.g. Zohar, 1980; Mearns *et al*, 1997; Lee, 1998) in an attempt to identify the main factors that comprise safety climate. As stated earlier, Cox and Cox (1991) developed a Safety Attitude Questionnaire (SAQ) to measure attitude, which comprises sixteen scales (for details, see instrument section). The rationale is that surveying workers' safety attitudes, using questionnaires as measurement instruments, may appear to be similar to management safety audits. They conducted safety research using the SAQ in more than 40 companies over six years, and concluded from their research that it is possible to measure attitudes towards safety in a valid and reliable way, and attitudes are predictive of safety performance. For instance, 14 out of the 16 safety attitude scales were found statistically significantly related to lost-time accidents (Donald, 1994). The implication of these results is, if a department's safety attitudes are surveyed, it is possible to predict the accident rates that are likely within that department and to take proactive corrective action.

Although such surveys produce a snapshot of an individual's safety climate the results tend to be aggregated at a group or organizational level to give a view of the overall safety climate of the organization. Recent interest in the measurement of safety culture has resulted in a number of reviews of the area. These reviews demonstrate the wide range of assessment tools, typically self-report questionnaires from large scale surveys that have been developed. Such assessment tools are often customized to a particular industry, principally the energy industry but also manufacturing and health. In a review of the area, Flin *et al* (2000) looked at 19 studies and found that 16 were derived from literature reviews of the safety research; of those 6 studies incorporated interviews and focus groups conducted at the workplace. The other 3 studies used existing questionnaires. Typically factor analysis is then used to identify underlying structures. Again, Flin *et al* (2000) found a large range of variation in the number of factors identified: from 2 to 19 in the studies that they reviewed.

Whilst Lee and Harrison (2000) extracted 28 factors in their assessment of safety culture in nuclear power stations. As Flin *et al* (2000) point out the dimensions of climate measures vary considerably in terms of criteria, statistical analysis, size and composition of workers and industry. Thus drawing comparisons between the measures is difficult not only because of the methodological differences outlined but also because of language and cultural variations.

Consistency amongst safety climate measurements is difficult. For example, Zohar (1980, cited in Glendon & Litherland, 2001) found eight safety climate dimensions amongst Israeli production workers including management attitudes, effects of safe conduct on promotion, work pace and status of safety officer and safety committee. However, when Brown and Holmes (1986, cited in Glendon & Litherland, 2001) used the same questionnaire on a sample of American Production workers they found only three safety climate factors: management concern, management activity and risk perception. Dedobbeleer and Beland (1991, cited Glendon & Litherland, 2001) tried to validate the three safety climate factors on American construction workers but found the two factors of management commitment and worker involvement, more appropriate than the 3.

Coyle *et al* (1995 cited in Glendon & Litherland, 2001) administered a safety climate questionnaire to two similar organizations and found that while 7 factors emerged for one organization only three factors emerged for the other. Varonen and Marrila (2000) however, used the same safety climate variables (organizational responsibility, workers safety concerns, workers indifference to safety and level of company safety precautions) as used in two previous Finnish studies and found similar results. They suggested that the results indicated that the safety climate structure is relatively stable among Finnish workers.

However, Cox and Flin (1998) identified the following as emergent factors; ‘management commitment to safety’, ‘personal responsibility’, ‘attitudes to hazards’, ‘compliance with rules’ and ‘workplace conditions’. Two years later Flin *et al* (2000) attempted to identify the most common themes which have emerged from recent research. They identified 18 published surveys from the years 1991 to 1998 which had a sample size of more than 100, were written in English and included only industrial sectors. They found that 50% of measures came from the energy/petrochemical sector which is currently leading the field in this area. Guldenmund (2000) carried out a similar review of the safety climate literature using 15 studies and found the common safety climate dimensions of management, risk, safety arrangements, procedures, training and work pressure. His analysis included a review of 11 of the research teams reviewed by Flin *et al* (2000).

Drawing on Guldenmund's (2000) analysis Flin *et al* (2000) suggest that there are three core themes namely "management, risk and safety arrangements". Other themes which emerged, though less frequently, include "work pressure, competence and procedures". These themes will be considered in the light of subsequent research from 1998 onwards in an attempt to identify what relevant literature exists to substantiate their inclusion.

Flin *et al* (2000) found themes relating to management and supervision in 17 studies, which makes this the main theme. Dedobbeleer and Beland (1998) in a review of safety climate surveys found evidence for two main factors, one of which they identified as management commitment. Aspects of management include perceptions of management attitudes and behaviours in terms of safety and production, along with other issues such as discipline and selection. In some of the studies however, the management label is used ambiguously making it difficult to ascertain the level of management which is being assessed. This is an important issue as each management level has distinct roles within an organisation and the workforce does perceive them differently. Thompson *et al* (1998) suggests that senior managers support safety through indirect means such as establishing safety policies and procedures, setting production goals etc. While supervisors act as the link between management and shop floor, they monitor worker compliance to safety and provide feedback to workers concerning their behaviour.

It is worth noting that psychological and behavioural measurement is generally collected from the individual perspective and then requires some amalgam of the measurement to gauge the collective culture. The techniques of observation, audit and survey are discussed below.

### ***OBSERVATION***

Observation is a technique to measure behaviours. Behaviour is one of the three major dimensions of the Cooper (1999) model. It is also worth recalling that Zohar (1980) believes that it is not necessary to measure behaviours as he assumes that attitudes measured through survey are enacted as behaviours. Zohar's (1980) work appears to support his assumption as his measurements were positively validated against measures such as accident rates and lost time incident frequency rates.

The UK Health and Safety Executive Safety Climate Measurement User Guide and Tool kit notes that observation can be direct or indirect. Indirect being used to collect data via reports and organisational records and direct usually using behavioural checklists tailored to the operation. An example of such a checklist is shown below at Table 4.

**Table 2.2: An Example Behavioural Checklist, adapted from the UK HSE Safety Climate Measurement User Guide and Toolkit**

| Tasks | Behaviour | Safe | Unsafe | Not Seen |
|---|---|---|---|---|
| **Daily Inspection** | Used checklist | | | |
| | Completed checklist | | | |
| | Avoided propeller arc | | | |
| | Used PPE for fuel drain and oil check | | | |
| | Steady space | | | |
| | Checked hatch/doors/caps for security | | | |
| | Certified appropriately | | | |

Cooper (1999) noted that the behavioural aspects of Safety Culture can be examined via peer observation, self-report measures and/or outcome measures. He also notes that analysing an organisations accident history for the previous two years often reveals a relatively small number of safety behaviours that have been implicated in the vast majority of organisational accidents. It seems reasonable to postulate this analysis to determine safety-implicated behaviours can significantly narrow the focus of the observation.

Cooper (1999) also notes other sources to glean safe behaviours includes risk assessment documentation, standard operating procedures, permits to work, group discussions etc, and further that the behaviours identified from these checklists are then placed on observational checklists and trained observers regularly monitor personnel against them. Cooper's (1999) considerations on measuring behaviours and the UK Health and Safety Executive Safety Climate Measurement User Guide and Tool kit considerations are both consistent in their approach which could be attributable, in part, to their collective reference to the UK Health and Safety Guides 48 (Human Factors in Industrial Safety) and 65 (Successful Health and Safety Management).

Helmreich and Merritt (1998) espouse the use of Line Operations Safety Audits (LOSA) in the operational domain of aviation. LOSA are programmes that use expert observers to collect data about crew behaviour and situational factors on normal flights. Helmreich and Merritt (1998) in accord with Cooper (1999) also indicate that specific behaviours have been associated with accidents and incidents and that data is collected via checklists. From the discussion above there appears to be general agreement that a review of organisational documentation precedes the observation so as to focus the observation on specific behaviours. The documentation review is also used to compose organisational and functional specific checklists. It seems reasonable to postulate that the confirmation of, or absence of, specific behaviours can be collected and extrapolated to form a picture of Safety behaviours within an organisation, however, significant research must be conducted before a useable audit can be conducted. This makes observing behaviours a time and resource consuming process.

***SURVEY-QUESTIONNAIRES***

Zohar (1980, 2000) measured the Safety Climate by surveying the employee's perceptions with regard the organisations Safety Climate. Zohar's (1980, 2000) work in measuring using surveys against traditional safety measurements of accident rates and lost time incident frequency rates appears to withstand analytical scrutiny. As noted previously there is a logical premise that just because you haven't had an accident doesn't mean an organisation is safe.

Following Reason's (2001) 'Swiss Cheese' model the better the layers of defence the safer the system. This does not invalidate Zohar's climate measurements however it does make the validity of the measurement problematic when adapting it to alternate domains. Regardless of the validity of the measurement, movement in the measurement can still be ascertained over time or, as in the proposed case, pre and post intervention. The attraction of this methodology is evident in its widespread use.

A very brief list of climate surveys is includes UK Health and Safety Executive Safety Climate Measurement User Guide and Tool kit, NASA's Safety Performance Survey (management and employee), John Hopkins University Safety-Climate Questionnaire, USA Nuclear Regulatory Commission Safety Culture and Climate Survey, Operators Flight Safety Handbook Safety Surveys, National Safety Council of Australia Safety Climate survey, and Airline Safety Culture Index (Edkins, 1999)

The utility of Zohar's (1980) work as a basis to move forward appears to come from the validity of its measurements. Zohar (1980) identified 5 key characteristics of low accident companies. He then developed a questionnaire and administered an initial version for analysis. Zohar then carried out principal component factor analysis and a discriminant analysis of the Safety Climate Questionnaire and identified 8 measurable factors. Since Zohar's initial work, a number of researchers (Glenon, 1982; Brown & Holmes, 1986; Dedobbeleer & Beland, 1991; Seppala, 1992; Glendon, Stanton & Harrison, 1994; Cooper, 1995; DeJoy, Murphy & Gershon, 1995) have developed additional safety culture instruments.

Edkins (1999) went on to develop an Airline Safety Culture Index (ASCI) and apply it in a major international Asia Pacific airline which was validated using principal component factor analysis. Further support for Safety Climate questionnaires has been provided by Williamson *et. al.* (1997) where they noted that the most striking finding in the development of this questionnaire was that there was little variation between respondents on a very large proportion of the questions originally selected. This indicated that clearly there are well-known beliefs about safety in the working community which need to be understood in order to progress the concept of safety culture.

The questionnaires noted above, appear similar in format as the five point Likert scale is predominately used, however the content, as would be expected, varies according to the domain and the occupation being measured in addition to the authors interpretation of the key dimensions of a Safety Culture.

Interestingly, Zohar (1980) noted that different categories of industrial organization had different characteristics and therefore different Safety Climate scores. For instance, chemical factories had the highest scores due to the technology and the risk whereas food-processing plants have the lowest scores. The value of this observation could be tested in the Australian aviation market to see if there are different Safety Climate scores between segments. Nonetheless, it appears that a Safety Climate questionnaire is an appropriate tool for the measurement of the proposed intervention. The measurements of the Safety Climate can be plotted on a radar graph as indicated in the UK Safety Climate Measurement User Guide and Toolkit, as reproduced at Appendix D.

### 2.5.4 Perceptions and Attitudes in Safety Climate

In understanding a workplace safety climate, the perceptions and attitudes of the workforce are important factors in assessing safety needs. Indeed safety solutions may fail if these prevailing attitudes and perceptions are not taken into account (Williamson *et al*, 1997). Attitudes are defined as a psychological tendency that is expresses by evaluating a particular entity with some degree of flavour or disfavour (Eagly and Chaiken, 1993). Neal and Griffin (2004), in their study, found that attitude measures exhibited greater variability than did perceptual measures, as attitudes are influenced by individual differences in addition to environmental factors. They argued that attitudes and perceptions of safety should be clearly differentiated. In an earlier work Neal and Griffin (2000) defined safety perceptions as how workers view safety related policies, procedures and other workplace attributes concerned with safety. They proposed a framework for investigating perceptions of safety within organizations. This framework differentiates between individual perceptions of the work environment and the factors that may mediate individual work performance from perceptions of the workplace.

As stated earlier, Zohar (1980) conceptualized safety climate as a summary of the beliefs and perceptions of employees about safety within the workplace. In its original conception it was assumed that the safety climate act as a frame of reference that guides behaviour, such that employees develop coherent sets of perceptions and expectations regarding behaviour-outcome contingencies and behave accordingly (Zohar, 1980). Donald *et al* (1991) revealed three facets of safety attitudes: people or the organizational role that make up the safety climate; attitudes, behaviour or aspects of an individual's safety behaviour; and safety activity or type of safety behaviour.

Neal and Griffin's (2000) study considered only those perceptions related to safety climate, viz. those involve individual's assessment of workplace attributes concerned with safety. For example, employees' views about management values for safety, and personnel policies about safety, are clearly perceptions about values and procedures within the wider work environment. So, in short, safety climate as a concept describes the safety ethic within a workplace, which is reflected in workers' beliefs about safety and is supposed to predict the way workers behave with respect to safety within the workplace (Williamson *et al*, 1997).

### 2.5.5 Safe Behaviour and Safety Climate

Various studies have revealed that safety climate can predict safety-related outcomes such as accidents or injuries (Zohar, 1980; Brown and Holmes, 1986; Diaz and Cabrera, 1997). Consequently safety climate is regarded as the manifestation of safety culture in the behaviour and expressed attitudes of the employees (Cox and Flin, 1998). Zohar (1980) was one of the first researchers to suggest a relationship between safety climate and specific measures of safety performance. Indeed he correlated safety climate scores with a ranking for safety practices and accident prevention programs. From a comparison of these rankings with an overall safety climate score, Zohar concluded that safety climate is related to the safety levels of the organization. Two years later Glennon (1982) compared safety climate scores with measures of safety performance. He found that safety climate appears to be related to traditional measures of safety performance. Canter and Donald (1990) and Cox and Cox (1991) also demonstrated, respectively, a correlation between safety climate and behaviour.

Tomas and Oliver (1995) found safety behaviour could be significantly predicted by workers attitudes, co-workers’ response, hazards and supervisors’ response. Further, Neal and Griffin (2000) found that safety climate influences safety performance. More recently, Mohamed (2002) examined the relationship between safety climate factors on Australian construction sites, as well as the correlation between safety climate and workers’ safe behaviour. In this particular study support was found, for the influence of management, safety and risk systems on safety climate. A significant safety relationship between safety climate and safe behaviour was also found. From the above overview, it is clear that a positive correlation exists between workers’ safe behaviour and safety climate within organizations. Additionally, workers’ attitudes towards safety appear to be influenced by their perceptions of risk, management, safety rules and procedure.

## 2.6 ATTITUDE AND BEHAVIOUR

The relation of attitudes to behaviour has been an enduring source of both fascination and frustration to researchers over many decades – and particularly since the belief and information integration research of Fishbein and Ajzein (1975). Ostrom, Skowronski and Novak (1994) assert that despite minor revisions to attitudinal theory the task of most attitude theorists, from the 1820s to the present, has been to develop a model of what leads a person to change his or her attitude. More recently, Flin (1997) argues that behaviour is governed to a significant degree by the attitudes we hold, and any attempt to change behaviour should begin with an attempt to identify underlying attitudes and beliefs relevant to the behaviours in question. Flin's (1997) assertion is noteworthy because it identifies the two arguably principal aspects to consider when examining attitudes and behaviours. Firstly, Flin recognizes that attitudes are multi-dimensional and underlie behaviours. Secondly, she identifies the aspects of relevancy in attitudinal analysis.

The aspects mentioned in the above paragraph are similarly highlighted by Gledon and McKenna (1995) in relation to the location of attitudes (underlying behaviour). These researchers suggest that attitudes may be considered as being located somewhere between deep-seated values and beliefs – which may well remain unchanged over a lifetime – and relatively superficial views and opinions – which may change frequently depending upon what information we have most recently been exposed to.

### 2.6.1 The links between attitude and behaviour

An important aspect of attitude is its link to behaviour. A long history of debate surrounds the proposition that attitudes are related to behaviour [ (1966), Wicker (1969), Liska (1975), Schuman and Johnson (1976), Ajzen and Fishbein (1977), Eagly and Himmelfarb (1978)]. In the early days of attitude research, most investigators accepted as a given that human behaviour is guided by social attitudes. The idea that attitudes affect behaviour seemed so logical, that for a long time, it was assumed to be true. Attitudes have generally been considered as steering behaviour in some fairly concrete way. Traditionally, it is thought that if you change someone's attitudes, then their behaviour will also change to fall in line with those changes.

The links between attitude and behaviour are however, somewhat more tenuous. Although there is evidence showing that this approach can work (for example: Fishbein & Ajzen, 1975), it has been suggested that it is not often the case and even when it is; those changes in behaviour are not as great as one would expect (Howarth, 1988). In addition, there is a problem in measuring attitudes – the attitudes that an individual claims to support are only true at the moment that they are requested. A large number of factors will affect those stated attitudes.

Some investigators challenged the view that verbal reactions to symbolic stimuli (i.e., attitude) provide insight into how people behave in the real world. In his famous article, LaPiere (1934) challenged the status quo by stating that there was no relation between attitudes and behaviours and demonstrated that people might say one thing and do the other. Whereas the first systematic investigation of the attitude-behaviour relation started with the assumption that behaviour has little to do with attitudes, the second study to examine this issue accepted the proposition that attitudes guide behaviour and tried to use a measure of attitudes toward cheating to predict the actual cheating in the classroom (Corey, 1937). This radical conclusion did not find much support until1966 when Irwin asserted that there was “no reason to expect to find congruence between attitudes and actions and every reason to find discrepancies among them”. Three years later, Wicker’s review of attitudinal-behaviour correlations found little relation between attitudes and behaviours. By the 1970’s, researchers began not only to question the assumed relationship between attitudes and behaviours, and, more importantly, why and when specific relationships are observed.

According to Snyder and Tanke (1976), there are two factors that will increase the probability of attitude correlating with behaviour: attitude availability and attitude relevance. Basically, if an attitude is available/accessible/active, then it is more likely to drive behaviour. If a given attitude is relevant, then it is also more likely to drive behaviour. Attitudinal availability and attitudinal relevance are only two factors of many factors that have been cited as affecting attitude behaviour relations. Myers and others have asserted just a few of the possible reasons we do not see the expected relationship between the two: situational constraints on behaviour, behaviours are multi-determined, error in measurement of attitude (Weigel, 1983), behavioural intentions, difference in level of specificity of attitude and behaviour measurement (Schuman and Johnson, 1976; Ajzen and Fishbein, 1977), reference groups individual differences in attitude-behaviour consistency (Myers, 1999).

Taylor, Peplau and Sears (2000:133) give a very simple definition of attitude which is often used by psychologists. They say, “Attitudes involve the categorization of a stimulus along an evaluative dimension, based on affective, behavioural, and cognitive information”. The affective component consists of all the person’s emotions and affects towards the object, especially positive or negative evaluations. The behavioural component consists of how the person tends to act regarding the object. The cognitive component consists of the thought that the person has about that particular object, including facts, knowledge and beliefs. These three components of attitude are not always closely related to each other and so it is important to consider all three aspects.

According to Wilkening (1978), an attitude is a learned and relatively enduring perception, expressed or unexpressed, influencing a person to think or behave in a fairly predictable manner towards objects, persons or situations. Glendon and McKenna (1995) assert that an attitude can be defined as a learned tendency to act in a consistent way to a particular object or situation. These definitions follow the approach to attitudes of leading attitudinal researchers Fishbein and Ajzein

(1975). According to Glendon and McKenna (1995), this definition indicates that attitudes can be described as having the following features:

- Specific to a particular situation or object – that is, they should not be thought of as being generalisable to other situations or objects
- Characterized by a degree of consistency – we tend to have clusters of attitudes that are generally mutually consistent
- Learned through social situations and other influences (i.e., are not innate)
- A tendency to act – although there is no guarantee that a person with a given attitude will actually act in a particular way

It was originally simply assumed that people's attitudes determine their behaviour. Yet in many instances behaviour does not follow from attitudes. There is, however, variation across situations in precisely how consistent the relation between attitude and behaviour is. The conditions that yield greater or lesser degrees of consistency between attitudes and behaviour appears to be:

- **Strength of the attitude.**

Anything that contributes to a strong attitude also tends to increase attitude-behaviour consistency. One contributing factor is the amount of information we have about the attitude object. Another factor that strengthens attitudes is rehearsing and practicing them. Attitude-behaviour consistency is greater when people think about and express their attitudes, presumably because this helps to strengthen the attitude. Having direct personal experience with an issue encourages us to think and talk about it more than if the issue is remote to us. It follows that attitude-behaviour consistency is greater when we have direct experience with the attitude object rather than when we only hear about it from someone or read about it. Another source of attitude strength comes from having some vested or selfish interest in the issue. A concept closely related to attitude strength is importance. Important attitudes are ones that reflect fundamental values, self-interest, and/or identification with individuals or groups that the individual values. Such attitudes are highly resistant to persuasions and also show a strong relationship to behaviour.

- **Stability of the attitude.**

Stable attitudes that are easily remembered are more likely to predict behaviour than attitudes that are less stable and not accessible in the memory. When people's attitudes are unstable, their current attitudes predict behaviour more than the attitudes they held some time ago. Therefore, consistency between attitudes and behaviour is at a maximum when they are measured at about the same time. Longer time intervals diminish the attitude-behaviour correlation because attitudes change.

- **Accessibility of the attitude.**

Attitudes that are more accessible in memory influence behaviour more strongly. A primary factor that determines whether an attitude is accessible in memory is how frequently it is expressed. Attitudes also become more extreme when they are expressed more frequently. Easily accessible attitudes also come to be viewed as important.

- **Relevance of attitudes to behaviour.**

When attitudes are relevant to behaviour, the two are more closely related. In general, behaviour tends to be more consistent with attitudes that are specifically relevant to it than with general attitudes that apply to a much larger class of potential behaviours.

- **Salience of the attitude.**

In most situations, several different attitudes may be relevant to behaviour. An important determinant of consistency of behaviour with a particular attitude is the salience of the attitude in question. Salience is particularly crucial when the attitude is not a very strong one. When an attitude is strongly held, it presumably, does not have to be brought forcefully to the person's attention to be strongly related to behaviour. Making the affective component of the attitude (i.e. the feelings the attitude issue prompts) more salient increases the influence of the affective component over behaviour, whereas making the cognitive component (i.e. the beliefs one holds about the attitude object) more salient makes the cognitive component the stronger determinant of behaviour. However, when the cognitive and affective components of an attitude are consistent with each other, it does not matter which is made salient. Both will be highly correlated with the behaviour when either is made salient.

- **Situational pressure.**

  When situational pressures are strong, attitudes do not determine behaviour as strongly as when such pressures are relatively weak (Taylor, Peplau & Sears, 2000:162-166).

Most studies concerned with the prediction of behaviour from attitudinal variables were conducted in the framework of the theory of planned behaviour (Ajzen 1991) and, to a lesser extent, its predecessor, the theory of reasoned action (Ajzen & Fishbein 1980). According to the theory of planned behaviour, people act in accordance with their intentions and perceptions of control over the behaviour, while intentions in turn are influenced by attitudes toward the behaviour, subjective norms, and perceptions of behavioural control. The cognitive foundations of these factors are consistent with an expectancy-value formulation. Support for the theory in general is summarized in a meta-analysis (Armitage & Conner 2000a) and a review of the literature (Sutton 1998), and another review summarizes its applications to health-related behaviour (Conner & Sparks 1996).

### 2.6.2 Reasoned action theory

Perhaps the most influential effort to generate and test a general theory of attitude-behaviour links, is Fishbein and Ajzen's theory of reasoned action

(Taylor, Peplau & Sears, 2000:166; Burns and Grove, 1997:170). This theory is an attempt to specify the factors that determine attitude-behaviour consistency. It begins with the assumption that we behave in accordance with our conscious intentions, which are based in turn on our rational calculations about the potential effects of our behaviour and how other people will feel about it.

The TRA provides a framework for linking each of the above variables together (see Figure 2.3). Essentially, the behavioural and normative beliefs -- referred to as cognitive structures -- influence individual attitudes and subjective norms, respectively. In turn, attitudes and norms shape a person's intention to perform a behaviour. Finally, as the authors of the TRA argue, a person's intention remains the best indicator that the desired behaviour will occur. Overall, the TRA model supports a linear process in which changes in an individual's behavioural and normative beliefs will ultimately affect the individual's actual behaviour. The central point of the theory of reasoned action is that a person's behaviour can be predicted form behavioural intentions. Behavioural intentions can themselves be predicted from two main variables: the person's attitude towards the behaviour and subjective social norms. The attitude and norm variables, and their underlying cognitive structures, often exert different degrees of influence over a person's intention.

Attitudes toward behaviour, refers to the degree to which a person holds a favourable or unfavourable attitude toward a particular behaviour. It is postulated to be the first antecedent of behavioural intention (Ajzen, 1991). It is an individual's positive or negative belief about performing a specific behaviour, and these beliefs are called outcome beliefs. Attitudes toward behaviour are determined by the person's evaluation of the outcomes associated with the behaviour and by the strength of the association. A person's attitude towards his or her behaviour is predicted using the expectancy-value framework (Fishbein and Ajzen, 1975). The desirability of each possible outcome is weighed by likelihood of that outcome.

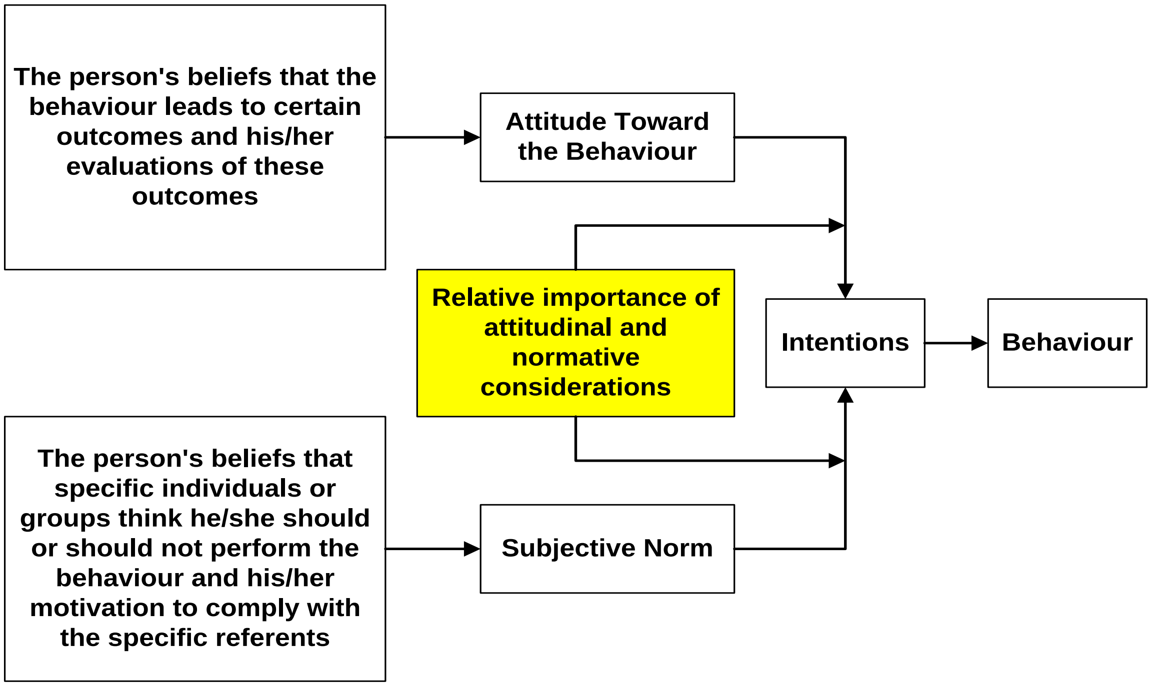


**Figure 2.3: The Reasoned Action Model of factors that determine a person's behaviour**

The subjective norm refers to the perceived social pressure associated with performing certain behaviours. It is a function of referent belief, that is what important others think is important to individuals. Important others might include a person's supervisors. The subjective Norm is considered to be a function of beliefs that important others' approve or disapprove of certain behaviours. An individual will tend to perform those behaviours when they perceive what important others think what they should pursue. The subjective Norm is subjective because it is what the agent thinks but may not know for certain. It is a norm because it is the agent's understanding of what he or she thinks they should do (East, 1997) based upon their perception of others' views. Subjective social norms are predicted by the perceived expectations of significant others weighed by the motivation to conform to those expectations.

### 2.6.3 The limitation of attitudes towards behaviour and subjective norm

After the application of the theory of reasoned action (TRA) on research for several years, doubts were raised about the completeness of the model. An individual may have total control over making decisions when there are no constraints of any type in adopting a specific behaviour. At the opposite extreme, there may be a total lack of control over decision making if adoption of a given behaviour requires opportunities such as resources or skills, which may be lacking. Control factors include both internal and external factors (Ajzen, 1985). Internal factors include personal aspects such as skills, abilities, information, emotions and stress. External factors include such things as situation or environmental matters.

Thus, even if an individual has a positive attitudes to a specific behaviour and other supportive people around this individual tends to encourage them to perform it, it does not necessarily mean individuals can perform the action without the necessary resources and skills. For example, if someone intends to study overseas, the available financial resources and the available time they have are two major factors, which they may be concerned about before their intention or behaviour to study overseas. Thus attitude towards behaviour and Subjective Norm are not the only two factors that can influence the intention or behaviour of people. To overcome the limitation of Attitude towards Behaviour and Subjective Norm, Ajzen modified the theory of reasoned Action by adding a third antecedent of intention called Perceived Behaviour Control (PBC). This transformation led to the development of Theory of Planned Behaviour (TPB)

### 2.6.4 The theory of planned behaviour

The theory of planned behaviour (TPB) has been one of the most widely adopted theories in research attitude. The theory offers an additional determinant, perceived behaviour control. Perceived behaviour control is defined by Ajzen (1991) as an individual's perception of the ease of performing the behaviour in question. These beliefs are called control beliefs. If people believe that they do not have sufficient resources or opportunities to do so, they are not likely to form a strong intention to perform such behaviour. If they hold positive attitudes towards the behaviour and believe that important others would approve of their behaviour, then they are more likely to form an intention to perform such behaviour. The main components of the TPB are a person's own attitude, subjective norms, perceived behavioural control, intentions, and behaviour (Ajzen, 1988). The relations among these variables are depicted in Figure 2.4.

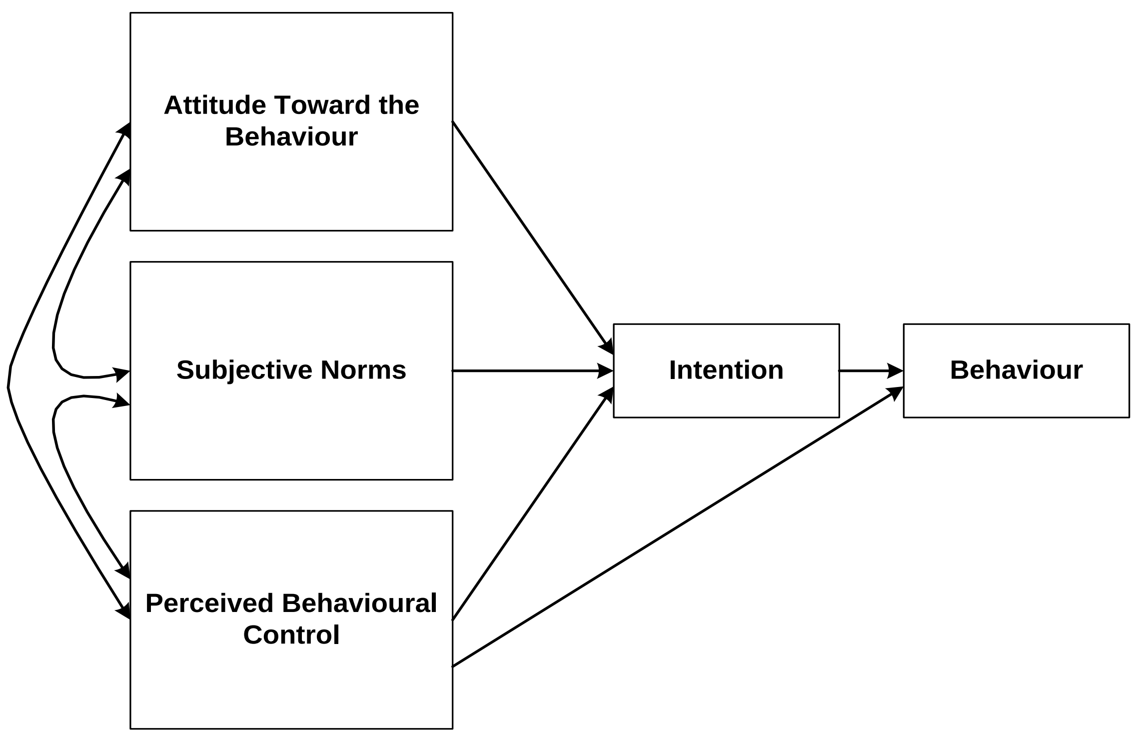


**Figure 2.4: The Theory of Planned Behaviour (Ajzen, 1988)**

Ajzen hypothesised that attitudes often fail to exhibit strong correlations with behaviour because of the large number of factors that potentially prevent the attitude from being converted to behaviour. Consequently, Ajzen introduced the concept of intention as a link between attitude and behaviour to strengthen the relationship. In this way, attitudes can be used to predict an individual's intention to perform a behaviour, which in turn can be used to predict the occurrence of the actual behaviour. The incorporation of intention as a mediating variable has served to strengthen the relationship between attitudes and behaviour in the application of the TPB across a variety of settings (e.g., Conner, Warren, Close, & Sparks, 1999; Furnham & Lovett, 2001).

The concept of subjective norms is more complex. Subjective norms refer to the beliefs and behaviours of people who are likely to influence the view of the individual. In a work situation, this is likely to include both managers and those co-workers who are closely associated with the individual. For example, if an employee does not believe that management or colleagues are concerned with safety, then they are less likely to consider safety as important.

The third predictor of intention and also a direct predictor of behaviour is the component of perceived behavioural control. According to Ajzen, perceived behavioural control strengthens the relationship between intentions and behaviour. Ajzen argued that people often intend to perform certain behaviours, yet fail because of factors which fall outside their control.

### 2.6.5 Attitude, behaviour and safety climate

The constructs included in the TPB mirror the individual, group, and organisational level variables measured in safety climate studies. Individual attitude toward safety is often used as a safety climate variable (e.g., Mearns *et al*, 2001). Safety climate studies have also looked at the influence of subjective norms. Individuals in organisations tend to regard themselves as members of workgroups. The norms developed by these groups influence the behaviour of employees who feel they are a part of any such group. The inclusion of group level factors in safety climate studies is supported by research that has looked at the role group norms play in safety behaviours (e.g., Hofmann & Stetzer, 1996; Zohar, 2000).

Finally, perceived behavioural control is represented throughout the safety climate literature by way of workplace pressures that prevent employees from following procedures. Perceived behavioural control suggests there are times where, despite best intentions to act in a certain manner, individuals feel incapable of fulfilling a planned activity. In the same way, employees may feel that they are not able to complete work tasks according to procedures and rules because of external factors that are beyond their direct control. Examples of these external influences include lack of equipment, lack of personnel, lack of time, and production pressures. In safety literature these factors are often combined under the construct of workplace pressures, elements of work that are beyond the control of individual workers, yet likely to impact on their perceived ability to complete tasks in accordance with procedures. Consequently, it is suggested that workplace pressures will be associated with employee intentions to violate and actual violations of procedures.

Thus, the TPB maps quite nicely onto models generated by some studies of safety climate (Fogarty & Neal, 2002). The safety climate research, in turn, suggests ways in which the TPB model can itself be refined. As shown in Figure 2.2, the relations among own attitude, subjective norms, and perceived behavioural control remain unanalysed. Safety related attitudes may affect middle and top management decisions, which also exert an influence on the conditions under which an employee's individual decision-making takes place. The attitudes may affect company priorities, as well as company policy, about safety. Additionally, they may affect employees' attitudes and behaviour, both directly and indirectly (Rundmo & Hale, 2003). Virtually everyone would say that they are in favour of high standards of workplace safety (i.e., people generally have a positive attitude toward safety), but this is not to say anything useful. It is necessary to specify what particular aspects of safety people hold attitudes about, for example, following safe procedures, and then ensuring that measurement instruments are designed with care.

The importance of management attitudes to safety is well-documented. It extends back to Zohar's (1980) initial study of safety climate. Zohar found that an employee's perception of his or her manager's attitudes toward safety was the most important predictor of safety climate. Since then, studies applying safety climate and culture to mining accidents, the aviation industry, and construction workers have all highlighted the important role played by management in ensuring the safety of organisations. Within the construction industry, research on attitudes, behaviour and safety management has been undertaken by authors such as Levitt *et al* (1976), Hinze (1978, 1979, 1981, 1988) and Dedobbeleer *et al* (1987, 1991) in the North America; Andriessen (1978) and Laufer (1987) in Holland; Matilla & Hydoymaan (1988) and Laiteinen & Ruohomaki (1994) in Finland; Lingard & Rowlinson (1994, 1997) and Sui *et al* (2003) in Hong Kong; MacDonald *et al* (2001) and Garavan & O'Brien (2001) in Ireland; Mohamed (2002) in Australia; and Fang *et al* (2004) in China.

A number of studies have been found showing that attitudes and behaviours are significantly associated. Studies based on the theory of reasoned action and planned behaviour (Ajzen & Fishbein, 1980) show a significant association between health attitudes and risk behaviour. The theory of reasoned action was developed as a means of explaining health related beliefs, attitudes and behaviour. Health related beliefs are similar to safety beliefs in that they might affect one's health. A major assumption in this theory is that people behave sensibly; that is they deliberately employ information from their surroundings and consider the implications of their actions.

## 2.7 LEGISLATIVE AND POLICY FRAMEWORK

Because of the high risks associated with chemicals, it is hardly surprising that that chemical laboratories handling, using, and disposing of hazardous materials would eventually be the subject of rule-making (Fawcett, 1992). Several laws regulating the use of chemicals in the workplace have evolved at a rapid pace (Pipitone, 1991). The intent of these laws is to protect the health and safety of the worker, the community and the environment. In many countries, legislative and administrative measures have been introduced to deal with chemical hazards. Whilst the origin of such measures can be traced back to the development by the courts of common law principles such as the law of nuisance, and to certain ancient statutes, the subject is essentially of chemical hazard is relatively of recent origin. This combined with the development of legislation in response to local as well as international developments has meant that the legislative control of chemicals has developed of its own accord. As a result, it is a highly complex area.

### 2.7.1 Regulations in South Africa

The needs and requirements of all those working with chemical substances are covered by various Acts and other requirements. South Africa's legislation on chemicals is extremely complex and fragmented, being spread across 14 Acts and 7 different government departments (Rother & London, 1998).

#### 2.7.1.1. Environmental legislation

South Africa's constitution establishes the right to a clean environment. The National Environmental Management Act and the Water Act are two key pieces of legislation intended to secure these rights in practice. A White Paper on Integrated Pollution and Waste Management for South Africa, developed in 2000, proposed legislation to increase cooperation and coordination on waste management, and recommended that pollution prevention and waste minimization be prioritized.

***a) National Environmental Managements Act (NEMA)***

The overall framework for national environmental management is set by the National Environmental Management Act (NEMA) under the Department of Environmental Affairs and Tourism (DEAT), in terms of which the DEAT is endorsed as the lead agency in co-ordinating environmental policy. Amongst the policy principles contained in the Act are an emphasis on prevention, the need to minimise negative environmental impacts, environmental justice and a risk-averse and cautious approach which takes into account the limits of current knowledge about environmental decision making.

***b) The Bill of Rights***

The most significant basic right in the context of the environment and hazardous chemicals is the Environmental Right (Section 24 and section 7 (2) of the Constitution, Act 108 of 1996) which provides that: *Everyone has the right to an environment that is not harmful to their health or well-being; and the right to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development. The state is required to respect, promote and fulfil these rights.*

### 2.7.1.2. Occupational Health and Safety Framework

The regulation of occupational health and safety primarily falls within legislation administered by the Department of Labour (DOL), Department of Health (DOH) and Department of Minerals and Energy (DME), although other departments such as National Department of Transport (NDOT) and Department of environmental Affairs and Tourism (DEAT) have a lesser role.

### *a) Occupational Health and Safety Act*

The Occupational Health and Safety Act (OHSA) is the primary law regulating health and safety matters. It was passed by parliament in 1993 but only came into operation on the 1st of January of 1994. It replaced another prevention law that was known as the Machinery and Occupational Safety Act (MOS Act). The MOS Act was replaced because it contains some major inadequacies that were affecting the ability of the law to improve health and safety conditions at work. MOS Act replaced another law in 1983 that was known as the Factories Act.

The Act is administered by the Department of Labour and compliance is monitored by an inspectorate under the Chief Inspector. This act deals with all aspects of health and safety in the workplace. While it places responsibility upon the employer to provide safe working conditions it also places obligations on the worker to act responsibly. The Act places particular emphasis on the duty to inform: the employer to warn employees of any hazards they are likely to encounter in the workplace; the manufacturer or the supplier to inform any customers of any hazards associated with a product or its use. It is therefore essential for anyone working in the chemical industry to understand the potential dangers of substances used and so protect themselves, their fellow workers and their workplace.

All employees have the responsibility to take reasonable care of their own health and safety as well as that of other persons who may be affected by their behaviour. It is the responsibility of employers to provide and maintain a workplace that is safe and without risk to the health of their employees. It is further the responsibility of the employer to ensure that employees are informed of (and understand and be trained in preventive measures) any hazard involved in actual work carried out and to ensure that the precautionary measures are implemented. Part of the management of health and safety is the requirement for health and safety representatives and Committees.

### *b) Hazardous Chemical Substances Regulations*

On 25 August 1995 new Regulations were promulgated that dealt specifically with exposure to hazardous chemicals. The regulations are known as The Regulations for Hazardous Chemical Substances. The regulations for Hazardous Chemical Substances apply to an employer who carries out work which may expose any person to the intake of a hazardous chemical substance at the workplace. These regulations require that an assessment of potential exposure be performed. Section 5 of the said regulations covering the assessment of hazardous chemicals, is considered a major requirement of the regulations and is recommended before monitoring occurs. The above implies that an employer must identify health and safety hazards in the workplace, and have identified hazards quantified by means of appropriate sampling and measuring techniques.

### *(i) General Administrative Regulations (GAR)*

The General Administrative Regulations (GAR) of 1996, under OHSA provide for the furnishing of MSDSs. Regulation 7(1) of the GAR requires manufacturers, importers, sellers and suppliers of hazardous chemical substances used at work to supply a Material Safety Data Sheet (MSDS) which must include information on any reproductive hazards. Every employer who uses a hazardous chemical substance must be in possession of the relevant MSDS and must make it available on request to affected persons. Where it is not reasonably practicable to do so, the manufacturer or importer must supply sufficient information to enable the user to take the necessary measures to ensure health and safety. The MSDS must be made available to employees and interested and, on request, affected parties.

***(ii) Hazardous Chemical Substances Regulations (HCSR)***

The Hazardous Chemical Substances Regulations, 1995, issued under OHSA apply to all employers who carry out activities, which may expose people to hazardous chemical substances. These employers must assess the potential exposure of employees to any hazardous chemical substance and take appropriate preventive steps. The Regulations set maximum exposure levels for some 700 hazardous chemical substances. The Hazardous Chemical Substances Regulations require employers to inform and train employees about, and in any substance to which they are or may be exposed. This must include information on any potential detrimental effect on the reproductive ability of male or female employees.

***(iii) Hazardous Substances Act***

The Hazardous Substance Act of 1973 provides for the control of substances which may cause injury or ill-health to or death of human beings by reason of their toxic, corrosive, irritant, strongly sensitising or flammable nature, and for the control of certain electronic products. It is also to provide for the classification of such substances and products according to the degree of danger. Its main provisions concern: definitions; declaration of grouped hazardous substances; sale, use and application of such substances; inspection; powers of inspectors; analysis; detention of imported substances; warranties and liabilities; offences and penalties; scope of regulations that can be issued under the Act. The Act also provides for the prohibition and control of *inter alia* the importation, manufacture, sale, disposal or dumping of such substances and products and to provide with matters connected therewith.

## 2.7.2 Regulations in the United States of America

An early conceptual framework for controlling hazardous substances transmitted through food in the USA was the Federal *Food and Drugs Act* of 1906. In the 1970s, there was a development of regulatory law, resulting from the exponential rise in chemical production. The US Congress enacted in 1970 the *Occupational Safety and Health Act* and in 1976 the *Toxic Substances Control Act (*TSCA) (Malich *et al*, 1998). Standard-setting procedures for the control of hazardous substances in the USA are initialized by Occupational Safety and Health Administration (OSHA) or commence in response to petitions from other parties, including the Secretary of Health and Human Services, the National Institute for Occupational Safety and Health (NIOSH), State Governments and others (Malich *et al*, 1998). Federal and state regulations place both a legal liability and legal obligations on an organization (Pipitone, 1992). Below is a list of some of federal regulations appropriate to chemical management:

#### 2.7.2.1 Occupational Safety and Health Administration (OSHA)

In 1970 the U.S. Congress passed the OSH Act; from which OSHA was established. OSHA is a federal rule-making body and administration that regulate the safety and health of employees in organizations. OSHA regulations are divided into subparts, which contain one or more paragraphs (Malich *et al*, 1998). Subparts are designated with capital letters, such as subpart Z, Toxic substances. Each subpart has several paragraphs, which are numerical and prefaced with 1910. For example, subpart H, Hazardous materials, has several paragraphs, one of which is 1910.106, Flammable and Combustible Materials. Each paragraph has subparagraphs, which are designated by lower case letters, for example, 1910.106(a). Subparagraphs are further organized.

***a. Hazard Communication Standard (Right to Know)***

Federal hazard communication standard (29CFR 1910.1200) became law in 1983 (Malich *et al*, 1998). This law requires employers whose employees use toxic substances to provide these employees with the following:

- Material safety data sheets that describes the properties, safe handling, and health hazards of the toxic materials.

- Labelling of all toxic substances with product name and a hazard warning, and
- Annual training on the hazards of toxic substances , safe handling procedures, and how to read MSDS

***b. Occupational Exposure to Hazardous Chemicals in Laboratories***

This legislation (29CFR; 1910.1450) requires all employers who are engaged in laboratory use of hazardous chemicals to appoint a chemical hygiene officer and develop a chemical hygiene plan (Malich *et al*, 1998). The plan should detail how each employee will be protected from overexposure to hazardous materials and describe specific work practices and procedures in the laboratory to minimize employee risk. Appendix A, Section D.2.b (Chemical Procurement, Distribution, and Storage), states that “Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity.

#### 2.7.2.2 Environmental Protection Agency (EPA)

The EPA was formed by order of the President under the passage of the Environmental Protection Act, signed into law in the 1970s (Clark, 1991). The EPA regulates the disposal of hazardous wastes, including wastes from academic laboratories (Malich *et al*, 1998). It has the responsibility to develop and promulgate regulations to protect the environment from contamination by hazardous chemicals or other hazards. One or more sections of the following parts of 40CFR are of interest to chemical management: 261-2, 266, 268, 302, 311, 355, and 372.

#### 2.7.2.3 Department Of Transport (DOT)

The department of Transport uses the hazardous materials transportation act, which governs the offering for transport, the transport, and receipt of hazardous materials (Malich *et al*, 1998). Whenever reagent chemicals or hazardous wastes are transported (except between buildings of a single campus), the materials must be packaged in accordance with DOT regulations, sections 171-77 0f 49CFR contains relevant information

### 2.7.3 Regulations in Canada

The Workplace Hazardous Materials Information System (WHMIS) is a Canadian system designed to ensure that all employers obtain the information that they need to inform and train their employees properly about hazardous materials, called "controlled products," that workers use in the work place. The three ways to provide information to workers about the hazards of controlled products are: through the labels on the containers, by means of materials safety data sheets (MSDSs), and by worker education and training. The WHMIS requires employers to utilize all three. WHMIS is put into effect by a combination of federal and provincial laws. The federal WHMIS legislation requires that suppliers provide health and safety information about their products as a condition of sale. Provincial WHMIS legislation requires that employers obtain health and safety information about hazardous materials in the workplace and use this information to protect workers from harm. Five federal measures relate to WHMIS: The Hazardous Products Act, the Controlled Products Regulation, the Ingredient Disclosure List, the Hazardous Materials Information Review Act, and the Hazardous Materials Information Review Regulations.

### 2.7.4 Regulations in United Kingdom

Several regulations and act of Parliament have over a period of time sought both to protect health and safety in the United Kingdom and to improve precise safety standards in respect to certain factories and other workplace involving particular processes or chemicals (Malich *et al*, 1998). In the UK, the standard-setting procedures for controlling chemicals are based on a tripartite institutional structure. This means that workers, industry, local government and independent experts are involved in decision-making processes and advisory bodies. These parties are represented in the Health and Safety Commission (HSC). The operational arm of the HSC is the Health and Safety Executive (HSE), which includes policy-making and the various health and safety inspectorates (Malich *et al*, 1998). Other U.K. legislation that relates to laboratories includes the Petroleum (Consolidation) Act of 1928, the Dangerous Substance Conveyance by Road Regulations of 1981, the Factories Act of 1961, and the Highly Flammable and Flammable Liquid and Liquid Petroleum Gases Regulations of 1972 (SI 1972 no. 917).

#### 2.7.4.1 The Health and Safety at Work Act

The Health and Safety at Work etc. (HSW) Act of 1974 introduces wide ranging legal duties, which include duties for the control of chemical hazards. More detailed obligations are contained in the Control of Substances Hazardous to Health (COSHH) Regulations of 1996, amending the 1988 and 1994 regulations. Besides the COSHH Regulations, the Chemicals (Hazard Information and Packaging for Supply) (CHIP) Regulations of 1994, and the Notification of New Substances (NONS) Regulations of 1993 are also relevant statutory requirements. These regulations implement European Directives which, together with the COSHH Regulations, form the main legal framework for controlling the supply, handling, and use of hazardous substances. There are also approved codes of practice which have a legal base in the HSW Act and a non-statutory base in *British Standards*, *Codes of Practice* and *Guidance* (Malich *et al*, 1998).

#### 2.7.4.2 The Control of Substances Hazardous to Health regulations

The Control of Substances Hazardous to Health (COSHH) regulations of 1988 are the most significant piece of safety and health legislation in the UK since the HSAWA of 1974 (Malich *et al*, 1998). They are a genuine attempt to redress the risk/benefit balance favour of the employee. The regulations came into effect on October 1, 1989; they place a duty on employers who carry out work that may expose an employee to any substance hazardous to health. Before any work is undertaken, employers must make an adequate assessment of risks to the health of employees created by such substances. The starting point in compliance with COSHH is identification of substances as hazardous pr non-hazardous. If no hazardous substances are handled, it is necessary to make a written assessment of the work activity under regulation 6. Otherwise, where hazardous substances are used, there may or may not be a need for controls, maintenance, exposure monitoring, some form of health surveillance, and training.

## 2.8 GLOBAL INITIATIVES ON CHEMICAL MANAGEMENT AND SAFETY

The international community has been working continuously for decades to develop principles, structures and practices which will provide the best means of promoting the safe management and use of chemicals, to avoid damage to health and the environment and to help ensure ecologically sustainable development (ESD). The goals of international cooperation on chemicals include transferring proven structures and capacities for effective chemicals management to developing countries. The aim is to implement the best possible technologies and management systems, and to allow developing countries to avoid mistakes other countries have made during industrialization (Keita-Ouane, 2003). Binding agreements that have grown out of international collaboration and negotiation on chemicals include the Montreal Protocol on Substances that Deplete the Ozone Layer, the Stockholm Convention on Persistent Organic Pollutants, the Basel Convention on Hazardous Wastes, and the Rotterdam Convention on Prior Informed Consent (Massey, 2006).

### 2.8.1 United Nations Conference on Environment and Development

The United Nations Conference on Environment and Development (UNCED) or 'Earth Summit', held in Rio de Janeiro, in June 1992, addressed a wide range of pressing global environmental problems amongst others. The conference delegates endorsed strategies for environmentally sound worldwide management of toxic chemicals, 'Environmentally sound management of toxic chemicals, including prevention of illegal, international traffic in toxic and dangerous products' (Wells *et al*, 1999).

### 2.8.2 Bahia Declaration

The Bahia Declaration was adopted at the third Forum meeting of the Intergovernmental Forum on Chemical Safety (IFCS) held in Salvador da Bahia, Brazil, October 2000, where a number of goals were agreed for the safe management of chemicals. This declaration re-affirmed the commitment of participants to the Rio Declaration including the principles of sustainable development, capacity building, community access to information and the precautionary approach. The targets agreed by the IFCS in Bahia were endorsed by the Johannesburg Plan of Implementation agreed to at the WSSD (Winder *et al*, 2005). The following actions in terms of the Bahia strategic actions are currently being undertaken in South Africa: the Rotterdam and Stockholm Conventions have been ratified; the preparation of a National Profile on chemicals management which will form the basis of the national coordination for the sound management of chemicals; a special unit has been set up in DEAT to implement a system aimed at preventing major industrial accidents, and systems for emergency preparedness and response; the process of preparing a National Implementation Plan (NIP) in terms of the Stockholm Convention has been initiated; and the implementation of the GHS.

### 2.8.3 World Summit on Sustainable Development (WSSD)

In 1992, the United Nations Conference on Environment and Development (the Rio Earth Conference) gave rise to the Agenda 21 Report (UNCED, 1992). This report outlined the responsibilities of States towards the achievement of sustainable development, and was adopted by heads of government in over 150 countries (Winder *et al*, 2005). At the WSSD, held in Johannesburg, South Africa during August/September 2002, the global community renewed its commitment (in the Rio and Bahia Declarations) to sound management of chemicals, and adopted a goal of minimizing adverse effects of chemicals on human health and the environment by 2020. Chapter 19 of Agenda 21 addresses the environmentally sound management of toxic chemicals, including basic programs for: adequate legislation, information gathering and dissemination, capacity for risk assessment and interpretation, establishment of risk management policy, capacity for implementation and enforcement, capacity for rehabilitation of contaminated sites and poisoned persons, effective education programs, and capacity to respond to emergencies. It also called for the formation of an intergovernmental forum to improve coordination and management of chemicals, and the International Conference on Chemical Safety duly met in Stockholm in 1994 (Winder *et al*, 2005).

### 2.8.4 United Nations Environment Programme on Chemical Safety Issues

UNEP Chemicals is currently assisting some 45 countries to develop their Stockholm Convention NIPs through Global Environmental Facility (GEF)-funded enabling activities, and is working with a further dozen countries to develop project proposals. These projects are part of a rapidly growing portfolio of GEF projects on POPs and persistent toxic substances. South Africa is currently in the process of initiating projects for the development of a NIP for the Stockholm Convention and its participation in the African Stockpile Programme (ASP).

UNEP provides the secretariats for the Stockholm Convention on Persistent Organic Pollutants and, jointly with the Food and Agriculture Organization of the United Nations (FAO), for the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. These secretariats, as well as UNEP support for these treaties, fall under the umbrella of UNEP Chemicals, which also facilitates close cooperation with the secretariat of the Basel Convention on the Control of Trans-Boundary Movements of Hazardous Wastes and Their Disposal.

### 2.8.5 Rotterdam Conventions

The Rotterdam Convention is based on the Voluntary Prior Informed Consent (PIC) procedure developed by the UN in the 1980s. PIC requires exporters trading in a list of hazardous substances to obtain the prior informed consent of importers before proceeding with trade (Keita-Ouane, 2003). In 1998 members voted to make the procedure a legal requirement under the Rotterdam Convention. It sets out to establish the first line of defence against chemical hazards by giving importing countries the tools and information they require to identify potential risks and exclude chemicals that they cannot manage safely. If a country chooses to import one of chemicals in question then the convention promotes their safe use through labelling standards and technical support.

### 2.8.6 Stockholm Conventions

The Stockholm Convention considered mechanisms for the development and implementation of recommendations of Chapter 19 of Agenda 21. The Stockholm Conference established the Intergovernmental Forum on Chemical Safety (IFCS) and the International Program for the Sound Management of Chemicals (IOMC) as a means for discussing and exchanging information. This conference is a global treaty designed to protect human health and the environment from persistent organic pollutants (POPs) (Keita-Ouane, 2003).

POPs are chemicals that remain intact in the environment for long periods of time, becoming widely distributed geographically, accumulating in the fatty tissue of living organisms and are toxic to humans and wildlife. Governments are required to take measures to eliminate the release of POPs into the environment.

### 2.8.7 IOMC Strategic Approach to International Chemicals Management

In 1995, the Inter-Organization Program for the Sound Management of Chemicals (IOMC) was established (Wells *et al*, 1999). The UNEP Governing Council at its 7th Special Session/Global Ministerial Environment Forum in February 2002 decided that .there is a need to further develop a strategic approach to international chemicals management and endorses the IFCS Bahia Declaration and Priorities for Action beyond 2000 as the foundation of this approach. The WSSD in its "Action for Implementation" confirmed this mandate to further develop a strategic approach by 2005 and urged that UNEP, IFCS, other international organizations dealing with chemicals management, and other relevant international organizations and actors to closely cooperate in this regard, as appropriate.

### 2.8.8 International Labour Organization

The ILO has been active in the area of safety in the use of chemicals at work since the year of its creation in 1919, including the development of international treaties and other technical instruments (Obadia, 2003). In the past two decades, most of ILO work has been carried out within the context of inter-agency collaboration framework linking the ILO, WHO, UNEP, FAO, UNIDO, UNITAR, and the OECD, Including the international Program on Chemicals (IPCS), the Inter-Organization Program for the Sound Management of Chemicals (IOMC),and the Intergovernmental Forum on Chemical Safety (IFCS). Research undertaken by University of Cape Town to evaluate the effectiveness of different strategies and the relative effectiveness of different ways of implementing hazard communication strategies, offers important opportunities to improve the impact of hazard communication with benefits to workers, employers and communities.

### 2.9.9 Basel Convention

The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal main objectives are the reduction of the production of hazardous waste and the restriction of trans-boundary movement and disposal of such waste (Johnstone, 1998). It also aims to ensure that any trans-boundary movement and disposal of hazardous waste, when allowed, is strictly controlled and takes place in an environmentally sound and responsible way. Locally, draft regulations are in preparation in an effort to control the movement of such waste (Johnstone, 1998). Improved international cooperation has resulted in better control of hazardous waste movements and complete transparency in cases where such movements do occur. The ban on hazardous waste movements from OECD countries to non-OECD countries for final disposal and recycling become effective in 1998, but have not been ratified by a sufficient number of parties. South Africa ratified the convention in May 1994 and DEAT coordinates its implementation in South Africa. Provinces serve on an Interdepartmental Basel Committee and must agree to any application for the importation of hazardous waste before permission is granted by DEAT.

### 2.9.10 Strategic Approach to International Chemicals Management

A global agreement on a strategic approach to international chemicals management (*SAIM*) has been reached in Dubai, United Arab Emirates, under the auspices of the UN (Industry news, 2006). This is the first global process promoting the sound management of all types of chemicals, and not just specific groups of substances, as is the case in the Montreal Protocol on ozone-depleting substances. The SAICM is an on-going process in which countries are working to achieve the goals that chemicals management all over the world is done in a manner that will help reach the target set at the 2002 WSSD, “to achieve, by 2020, [a scenario where] chemicals are used and produced in ways that lead to a minimisation of significant adverse effects on human health and the environment (Industry news, 2006). Among other functions, the SAICM process provides a way for countries to work together to improve implementation of existing treaties and protocols (Logomasini, 2006).

## 2.9 IMPROVING CHEMICAL SAFETY IN THE WORKPLACE

There are four steps in the prevention and control of workplace chemical hazards:

- identification of the hazard;
- evaluation of the hazard and risk;
- organization to prevent, control or eliminate the risk; and
- Controlling the hazard through specific actions.

### 2.9.1 Identification

All workers have the right to know the possible effects of their work on their health and safety. This includes the right of access to information about the health effects of chemicals, other substances and work processes and about procedures for healthy and safe systems of work.

In some countries, the right to know this information is backed up by special laws. Under these laws, employers and manufacturers, suppliers and importers of chemicals must provide clear, detailed information about the particular chemical, substance or product, its possible health effects, including the results of animal tests and surveys of exposed workers, and means of protecting workers from any harmful effects. These legal rights may apply to each worker or to elected health and safety representatives or committees. Find out from your employer, trade union or government occupational health agency if you are covered by such a law.

### 2.9.2 Evaluation

If "right-to-know" laws operate, employers, manufacturers and suppliers of chemical products are required to:

- produce Material Safety Data Sheets (MSDSs) for all chemicals used in the workplace;
- label chemical products clearly to indicate their (potentially) harmful effects, and provide guidance on how to use the products as safely as possible; and
- Instruct workers in the meaning of labels and MSDSs.

Development of a workplace chemical register is one means of evaluating hazards. This is simply a list of every chemical used in the workplace. An MSDS should be available for every chemical on the Register. Workers should have the right to refuse to work with chemicals for which full health and safety information is not available. If you experience difficulty obtaining full information from your employer, contact your government health or labour ministry, trade union or a workers' health or environmental organization for help. Most HSGs available from the IPCS also contain an ICSC or Summary of Chemical Safety Information for the chemical concerned. Each ICSC is a brief, internationally reviewed summary of the properties, hazards, preventive methods and emergency treatment relating to the chemical in question. Workers' representatives should be given the opportunity to review complete health and safety information *before* any new chemical is introduced into the workplace. Arrangements for the safe use of new chemicals should be finalized and put into practice before a chemical is introduced.

### 2.9.3 Safety Organization

All workplaces should implement effective safety procedures for protection against chemical hazards agreed jointly by employer and workers. In some countries, these agreements will be negotiated as collective bargaining agreements or health and safety agreements between management and workers. Sometimes these agreements are additional to the minimum obligations imposed on employers by workplace health and safety laws.

The employer and elected worker health and safety representatives and/or committees in each workplace should participate in the identification and control of chemical hazards through:

- regular inspections with standard checklists for particular chemicals and chemical processes;
- investigation of workers' complaints;
- use of accident and sickness records;
- regular surveys of workers' health;
- environmental and biological monitoring;
- assessment of government inspectors'/consultants' reports;
- investigation of the causes of accidents and their prevention; and
- Development of a workplace chemical register.

### 2.9.4 Controlling the Hazards

The prevention of adverse health effects arising from occupational exposure to chemicals requires a comprehensive control strategy. Ideally, exposure should be prevented altogether, i.e. at the source, through substitution or enclosed processes, for example. If this cannot be achieved, the level of exposure should be reduced as much as possible, i.e. during the transmission stage, through ventilation and the use of protective clothing – and, certainly, to levels at which neither health effects nor irritation occurs. A third strategy comprises measures to counteract the effects of exposure through early diagnosis of any disease and attempts to prevent the progression of existing disease, through regular medical monitoring.

The following controls may be used, in descending order of priority:

- substitution of hazardous chemicals or processes with less hazardous ones;
- engineering controls, e.g. improved ventilation;
- development of safe working procedures;
- reduction of the number of exposed workers;
- reduction of the duration and/or frequency of exposure of workers;
- use of personal protective equipment, e.g. respirators, goggles; and
- Regular environmental and biological (medical) monitoring or surveillance to check that the above control methods are proving effective.

#### 2.9.4.1 Substitution

The most effective control measure for any hazardous chemical is to remove it entirely from the workplace and replace it with a less hazardous chemical. This is crucial for very toxic chemicals, carcinogens, chemicals that can damage the reproductive system and sensitizing agents. This approach should, of course, be applied to all chemical hazards.

An example of substitution is the replacement of the solvents 2-methoxy- and 2-ethoxy-ethanol (commonly used in paints and lacquers) with the solvent 2-butoxy-ethanol. Both 2-methoxy- and 2-ethoxy-ethanol cause reproductive health effects (including shrinking of the testicles and birth defects) in animals at low levels of exposure; 2-butoxy-ethanol has not been found to cause these effects. In terms of solvent properties, there is no significant difference between any of these three solvents.

Care must be taken to obtain all available information on proposed alternative chemicals. Substitutes may turn out to be just as hazardous as or even more hazardous than the materials they replace. It is also often possible to substitute safer processes. In this connection, a process is the sequence of steps involved in the manufacture or use of a chemical. The manufacture of chemicals usually entails a series of intermediate stages. The chemicals produced during these stages (called **intermediates**) are sometimes more toxic than the starting or final materials. Whenever possible, dangerous processes should be substituted to avoid the production of toxic intermediates.

#### 2.9.4.2 Engineering Controls

***a. Total enclosure***

If a chemical hazard cannot be removed from the workplace by substitution, then the next best solution is to physically enclose the hazard to prevent it from coming into contact with either workers or the environment. This is known as total enclosure or **containment** of a process. For example, open tanks from which chemical vapours can escape into the workplace air can be replaced with closed tanks with inlet and outlet ports for filling and emptying. Liquids such as solvents can be transferred by being pumped through sealed pipes rather than poured in the open air.

***b. Ventilation***

Ventilation systems are one means of removing contaminated air from the workplace. There are two general types of ventilation:

- dilution or general ventilation; and
- local exhaust ventilation.

Dilution ventilation is simply the process whereby clean air is mixed with contaminated air. The concentration of the airborne contaminant is thus reduced, although the workplace air will still contain some of the contaminant. A simple dilution ventilation system consists of two major components: a source of clean air and an exhaust fan for removing the contaminated air. The ventilation system can be totally passive, which means that the exhaust is a chimney or open vent in the ceiling from which the dirty air is expelled, and the source of clean air an open inlet in one of the workplace walls. This is the most basic, i.e. least effective, system. An improvement on this system would be a fan at the exhaust forcing the dirty air out. An even better system would have both an exhaust fan and an inlet fan.

Dilution ventilation is rarely an adequate means of safeguarding health in the workplace, as:

- it does not prevent the release of a contaminant into the workplace air;
- it is ineffective against dusts, metal particles and metal fumes that are too heavy to be removed by gentle air movement;
- it does not provide sufficient protection against highly toxic chemical vapours and gases, carcinogens or chemicals causing reproductive effects;
- it is ineffective against "surges" of gases and vapours or irregular emissions of contaminants; and
- workers very close to a contaminant source may still experience very high levels of exposure.

Local exhaust ventilation systems remove airborne contaminants near their source. Such systems must be properly designed and maintained and must work effectively so that workers will not inhale contaminated air. For any work process that uses or produces moderately toxic or highly toxic chemicals that cannot be effectively enclosed, a local exhaust system is essential. A local exhaust ventilation system contains four major parts: a hood, ducts, an air cleaner and a fan. Contaminants are drawn in through the hood, transported inside the ducts, removed by an air cleaner and sucked through the system by a fan.  A local exhaust system always needs a suitable inlet of clean replacement air.

Some of the advantages of local exhaust ventilation include:

- the capture of hazardous contaminants at their source, and the removal of contaminants from the workplace;
- the capacity to handle all types of contaminants, including dusts, metal particles and metal fumes; and
- the capacity to protect workers close to the contaminant's source.

To be effective, however, a local exhaust ventilation system must be carefully designed for the specific process, and the appropriate parts selected.  The hood should be close enough to capture all contamination and pull it away from, not past, the worker's breathing zone.

Moreover, local exhaust systems require regular cleaning, inspection and maintenance (e.g., regular filter changing, checking of the airflow rate with an anemometer, checking for leaks or holes in the ducting and checking for blockages).  It should be noted that exhaust air will be contaminated and may endanger the health of people outside the workplace.

#### 2.9.4.3 Safe Working Procedures

Workers involved in the manufacture or use of chemicals are usually given a list of instructions by their employer on how to weigh, measure and combine the various chemicals used in their workplace.  Often these instructions tell the worker what to do to make the product but carry no information on the hazards or risks involved or on ways to protect against the chemical hazards present, e.g. how to operate ventilation systems or when to change filters on breathing masks.

A safe working procedure should include instructions for each step in a process, as well as the steps necessary for workers to protect themselves from the health effects of the chemicals used in that process.

A "Code of Practice" is a more general description of safety measures to be adhered to during a particular type of process or by a particular industry. The International Labour Organisation (ILO) has developed codes of practice for some processes, and some countries have national codes of practice. For shop-floor use, a relevant code of practice should include:

- a list of all chemicals used in that process;
- a summary of the health effects of those chemicals and the way in which exposure to, and absorption of, the chemicals may occur;
- an outline of the equipment necessary to complete a task correctly and safely;
- the procedures for operating that equipment correctly. For example, if a chemical has to be heated, information should be included on the maximum temperature, the consequences of heating the chemical too much (the risk of explosion or fire) and the ventilation system required to protect workers and the general public against fumes or vapours of the heated chemical;
- a description of any personal protective equipment that may be necessary, such as face masks or gloves, together with the specifications and standards these must meet and information on exactly how and when the equipment should be used; and
- Details of how often and what environmental and biological monitoring should be performed and of procedures for action if "trigger" levels (see below) are exceeded. For example, carbon monoxide is a highly toxic but colourless and odourless gas produced by many industrial processes that involve heating or burning (e.g. blast furnaces and coke ovens). The carbon monoxide level in the workplace air should be monitored continuously while the process is in operation. When the carbon

monoxide level reaches a set percentage of the exposure limit, an alarm should sound and workers should leave the workplace until the carbon monoxide level has fallen to a safe level.  This "action" or "trigger" level must be a small fraction of the exposure limit (around 10%) to allow room for error in measurement and delay in alerting workers to the hazard.

Some work procedures require **clearance** or a **"permit-to-work"** certification. The latter is essentially a document that sets out the work to be done, the hazards involved and the precautions to be taken, such as testing the working area for chemicals before entering.  It predetermines a safe drill and is a record that all foreseeable hazards have been considered in advance and precautions taken.  It is of particular importance with respect to maintenance workers, for the repair of chemical-bearing lines, for work in confined spaces and so on.

A permit-to-work system does not in itself make a job safe but is designed to protect the workers involved.  Workers should therefore be well trained in the accompanying procedures.

#### 2.9.4.4 Reducing the Number of Exposed Workers and their Duration of Exposure

Only those directly involved with a job or chemical process should be exposed to any chemical hazards present.  For example, if chemicals that give off vapours are being heated, then only those workers needed for the job should be in the area.  Maintenance workers, electricians, cleaners or other workers should do their work when the chemical hazard is not present.

The risk to maintenance workers is often ignored or seriously underestimated when planning chemical control measures. Maintenance workers may be more highly exposed because normal control procedures are not geared to their work; these procedures may not be operational at times when they do their work; and they may be in closer proximity to hazardous plants and processes than other workers when they do repair or maintenance work. Specific provisions for the protection of maintenance workers must be included in any chemical safety procedure. In certain circumstances, the reduction of the duration or the frequency of exposure of workers may be achieved by job rotation. However, it is never acceptable to simply expose more workers less often to unacceptably high levels as an alternative to reducing exposure levels.

### 2.9.4.5 Personal Protective Equipment

#### *a. Principles*

Whereas engineering controls place a barrier around a hazardous process or chemical, personal protective equipment is often used to create a "barrier" around a worker to prevent chemicals already released into the workplace air from reaching the worker's lungs, skin, etc. The use of personal protective equipment should be resorted to only after the methods outlined above -- substitution and engineering controls -- have first been considered and acted upon. Personal protective equipment is rated as the least effective method of protection and is often uncomfortable or difficult to work with. Personal protective equipment against chemicals includes:

- face shields, goggles and safety glasses;
- gloves;
- rubber boots;
- plastic or rubber overalls and aprons;
- hard hats;
- respirators; and
- dust masks.

A personal protective equipment programme requires the following steps and resources:

- the correct equipment -- e.g. a respirator designed to protect against dust is useless if the hazardous chemical is present as a gas; and many solvents can rapidly penetrate natural rubber gloves;
- a thorough training programme for workers who are required to use the equipment, with follow-up training at regular intervals;
- tests to ensure that equipment fits correctly. This is particularly important for face masks and respirators;
- a regular equipment maintenance programme. This includes regular cleaning of equipment, inspection to ensure that it is operating correctly and regular replacement of items such as gloves or disposable parts such as respirator filters. Respirator filters should be replaced at regular time intervals rather than only when they have become clogged; and
- a personal set of equipment for each worker and a secure and clean place in which to store it.

In some situations, the use of personal protective equipment is unavoidable. This applies particularly to eye goggles, face shields, boots and hard hats. Because these items are designed to protect the worker against accidents and unexpected exposures, they must be worn at all times. For some jobs, such as pesticide spraying by hand, no other means of protection is possible, in which case protective clothing, gloves and respirator masks must be worn.

***b. Protective clothing***

Not all protective clothing protects its wearer from all chemicals. Gloves, aprons and overalls, for instance, must be made from a material that is not penetrable by the chemical in use at the time. Otherwise, chemical solvents may pass unnoticed through the material, emerging in an invisible but hazardous form inside gloves or other protective clothing. If this occurs, the chemical will come into contact with the skin and could prove as dangerous as would be the case if the individual were working without any protective clothing.

### *c. Gloves*

General advice about choosing protective gloves includes the following:

- For maximum protection against skin absorption, gloves should be of suitable material, fit properly and be in good condition.
- It is important to get information from the suppliers of protective equipment about what equipment has been tested and found to be resistant to the particular chemicals you are using. Ask specifically about the chemical's breakthrough time, i.e. how long you can wear the gloves before the chemical penetrates through to your hands. Some gloves, especially PVA (polyvinyl alcohol) gloves, actually disintegrate on contact with water.
- Only use gloves once when working with chemicals that have a quick breakthrough time. Remember, the chemical may still be penetrating the gloves after you have removed them.
- Cotton flock or fabric lining in gloves helps absorb perspiration and also partly insulates the hands against heat or cold.
- Double gloving is recommended if little is known about the chemical in use.
- Unless gloves are thoroughly cleaned when they are taken off, any chemical picked up on the glove lining could come into contact with the skin.
- Dusts from recently activated resins are almost as irritating and harmful to the skin as the original liquid; gloves should be worn even when handling the resultant laminate.
- Some chemicals in combination will penetrate gloves more quickly than they would separately, e.g. pentane and trichloroethylene.
- Solvents may also carry other substances through the gloves; e.g. xylene carries organophosphates through PVC (polyvinyl chloride) gloves.
- Search for a listing of gloves available in your country and information on their suitability for different jobs. The local safety inspectorate may have such a list.

### *d. Respirator*

There are many different types of respirators available. This section will help you to ask the right questions to make sure that you are being provided with the correct type of respirator for your work process. A suitable respirator can be chosen only after the questions below have been answered.

- What are you exposed to?

This will depend on the type of hazard, i.e. whether the contaminant is a gas, vapour, dust, mist or fume; whether there is a potential for oxygen deficiency (in the USA, if the oxygen level is likely to fall below 17%, or 19.5% in some countries, fresh air must be provided); or whether the atmosphere is immediately dangerous to life or health, e.g. high concentrations of cyanide fumes.

- What concentration of the chemical are you exposed to?

It is important to know how much of the chemical is present in the air you are breathing, because different types of respirators have different levels of efficiency. You should know what concentration of the chemical you are exposed to and the concentration that is classified as acceptable (see section 7.1 of this Manual on "exposure limits" for reasons why even these limits may not be safe inside a respirator). Once you know these two concentrations of the chemical, you will be able to work out the amount of protection you need from a respirator. For example, if the acceptable level of exposure for Solvent B is 10 ppm and the concentration in the workplace is 100 ppm, you will need an air filter with a "nominal protection factor" of 100/10 = 10.

- Does the chemical have any warning signs?

You will need to know how long you can wear the respirator before you have to change the filter or cartridge/canister or before the air supply runs out in a self-contained breathing apparatus. You will also need to know whether the chemical has a particular smell or is irritating (either will serve as a warning if the chemical begins to break through the absorbent material in the respirator). This is particularly important when air-purifying respirators are used against gases and vapours.

- Is there any other chemical present that you also need protection against?

If a mixture of gases or vapours or particulates is present, this will influence the choice of respirator.

- Can the chemical be absorbed through the skin?

If the answer is "Yes", then the rest of the body, including the face, must be protected and a full-face respirator worn.

- Can the chemical irritate the eyes at the expected concentration?

If "Yes", then the eyes must be protected -- either separately through the use of goggles or by use of a full-face respirator.

### e. *Types of respirators*

*I Air-purifying respirators*

The air is drawn in through an absorbent material in the case of gaseous contaminants or through a filter in the case of particulate contaminants.

(i) Air-purifying respirators for gaseous contaminants

These consist of a face-piece with a cartridge or canister to remove the gas or vapour. The face-piece can be quarter-mask, covering the nose and mouth but not fitting under the chin; half-mask, covering the nose and mouth and fitting under the chin; or full-face mask, covering the face from the hairline to under the chin. The full-face mask offers greater protection than half- or quarter-masks, as the mask will fit the face more closely, giving a better seal. The cartridge or canister containing the material that removes the gas or vapour is fitted to the front of the face-piece and air drawn through it. A cartridge offers less protection than a canister. A cartridge can be used to protect against gases or vapours of relatively low toxicity. A canister will remove limited concentrations of certain toxic gases or vapours for a specified time, after which the canister must be replaced.

(ii) Air-purifying respirators for particulate contaminants

These consist of a face-piece and a filter. The face-piece can be a quarter-, half- or full-face mask. The filters are classified as:

- low efficiency – used against dusts and mists of low toxicity, in low concentrations;
- medium efficiency – used against dust and fume concentrations up to 10 times the exposure standard, except where the dust or fume is highly toxic, e.g. hexavalent chromium; and
- high efficiency – used, with a full face-piece respirator, where toxicity or concentration of a chemical is high.

A combined gas and dust respirator should be used where both gases/vapours and dusts are present.

(iii) Air-purifying respirators for both gaseous and particulate contaminants

These respirators can be used where a combined hazard is present, e.g. paint spraying or spraying with pesticides. Some particulate filters will also absorb some gases/vapours, but you must insist that evidence is provided that they will protect against both. The filters should be marked to show what they protect against. The length of time a cartridge or canister can be used depends on the concentration of gas, vapour or particulate and the activity of the wearer. If you are doing hard physical work, you will breathe more deeply and the canister will become saturated sooner. Air-purifying respirators should not be used in a confined space, or there might be a shortage of oxygen. Face masks that do not fit the worker or that are worn out or blocked by particulates can result in serious injury, as the wearer believes him/herself protected and is therefore unaware that he or she is exposed. The presence of facial hair can also mean that the face mask does not fit perfectly, with the result that contaminated air could enter between the mask and the skin.

***II Supplied air units***

These respirators supply clean air directly into the respirator, rather than filtering out the chemical from the air in the work environment. There are two types:

(i) Supplied air respirator -- Air is supplied through an air supply line or hose**.** In the case of an air supply line, the air comes from a compressed air source through a high-pressure hose. The air can be supplied to a half- or full-face mask, helmet, hood or complete suit. These respirators can be used against particulates, gases or vapours. They provide a high degree of protection but cannot be used in atmospheres immediately hazardous to life or health, as any fault with the air supply or air line could render the worker highly vulnerable. For hose masks, air is supplied from a clean-air area through a large-diameter hose to the face-piece. Compressed air is not used. The air can be either pumped in by a hand- or motor-operated blower or simply drawn in by the wearer. These respirators always have a full-face mask, which must fit the face well. They should also not be used in atmospheres immediately dangerous to life or health.

(ii) Self-contained breathing apparatus -- This allows the wearer to carry a respirable breathing supply, which may last from a few minutes to four hours, depending on type. With some, a negative pressure is created inside the face-piece when the wearer breathes in, so the air is drawn into the face-piece only when the wearer breathes in, instead of being supplied to the face-piece before the wearer breathes in. If the face seal is not good and a negative pressure is created inside the face-piece, contaminated air may be sucked into the respirator through the gaps between the face and the face-piece. These negative-pressure types of breathing apparatus should not be used in atmospheres immediately hazardous to life or health.

#### *f. Training and fitting*

Workers must be trained as to why respirators must be worn and how to choose, fit and use them *before* they are expected to use them. Respirators are uncomfortable to wear, and workers will often not use them if they do not fully understand the health risks they face.

#### *g. Respiratory protection programme*

If respirators are to be used correctly and effectively, a respiratory protection programme administered by a trained person should be established. The programme should include written standard operating procedures and specifications for:

- respirators (selected on the basis of hazards);
- instruction and training of the user;
- cleaning and disinfection;
- storage;
- inspection;
- surveillance of work area conditions;
- evaluation of the respiratory protection programme;
- use of certified respirators; and
- medical review.

### 2.9.5 Monitoring the hazard

Monitoring should be performed to check the efficiency of control methods in the workplace. There are two types of monitoring – environmental monitoring to measure workers' exposures to air contaminants, and biological monitoring of individual workers to test for degree of exposure, whether dermal, respiratory, via ingestion, etc. The results can be compared with safety standards for workplace air or biological materials.

#### 2.9.5.1 Environmental monitoring

Monitoring of the workplace environment for contaminants may be undertaken in two ways: through integrated sampling or, for some substances, use of direct reading instruments. Direct reading instruments give an immediate result, but for many substances such devices are not available. In addition, they must be carefully calibrated. Integrated sampling, on the other hand, can be used for a wider range of substances, although the result is available only following laboratory analysis. Integrated sampling involves measuring the concentrations or levels of dusts, mists or gases in the workplace air, by sampling known amounts of air containing the dust, mist or gas with special pumps and filters and then chemically analysing the results. This monitoring may be technically complicated and must usually be carried out by an industrial hygienist; in some cases, it is less complex and can be done by trained workers.

There are two main types of integrated sampling:

- Static monitoring -- in which an air pump is set up at a fixed point. This is useful for chemicals that are expected to spread evenly throughout the entire workplace. Static monitoring may over- or underestimate the exposure individual workers are receiving, depending on where measurements are made.
- Personal sampling -- in which air is sampled from individual workers' breathing zones by a portable pump attached to the workers' clothing. This method gives a much better indication of an individual worker's exposure to a chemical and, of the two air sampling techniques, is the method of choice. The advantage over static or fixed-point monitoring is that a reading for exposure is obtained that better reflects contamination in

the worker's breathing zone. With static or fixed-point monitoring, concentrations in the worker's breathing zone will not be measured if the measurement is taken at too great a distance from the source.

The following questions should be considered in any environmental monitoring programme:

- Are the samples being taken at the right place, i.e. near the breathing zones of operators?
- Is the sample being taken at the time when pollution levels are highest? The aim of environmental monitoring should always be to determine the highest level of exposure, not the average or usual level of exposure.
- Are all contaminants being measured?
- Have workers been involved in the planning of monitoring of their workplace?
- Are the test results being made available to safety representatives and safety committees regularly, and are the results being discussed?

Environmental monitoring should be performed before decisions are made regarding methods for controlling chemical exposure. In this way, control methods can be designed that cope with the highest levels of chemicals measured, not the average levels. In other words, control measures must be able to cope with the "worst case".

After methods to control exposure (e.g. exhaust ventilation) have been introduced, environmental monitoring should be repeated regularly to ensure that the control methods are operating satisfactorily.

#### 2.9.5.2 Biological monitoring

Biological monitoring of chemical exposure aims to measure either the amount of a chemical that has been absorbed by a worker or the effect of that absorbed chemical on the worker (as opposed to environmental monitoring, which measures the level of exposure).

Biological monitoring involves taking a sample of body fluid, usually blood or urine, and measuring the level of the chemical or its metabolite. Alternatively, an effect of that chemical on the body may be determined by measuring the level of an enzyme or other chemical in the blood or urine.

A good example is biological monitoring for lead absorption. All workers regularly exposed to lead or to significant levels of lead should have blood samples taken regularly. The level of lead in the blood can then be measured directly, and this will give an accurate estimate of how much lead that worker has recently absorbed. One of the effects of lead on the body is the poisoning of red blood cells. By measuring the level of protoporphyrin – a chemical in the blood produced by poisoned red blood cells – an estimate of the effects of lead absorption can be obtained.

Many chemicals can be monitored biologically, but the results do not always reflect the level of absorption. Each chemical should be considered separately when deciding whether to perform biological monitoring. Lists of those chemicals for which biological monitoring is recommended are available, and some such chemicals may have a value – i.e. a biological exposure index – that should not be exceeded.

## 2.10 SOUND CHEMICAL MANAGEMENT PRACTICES

The sound management of chemicals (SMC) is defined as the application of best management practices throughout the life cycle of chemicals to minimize, and where feasible eliminate, the potential for exposure of people and the environment to toxic and hazardous chemicals, as well as those chemicals suspected of human and/or environmental toxicity. Institutions need to address the threat that existing and increasing chemical use will have on human and environmental health. The costs of managing chemicals are far more than just the product price, but the life-cycle management of chemicals can be optimized to cut these peripheral costs. *"By adopting best practices, the chemical management process is more integrated into the business process, becoming a strategic advantage to the organization, raising efficiency on a number of fronts, decreasing legal liability and risk and improving plant/laboratory safety, as well as offering bottom line cost savings." (*Diamantidis*, 2006)*

### 2.10.1 Prudent Management of Chemicals

The prudent management of hazardous materials, from their procurement to their disposal, is a critical element of a successful laboratory safety program. Chemical management includes the following processes: Chemical Procurement, Chemical Storage, Chemical Handling, Chemical Inventory, Transportation of Chemicals and Chemical Waste.

1. **Roles and Responsibilities.** An essential component of any chemical management program is to clearly articulate and clarify the different roles and responsibilities of all the stakeholders who work or visit in areas where chemicals are present. Clarifying roles and responsibilities for implementing the chemical management program will establish accountability, streamline processes, enhance safety, and avoid confusion and questions in meeting the programs objectives.
2. **Chemical Procurement.** When preparing to order a chemical for an experiment, there are several questions that one should ask (page 32-33). Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved and no container should be accepted without an adequate identifying label.
3. **Chemical Storage.** In the event of a chemical spill or fire, incompatible chemicals that are stored in close proximity can mix to produce fires, toxic fumes, and explosions. To protect the laboratory worker, chemicals must

be separated and stored according to hazard category and compatibility. The following should be considered while storing chemicals: Store chemicals by hazard class. Maintain adequate separation of incompatible chemicals, Store flammable solvents and strong acids or bases separately and in appropriate cabinets, Secure compressed gas cylinders (strap, chain or cylinder stand), All stored chemicals must be in appropriate containers, tightly sealed, properly labelled, and in good condition, Highly toxic substances should be segregated in a well-identified area with local exhaust ventilation and Stored chemicals should be examined periodically (at least annually) for replacement, deterioration and container integrity.

4. **General housekeeping.** Follow good hygiene practices and regularly inspect your PPE. Use proper disposal techniques. Read the MSDS and heed the precautions regarding the storage and handling requirements of the chemicals in your laboratory. All chemical containers must be properly labelled. Chemical storage rooms must provide proper ventilation, two means of access/egress, vents and intakes at both ceiling and floor levels, and automatic water sprinklers (with the exception of water-reactive chemical storage). Rooms must be a spark-free environment and one must use only spark-free tools within the room.
5. **Chemical Handling.** Important information about handling chemicals can be found in the MSDS. A comprehensive file of MSDSs must be kept on file in the laboratory or be readily accessible online to all employees during all work shifts. Workers should always read and heed the label and the Material Safety Data Sheet before using a chemical for the first time. Know the types of PPE that you will be required to wear when handling the chemical.
6. **Chemical Inventory.** Good inventory management lowers inventory, which requires less space for storage, lower carrying costs and less capital tied up in stored materials. Stored chemicals should be examined periodically for replacement, deterioration, and container integrity. The amounts of hazardous materials should be carefully monitored in the

laboratory. A physical chemical inventory should be performed at least annually. A thorough inventory will eliminate unneeded or outdated chemicals and will ultimately result in more efficient use of laboratory storage space. Promptly date all incoming chemical shipments and rotate stock to ensure use of older chemicals. The chemical inventory should include: Chemical name, Hazard warning, Chemical Abstract Service number, Manufacturer, Owner, Room number and Location of chemical within the room to avoid accidents and potentially costly fines from regulatory agencies.

### 2.10.2 General principles for safe laboratory work

In addition to the above recommendations, general principles for safe laboratory work and best practices for chemical management include the following:

1 **Minimize all chemical exposures.** Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals. Skin contact with chemicals should be avoided as a cardinal rule.

2 **Avoid underestimation of risk.** Even for substances of no known significant hazard, exposure should be minimized. For work with substances which present special hazards, precautions should be taken. One should assume that any mixture can be more toxic than its most toxic component, and that all substances of unknown toxicity are toxic.

3 **Provide adequate ventilation.** The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by the use of hoods and other ventilation devices.

4 **Institute a chemical hygiene program.** A chemical hygiene program designed to minimize exposures is needed and should be a regular, continuing effort, not merely a standby or short-term activity. Its recommendations should be followed by all laboratory workers.

5 **Observe the Permissible Exposure Limits (Peels) and the Threshold Limit Values (TLVs).** PELs, set by OSHA, or TLVs should not be exceeded.

6 **Develop written standard operating procedures (SOPs).** For work involving highly toxic chemicals, SOPs should be developed which include general safety procedures, housekeeping practices, personal protective equipment, waste disposal and emergency response procedures, etc.

7 **Manage inventory well.** Keep information on inventory levels accurate and up to date.

8 **Manage and reduce hazardous waste.** The obvious first step to cost-savings in waste disposal is to minimize the waste. Chemical waste disposal is the most expensive cost associated with a chemical, and sometimes it is greater than the cost to purchase that chemical. Efficient inventory of hazardous materials necessarily decreases the amount of waste disposed.

## 2.11 FRAMEWORK FOR ANALYSIS

Attitudes, both personal and organizational, affect the development of a safety culture in a workplace. The environment in which people work and the systems and processes in an organization also influence the safety culture. Each organization needs to consider all of these aspects in developing and nurturing a safety culture that suits the organization and the individuals within it. This project is directed towards the evaluation of employees' attitude and commitment to chemical safety, management's commitment and action to safety, perceived risk and emergency response. The methodology entails collecting a variety of information that is largely based upon the perceptions of the individuals in an organization, as well as conducting structured observations of individuals performing work activities. Perceptions are often reality when it comes to influencing behaviour and understanding basic assumptions. Therefore, the data collected regarding individuals' perceptions are critical to this type of evaluation.

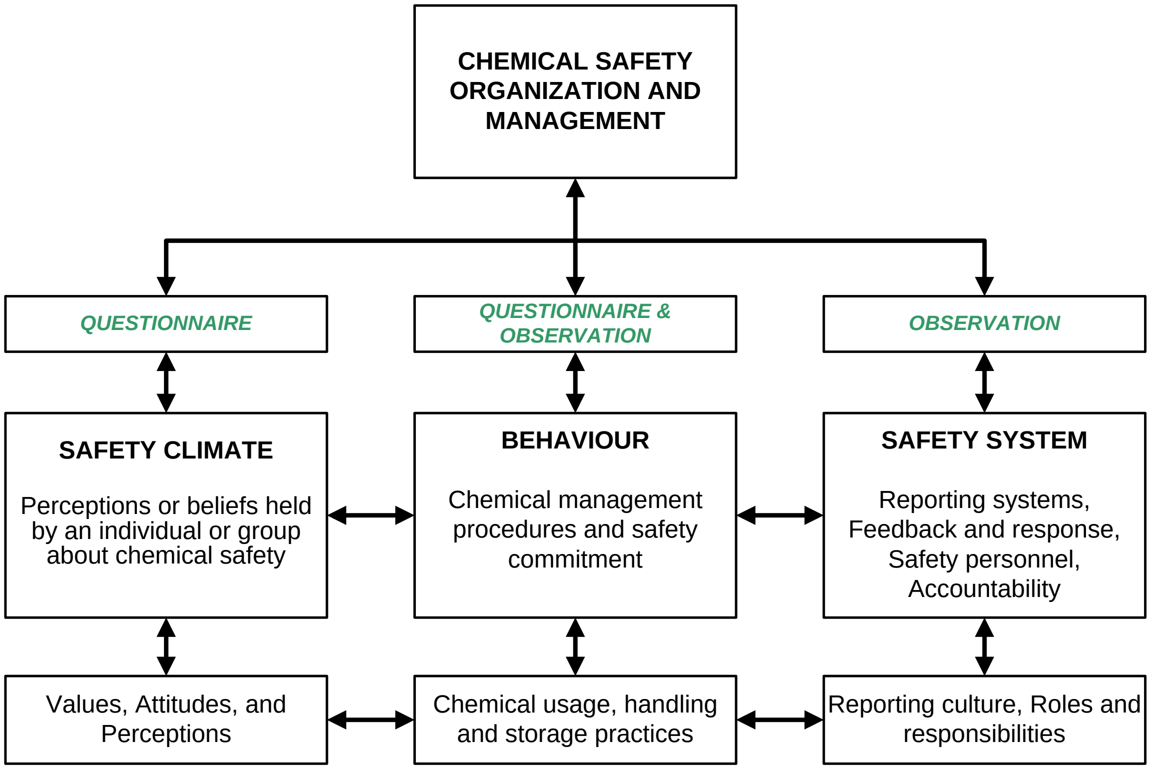


**Figure 2.5: Research Framework**

## 2.12 SUMMARY

It is necessary to address chemical management issues in any academic department and proper management of those chemicals is important for avoiding all the problems associated with them (Deisler, 1983). Measures and systems need to be developed to reduce exposure to negative impacts and to reduce human vulnerability. Facilities, however, face challenges related to the availability of information and the communication of this to users, inadequate capacity to effectively monitor the use of chemicals, poor capacity to deal with general chemical management issues as well as lack of knowledge of regulatory requirements. Effective control is also essential to minimize possible hazards associated with a particular reaction system and, to allow one to achieve such control, relevant knowledge is necessary for one to assess potential hazards in the system.

Developing a more effective chemical management system requires addressing the specific challenges institutions face in management. The complexity of the system and its major elements (environment, procedures, people and information) depend on the type and amount of chemicals stored. Maintaining chemical safety program requires care in ordering, storing, using, and disposing of chemicals, and a successful chemical safety program involves the daily commitment of everyone in the department to ensure a safe and healthy environment in which to teach, learn and perform research. Adequate safeguards against risks associated with chemicals must be provided within the systems for chemical management, and everyone should adopt a more progressive and responsible attitude towards chemical management.

# CHAPTER 3

# RESEARCH DESIGN AND METHODOLOGY

## 3.1 INTRODUCTION

This chapter focuses in the methodological aspects and the empirical design of this research. Thyer (1993) suggests that a research design is a blueprint or detailed plan for how a research study is to be conducted. Punch (2000) almost similarly describes a research design as a basic plan for a piece of empirical research that includes strategy, conceptual framework, who or what will be studied, and tools and procedures to be used for collecting data and analysing empirical materials. Welman *et al* (2005) also suggests that the research design have to specify the number of groups that should be used, whether these groups are to be drawn randomly from the populations involved and whether they should be assigned randomly to groups, and what exactly should be done with them in the case of experimental research.

Zikmund (2003) proposes that the objectives of the study determined during the early stages of the research should be included in the design to ensure that the information collected is appropriate for solving the problem. The researcher must also specify the sources of information, the research method or technique (e.g. survey or experiment), the sampling methodology and the schedule and the cost of the research. The next section looks into the research paradigm followed in this study. The chapter commences by highlighting the characteristics of qualitative research paradigm. Thereafter, an explanatory introduction to research design and methodology is presented. These will focus on the plan, structure and strategy of investigation, which the researcher will adopt to answer the research questions or solve the problem in the study (Kumar, 1999).

## 3.2 QUALITATIVE RESEARCH PARADIGM

Creswell (2003) states that "a *qualitative* approach is one in which the inquirer often makes knowledge claims based on constructivist perspectives (i.e., the multiple meanings of individual experiences, meanings socially and historically constructed, with an intent of developing a theory or pattern) or advocacy/participatory perspectives (i.e., political, issue-oriented, collaborative, or change oriented) or both." This approach requires the researcher to interact with that which is being researched. This interaction assumes a form of close observation of informants and sometimes living with them (where required). The strategies of inquiry that are usually used are ethnography, action research, grounded theory, phenomenological research, case studies, etc. All these strategies of inquiry debunk the assertion that 'reality' is rooted in objective fact.

Qualitative research is concerned with developing explanations of social phenomena. That is to say, it aims to help us to understand the world in which we live and why things are the way they are. It is concerned with the social aspects of our world and seeks to answer questions about:

- Why people behave the way they do
- How opinions and attitudes are formed
- How people are affected by the events that go on around them
- How and why cultures have developed in the way they have
- The differences between social groups

Qualitative research paradigm has its roots in cultural anthropology and American sociology. The intent of qualitative research is to understand a particular social situation, event, role, group, or interaction. It is largely and investigative process where the researcher gradually makes sense of a social phenomenon by contrasting, comparing, replicating, cataloguing and classifying the object of study. It is concerned with finding the answers to questions which begin with: why?, how?, and in what way? Quantitative research, on the other hand, is more concerned with questions about: how much?, how many?, how often?, and to what extent?

### 3.2.1 Qualitative Research

A qualitative research study is utilized in this research with the aim to reveal the participants' safety attitudes towards chemical management. The following are the significant characteristics of qualitative research:

- Qualitative research is strategically conducted, yet flexible and contextual (Mason, 2001). This means that in qualitative research, the researcher makes decisions on the basis not only of a sound research strategy, but also of sensitivity to the changing contexts and situations in which the research takes place.
- The researcher will have to conduct this qualitative research as an ethical practice.
- Qualitative research will produce social explanations which are transferable in some way, or which have a wider resonance (Mason, 2001).
- Qualitative research produces social explanations to intellectual puzzles. Descriptions and explorations involve selective viewing and interpretation. The elements which a researcher chooses to see as relevant for a description or exploration will be based implicitly or explicitly, on a way of seeing the social world, and on a particular form of explanatory logic (Mason, 2001).
- The researcher is an instrument for data collection and analysis (Merriam, 1991).
- Qualitative research is concerned with the process, perceptions and interpretations of experiences (Merriam, 1991). It tries, by all means of empathy, to understand motive behind human reactions.

### 3.2.2 Explorative Research

The purpose of exploratory research is to investigate phenomena or situations that are not familiar (Reaves, 1992). Scientists and researchers use an exploratory research when they are just beginning to examine a question and there is not much information to give an idea of what sort of answers might be found (Reaves, 1992). The main aim of this research is to explore safety attitudes and perceptions, and their contribution to the management of chemical operations within a university department. The assessments of safety culture in academic departments are relatively new innovations. As an exploratory inquiry, this research tends to be primarily descriptive but still differs from a purely descriptive research by virtue of its interest in going beyond simple description to understanding or explaining the situation (Reaves, 1992). If it is well done, an exploratory research can produce surprises, insights and many more questions than answers (Reaves, 1992). Scientists often use this research design when they want to "observe things as they are in their natural state" (Reaves, 1992).

The current research is conducted in such a way that the topic can be explored and information gathered (Mouton & Marais, 1991). This information can be used for further research, to obtain insight and understanding and to formulate a hypothesis. The explorative self-administered questionnaire survey was chosen because it seeks to explore the perceptions and interpretations of lived experiences of specific observable facts. Since it employs questionnaires, observations and field notes which are methods of data collection, the perceptions of the respondents are clarified and thus enhancing better understanding. Cooper and Schindler (2001) state that an exploration typically begins with a search of published data. In addition, researchers often seek out people who are well informed on the topic. Research participants will be chosen from individuals who use chemicals in the work areas.

### 3.2.3 Descriptive Research

Descriptive research focuses on prevailing conditions, on how a person, group or thing behaves or functions in the present. According to Cooper and Schindler (2001) a descriptive study is a study that strives to discover answers to the questions who, what, when, where and sometimes how. The researcher attempts to describe a subject often by creating a profile of a group of problems, people or events.

This research is partly descriptive in nature. A purely descriptive research has no purpose other than to describe a particular situation or event (Reaves, 1992). Reaves (1992) also contends that purely descriptive research is relatively rare because researchers can seldom avoid the urge to draw some conclusions or make some recommendations on the basis of their findings.

As mentioned earlier, this research is also not purely descriptive. The descriptive nature of the research makes it remarkably useful. Reaves (1992) posits that descriptive research is useful both for the picture it gives us of how the world is now, and for the insights it can offer into what it might be and how to accomplish change. The research gives a picture of employee safety perceptions and attitudes and how these contribute to chemicals management safety behaviour.

### 3.2.4 Contextual Research

According to Lincoln and Guba (1985) a phenomenon must be studied in its natural setting because individuals take their meaning from themselves within their context. Mason (2001) warns that the researcher should not forget the context, which produced the sections of data which she is indexing. This means that it is important to remain within the unique understanding and perceptions of safety on chemicals management. The information will be interpreted within the literature's guidelines and those perspectives given by the employees.

## 3.3 THE RESEARCHER'S ROLE

As mentioned in the list of characteristics, qualitative research is interpretive research, with the inquirer typically involved in sustained and intensive experience with participants. This introduces a range of strategic, ethical, and personal issues into the qualitative research process. With these concerns in mind, inquirers explicitly identify their biases, values, and personal interests about their research topic and process. The role of the researcher as the primary collection instrument necessitates the identification of personal values, assumptions and biases at the outset of the study.

The investigator's contribution to the research setting can be useful and positive rather detrimental. In this study, researcher's perception of safety attitudes and chemical management practices of employees in academic departments have been shaped by the researcher's personal experiences. From January 1997 to September 2007, the researcher served as a senior Laboratory Assistant in an academic department. As an employee, the researcher was involved in chemical management activities and safety decisions, and has also witnessed chemical accidents and warnings from the department of labour. The researcher believes that this understanding of the context and the role enhances awareness, knowledge and sensitivity to many of the challenges, decisions and issues encountered as an employee in an academic department and will assist the researcher in working with the informant in this study

Due to previous experiences working with chemicals in an academic department, the researcher brings certain biases to this study. Although every effort will be made to ensure objectivity, these biases may shape the way the researcher view and understand the data collected and the way the researcher interpret personal experiences. The researcher commences this study with the perspective that employees in academic departments have negative safety culture which contributes poor chemical management practices.

## 3.4 SETTING, ACTORS, EVENTS AND PROCESSES

Marshall and Rossman (2006) contend that unless a study is quite narrowly construed, researchers cannot study all relevant circumstances, events, or people intensively and in depth. Instead, they select samples. The first and most global decision – choosing the setting, site, population, or phenomenon of interest – is fundamental to the design of the study and serves as a guide for the researcher. This early, significant decision shapes all subsequent ones and should be clearly described and justified.

**Setting:** The current study is site specific in that it focuses in chemical management behaviours and safety attitudes of employees in university departments. This study will be conducted on the campus of the University of Limpopo which is in the Limpopo Province. The university is situated in Mankweng which is about 30 km away from Polokwane town.

**Actors:** The informants in this study are the employees of the University of Limpopo that work with chemicals. The primary informants in the study are those employees working with chemicals. However, the researcher will be observing them in the context of chemical management behaviours.

**Events:** The focus of this study will be the chemicals management practices/behaviours as observed by the researcher, and the safety perceptions, values and attitudes attached to those behaviours as expressed by the informants. This includes the assimilation of surprising events or information, and making sense of critical events and issues that arise.

**Processes:** Particular attention will be paid to employees' chemical safety attitudes as well as the chemical safety-related activities, actions and behaviours exhibited by employees

## 3.5 RESEARCH APPROACH

The current investigation involves a survey research design in that it investigates the existence of a relationship between the variables. The choice of a qualitative research method was influenced by a number of factors that included the researcher's points of view and personal preference, and the aims of this research.

The research work will be divided into three (3) major tasks: (1) a survey of employees' safety attitudes and perceptions, (2) determination of current chemical management practices/behaviours, and (3) development of a set of recommendations. The research will be conducted in a collaborative and consultative manner with various university employees (Laboratory personnel, Teaching staff, Head of Department, Director of School, and the Safety personnel) and experts from the provincial government and other local regulatory agencies. Recommendations will be developed through consensus and implementation of the recommendations will be suggested in consultation with a wide range of affected parties and experts.

The inductive research will be conducted from the literature to identify sound chemical management practices. Observations and questionnaires will be used to gather information and the research will adopt the following approaches:

1. Evaluate and assess the existing/current systems and procedures (laboratory operations and chemical safety)
2. Identification of areas to be clarified or explored (chemical management)
3. Exchange of views and inputs with personnel and experts
4. Visitation of facilities (Physical resources - laboratory and storage facilities)
5. Report on findings and views
6. Recommendations to the Head of the Department.

## 3.6 SAMPLING

Once the initial decision has been made to focus on a specific site, a population, or phenomenon, waves of subsequent sampling decisions are made. Decisions about sampling people and events are made concurrently with decisions about the specific data collection methods to be used and should be thought through in advance. The population for this study included the academic departments in the University of Limpopo that uses chemicals. This covered all the departments in the faculty of Science and Agriculture. The number of departments and staff in the faculty is not easily determined. Hence, this study is limited to the departments in the School of Physical and Mineral Sciences. To find out more about the influence of employee safety attitude on the chemical management practices in academic departments, it was necessary to select a target population that work with chemicals over a long period of time. This target population comprise of employees within the chemistry, microbiology and biochemistry departments at the only two universities in Limpopo.

Sampling refers to the process by which a sample is drawn from the population. The idea behind qualitative research is to purposefully select participants or sites (or documents or visual material) that will best help the researcher understand the problem and the research question. Understanding what purpose the research will serve should be a decisive factor in selecting a qualitative sample. A researcher has many sampling choices available that may stem from theory, method, or simple practicalities, such as time and money. A sample, therefore, is chosen purposefully, and many sampling strategies can be used. Punch (2000) posits that qualitative researchers "would rarely use probability sampling, but rather would use some sort of deliberate sampling: 'purposive sampling' is the term often used".

In purposive sampling, the researchers use their special knowledge or expertise about some group to select subjects who represent this population (Berg, 1998).

It involves the use of judgment on the part of the researcher. In this study purposive sampling was used because it selects unique cases that are especially informative and representative of the population. The research focuses at academic departments of a university in Limpopo. A purposive or judgemental sampling method was used as the departments in the Faculty of Science and Agriculture are major groups using chemicals within the university community and these groups will be conveniently accessible to the researcher. The study will include laboratory staff, teaching staff and administrative staff from various departments. The unit of analysis is the individual people, that is, staff from a university department in Limpopo who use chemicals in their operations. These people completed the questionnaire used in the investigation.

## 3.7 DATA COLLECTION

Comments about the role of the researcher set the stage for discussion of issues involved in collecting data. The data collection steps include setting the boundaries for the study. Collecting information through structured (or semi-structured) observations and interview, documents, and visual materials, as well as establishing the protocol for recording information. Qualitative approaches to data collection usually involve direct interaction with individuals on a one to one basis or in a group setting. Researchers in qualitative research typically rely on four methods for gathering information: (a) participating in the setting, (b) observing directly, (c) interviewing in depth, and (d) analysing documents and material culture (Marshal and Rossman, 2006).

Data collection methods are time consuming and consequently data is collected from smaller numbers of people than would usually be the case in quantitative approaches such as the questionnaire survey. The benefits of using these approaches include richness of data and deeper insight into the phenomena under study. The main methods of collecting qualitative data are individual interviews, focus groups and observation. Data collection is critically looked at from sampling, the researcher as an instrument and data collection methods.

Data will be collected over a period of 3 months through participant observations of the participants' safety behaviours in terms of chemical management practices and, self administered questionnaires which will be distributed to the participants to assess individuals' safety perceptions and attitudes. Questionnaires will be hand delivered to the respondents and will be collected back at a later stage. A pilot study will be conducted in order to pre-test the questionnaires. The researcher will explain the purpose of the study to the participants so that they can have a profound understanding of what they are about to do. A consent form will be developed for participants to sign before they engage in the research. This form will acknowledge the protection of the participant's rights and protection during data collection.

### 3.7.1 Questionnaire Design

Researchers administer questionnaires to some of a population to learn about the distribution of characteristics, attitudes, or beliefs (Marshall and Rossman, 2006). According to Wiersma (1986), questionnaires are a list of questions or statement to which the respondents are asked to respond in writing during an interview. Questionnaires typically entail several questions that have structured response categories; some open-ended questions may also be included (Marshall and Rossman, 2006). The questionnaire can either be administered under the supervision of a researcher or as a postal survey.

In the current study a questionnaire was used to collect the data. The researcher personally delivered the questionnaire to the respondents. A first draft of the questionnaire was developed on the basis of a review of the literature regarding safety climate (Wu, 2001; Diaz & Cabrera, 1997; Hayes *et al,* 1998; Williamson *et al*, 1997; Cooper, 1998; Coyle *et al*, 1995). The content of the draft questionnaire was discussed with the research supervisor. Each item of the questionnaire was considered. The amended questionnaire was then sent to two (2) academic laboratory employees who were asked to review the questionnaire and give their feedback. The final draft version of the questionnaire contained a total of 40 questions; it was three (3) pages long including a cover page of instructions and contained closed format questions.

The questionnaire contained 40 questions and included closed-ended questions. Closed questions required the respondents to rate their opinions on issues relating to general information, safety climate and chemical management practices/behaviour. The questionnaire was anonymous and it was made clear to employee respondents that only the general finding of the study would be available to management. Respondents were not asked for their names or the names of their departments. They were asked to give a frank and honest account of their opinions. The questionnaire used is based on the Likert scale. According to Welman and Kruger (2001) there are four different types of attitude scales, however the summated or Likert scale is regarded as the easiest to compile than any of the other scales. It can also be used for multi-dimensional attitudes, which is impossible to do with the other scales.

The Likert scale consisted of a selection of statements about the attitudinal object, which can either be positive or negative. In respect to each statement, the responses are divided along a five-point scale: strongly agree to strongly disagree. The questionnaire contained positively and negatively formulated items. The positive items were regarded as having the same attitudinal intensity as negative items. In this study, however respondents could also select an 'Indifferent' category, which in itself can define the knowledge or interest on the subject tested. All the positive responses were added, e.g. the results of the strongly agree section plus the agree section, similarly with all the negative responses and is reported as one percentage.

### 3.7.2 Questionnaire Contents

The questionnaire was available in English and contained the following three sections:

- Sample Profile (biographical details)
- Safety Climate
- Chemical Management Operation/Behaviour

#### 3.7.2.1 Profile of the sample

This section was designed to determine the profile of the respondents being surveyed. This approach will assist in determining whether the sample is representative of the department and to determine any correlations between the profile and the other dimensions. The profile includes post level, reporting level and gender.

#### 3.7.2.2 Safety Climate

This section was designed to measure safety climate, based on the safety attitude dimensions. Attitude measures refer to the data gathered from individuals regarding their views on, and feelings about, safety where they work, using the questionnaire tool. These included how they view management commitment to safety, the problems they might have with safety communication, and so on. These measures give some indication of how people view their work and work environments, value safer working practices, and the extent to which they work safely or unsafely; that is, to what degree certain views and beliefs are shared among the workforce. Furthermore, people's attitudes will affect, to some degree, how they behave at work; gauging attitudes to safety will provide an important indicator of an organization's safety climate.

As explained earlier in Section 3.7.1, the items for a questionnaire were taken from literature review and recent studies conducted by Flin *et al* (2000), McDonald *et al* (2001), and Mohamed (2002). These studies helped in identifying the themes of safety climate and development of items, which assisted in exploring the perceptions and attitudes of academic department employees. The design rationale for the survey parameters used was to elicit qualitative attitudinal data that will enable respondents to explain their perceptions in broader and qualitative detail. Qualitative analysis by definition has the potential to yield significant information in terms of the descriptions and explanations of events that occur within a specified environment. Miles and Huberman (1994) assert that the key advantage of qualitative data analysis is the capacity to situate the data collection and analysis within the real world environment.

***A. Organizational Context***

1. *Management Commitment* – Measures perceptions of management's overt commitment to health and safety issues
2. *Communication* - Measures the nature and efficiency of health and safety communications within the organization
3. *Priority of Safety* - Measures the relative status of health and safety issues within the organization
4. *Safety Rules and Procedures* - Measures views on the efficacy and necessity of rules and procedures

***B. Social Environment***

5. *Supportive Environment* - Measures the nature of the social environment at work, and the support derived from it
6. *Involvement* - Measures the extent to which safety is a focus for everyone and all are involved

***C. Individual Appreciation***

**7.** *Personal Priorities and Need for Safety* - Measures the individual's view of their own health and safety management and need to feel safe

**8.** *Personal Appreciation of Risk* - Measures how individuals view the risk associated with work

***D. Work Environment***

**9.** *Physical Work Environment* - Measures perceptions of the nature of the physical environment

The questionnaire comprised statements of opinions to which participants were asked to respond using a five-point Likert-type scale ranging from "Strongly Agree" to "Strongly Disagree" which allows respondents to indicate the extent of their agreement with each statement. There are four main dimensions to this scale and each has a number of sub-dimensions (total of nine). The aim is to profile employees on each of these 9 sub-dimensions.

### 3.7.3 Observation

Another way of collecting qualitative data is to actually go on-site and observe what is going on. Observation is a fundamental and highly important method in all qualitative inquiry. Marshall and Rossman (2006) contend that observation entails the systematic noting and recording of events, behaviours, and artefacts (objects) in the social setting chosen for study. It is a technique that can be used when data collected through other means can be of limited value or is difficult to validate. For example, in interviews participants may be asked about how they behave in certain situations but there is no guarantee that they actually do what they say they do. Observing them in those situations is more reliable: it is possible to see how they actually behave. Observation can also serve as a technique for verifying or nullifying information provided in face to face encounters.

Depending on the researcher's needs for the evaluation, everything can be captured, including the physical environment, social organization, program activities, as well as behaviours and interactions of people. Or a more narrow focus can be taken. In some research observation of people is not required but observation of the environment. This can provide valuable background information about the environment where a research project is being undertaken. For example, an action research project involving an institution may be enhanced by some description of the physical features of the building. An ethnographic study of an ethnic population may need information about how people dress or about their non verbal communication. In a health needs assessment or in a locality survey observations can provide broad descriptions of the key features of the area.

The type of observational data used in qualitative analyses can be different than that used in quantitative analyses. In the latter, specific observations are always being sought: e.g., whether a particular procedure is being done correctly or if a particular work-site condition is observed. In contrast, for the purpose of qualitative analysis, specific types of observations might not be defined beforehand. Observational data is especially helpful in evaluating safety programs as an external evaluator. An understanding of the physical and social environment will be increased. The researcher may catch issues that might go unreported during the interviews or questionnaire surveys because the insiders are too close to their situations. As well, people might not speak or express themselves freely during interviews or questionnaire surveying in fear of reprisal from co-workers or management. Finally, an on-site visit can be the best way to verify that intervention activities are occurring as described.

If the researcher is an internal evaluator planning to use observations, he/she should be aware that one's view of things is influenced by one's background and position within the organization. Thus, if observations are going to play a large role in an evaluation, the researcher must consider bringing in an external, more neutral observer. Similarly, the researcher might have to choose between being an observer or a participant, or something in between. The more the researcher participates, the more first-hand the researcher's knowledge will be. The disadvantage is that it becomes more difficult to maintain "objectivity" and the researcher's presence could influence those around him/her.

The current research uses passive participation where the researcher remains an outside observer. *Passive Participation* means the researcher is present at the scene of action but does not interact or participate. The researcher finds an observation post and assumes the role of a bystander or spectator and remaining unobtrusive (Babbie & Mouton, 2001). As Marshall and Rossman (1995) put it, for studies relying on observation such as this one, the researcher makes no special effort to have a particular role; to be tolerated as an unobtrusive observer is often enough.

The collection of data described in this section uses both direct and indirect observation. Data will be collated from reports, such as organizational records (indirect observation), as well as from direct observation of individual behaviour. Behavioural indicators refer to a set of performance indicators which give some idea of how the organization is behaving. These indicators of safety climate will not only augment the overall picture being built up by the measures described in the attitudes and perceptions questionnaires, but they are valuable in their own right. They help to identify the major factors in accidents and incidents as well as providing yet another avenue for continuous improvement. Behavioural indicators are derived from a number of sources that include direct observation of safe and unsafe acts using a behavioural checklist for critical tasks and indirect observation involving examination of documentation and practices

Direct observation of individuals will be achieved using a behavioural checklist (see Appendix B). Even in organizations with extremely good reporting systems, many minor accidents go unreported. One way of identifying the nature and number of such minor accidents and of near miss incidents is through direct observation of work behaviour. The behavioural checklist comprises a list of behaviours most commonly associated with preventing accidents, incidents and near misses in a particular area. To be ticked off, the items on the checklist must be observable and specified in observable terms, for example, wears eye protection when working with chemicals. General items on a checklist include personal protective equipment (PPE) (appropriateness for the job, condition and fit); tools/equipment (conditions, use); and housekeeping for example.

Indirect observation will be determined by the availability and nature of company records. Indicators will then be identified and evidence of these indicators will be compared with the stated criteria in order to formulate a score for each, and an overall score for the evidence collected from an examination of documentation. It is necessary to tailor the length and frequency of observations to the researcher’s requirements. This can range from a single two-hour site visit to verify program implementation to a full-time, year-long presence to fully understand, for example, a change in safety climate. Field notes are the primary means of recording observational information. This can be supplemented with photographs or videos, although such methods are often obtrusive. Good field notes require a selectivity that can focus on the important details, yet not severely bias the notes.

### 3.7.4 Techniques for Collecting Data through Observation

Observation entails the systematic noting and recording of events, behaviours and artefacts (objects) in the social setting chosen for study (Marshall & Rossman, 1995). Merriam (2001) contends that a qualitative study is richly descriptive and in that words and pictures rather than numbers are used to convey what the researcher has learned about a phenomenon. Observation can range from highly structured, detailed checklist guided notions to more holistic description of events. Observational techniques used principally in qualitative research require a highly structured set-up, perhaps more so as they are open to charges of subjectivity (Swetnam, 1997).

***Written descriptions***

The researcher can record observations of people, a situation or an environment by making notes of what has been observed. The limitations of this are similar to those of trying to write down interview data as it occurs. First there is a risk that the researcher will miss out on observations because he is writing about the last thing he noticed. Secondly, the researcher may find his attention focusing on a particular event or feature because they appear particularly interesting or relevant and miss things which are equally or more important but their importance is not recognized or acknowledged at the time. In this study, the researcher personally goes to departments, observes settings and records field notes (using a notebook) on those observed natural and other visible manmade aspects of environments.

***Photographs and artefacts***

Photographs are a good way of collecting observable data of phenomena which can be captured in a single shot or series of shots. For example, photographs of buildings, neighbourhoods, dress and appearance. Artefacts are objects which inform us about the phenomenon under study because of their significance to the phenomena. In the current research data in the form of photos is taken, as a normative requirement in qualitative studies, and included to support the findings of the study (Merriam, 2001).

***Documentation***

A wide range of written materials can produce qualitative information. They can be particularly useful in trying to understand the philosophy of an organization as may be required in action research and case studies. They can include policy documents, mission statements, annual reports, minutes or meetings, codes of conduct, etc. Notice boards can be a valuable source of data.

## 3.8 DATA ANALYSIS

How data will be recorded, managed, analysed, and interpreted should be discussed once the researcher has settled on a strategy, chosen a site, selected a sample, and determined a method of collecting data (Marshall and Rossman, 2006). The process of data analysis involves making sense out of text and image data (Creswell, 2003). It involves preparing the data for analysis, conducting different analyses, moving deeper and deeper into understanding the data, representing the data, and making an interpretation of the larger meaning of data.

Merriam (1998) and Marshall and Rossman (1999) contend that data collection and data analysis must be a simultaneous process in qualitative research. Unlike quantitative data, raw qualitative data cannot be analysed statistically. The data from qualitative studies often derives from face-to-face interviews, focus groups or observation and so tends to be time consuming to collect. Samples are usually smaller than with quantitative studies and are often locally based.

Qualitative data are exceedingly complex and not readily convertible into standard measurable units of objects seen and heard; they vary in level of abstraction, in frequency of occurrence, in relevance to central questions in the research. The process of bringing order, structure, and interpretation to a mass of collected data is messy, ambiguous, time consuming, creative, and fascinating. It does not proceed in a linear fashion; it is not neat.

Typical analytic procedures fall into seven phases: (a) organizing the data; (b) immersion in the data; (c) generating categories and themes; (d) coding the data; (e) offering interpretations through analytic memos; (f) searching for alternative understandings; and (g) writing the report or other format for presenting the study. Each phase of data analysis entails data reduction, as the reams of collected data are brought into manageable chunks, and interpretation, as the researcher brings meaning and insight to the words and acts of the participants in the study.

### 3.8.1 Questionnaire Data Analysis

The following bullet points provide a step-by-step guide to scoring questionnaire responses:

- Each item should be scored by giving a value of 5 to the 'strongly agree' category, 4 to the 'agree' response, 3 to the 'neither agree nor disagree' category, 2 to the 'disagree' response, and 1 to the 'strongly disagree' category.
- Some of the items in the questionnaire are negatively worded and care should be taken to reverse the scoring for negative items in the questionnaire when coding the item responses, this is usually achieved by subtracting the item score from 6 to reverse the scoring. For example, a score of 2 on a negatively worded item would be reversed to a score of 4.
- Scores should be averaged for each item, across the whole group (or groups).
- These average item scores can now be used to calculate dimension scores. Dimensions in the current questionnaire have different numbers of items and, therefore, scores need to be standardized before plotting and comparing these dimensions. Converting the scores to a 1 to 10 scale can be achieved by dividing the actual score by the total possible score and then multiplying by 10.

### 3.8.2 Observational Data Analysis

Direct observation of individuals is achieved using a behavioural checklist. The behavioural checklist comprises a list of behaviours most commonly associated with preventing accidents, incidents and near misses in a particular area. The item on the checklist is ticked off when observed. The number of times each type of behaviour is observed, either safe or unsafe, is counted and recorded in the appropriate column. Observable behaviours can be scored in this way, in terms of percent (%) safe behaviours to provide another climate indicator to add to those collected in the questionnaire. The total from this exercise will be divided by 10 to produce a score on the same scale as the others in this section.

## 3.9 VALIDITY AND RELIABILITY

Concerns about validity and reliability apply to qualitative data, just as they do to quantitative data. Thus, anyone reading a report of a qualitative investigation wants to know that the stated methods have been used consistently throughout the study (reliability concerns). They also want to know that there are no hidden biases in the data collection, the data analysis nor the conclusions drawn (validity concerns). The research design and method should be cautiously applied to yield valid and reliable research results.

The importance of validity and reliability of the research can hardly be overstated because, as Merriam (2001) states, all research is concerned with producing valid and reliable knowledge. Merriam (2001) postulates that validity and reliability in qualitative research involves conducting the investigation in an ethical manner. From that, the remaining part of this chapter deals with validity, reliability and ethical considerations of this research. The next section immediately delves into the validity of the research findings.

### 3.9.1 Validity of the Research

***Minimizing evaluator bias***

The product of a study no doubt bears the personal mark of the people conducting it. However, researchers generally try to reduce their effect on their research by using concepts and methods agreed upon by other researchers.

Ways to guard against bias include the following: outlining explicit methods for data collection and data analyses; adhering to these methods; having more than one researcher collect data; having a second, non-biased person summarize and/or draw conclusions from the data; and letting the data speak for themselves and not forcing them into a framework designed by the researcher.

Multiple measures were used to capitalize on the strengths of each data collection method. For example, survey data on classroom practices was supplemented with onsite observation data to enhance validity. Similarly, validity on the management of the QMS was enhanced when such data was gathered with different approaches and formats, including completion of tasks and projects, interviewing, surveys, observations, rubrics and learners' profiles. McMillan and Schumacher (1993:43) maintain that the use of multiple measures and approaches enhances the validity, reliability, equity, and utility of the data as well as decisions about the phenomena.

### 3.9.2 Reliability of the Research

***Appropriate sampling***

A person reading an evaluation would want to be sure that the right sample has been selected for the stated purpose. For example, one could not claim to be truly representing workplace perceptions of the effectiveness of an intervention, if either management or employee representatives are not represented. Thus, the rationale and method of sampling must be explicit and justified with respect to the study's aims.

***Validation by subjects***

One of the best ways to determine whether or not the researchers has "got it right" in their study, is to check with the subjects they are studying. This involves confirming the accuracy of the data collected, the reasonableness of the method used to summarize it, and the soundness of the conclusions. Of course the potential biases of the subjects consulted must be kept in mind when weighing their opinions.

***Thorough methods of drawing conclusions***

It is imperative to avoid drawing conclusions too soon. This can be caused by researcher bias or pressure to come up with answers quickly. In contrast, well-grounded conclusions require time for at least some of the following activities: 1) reviewing collected data to identify anything which has been overlooked; 2) searching for evidence which contradicts preliminary conclusions, either by reviewing data already collected or by gathering new data; 3) confirming important data or conclusions through "triangulation", i.e., finding agreement when using a different data source, methodology or researcher; and 4) exploring alternative explanations for patterns observed in the data.

***Conduct a pilot study***

Conducting a pilot study or trial run with the proposed research methods is often of great value. A pilot study was done at one Department with two respondents to test the questionnaire and to develop the sequence for this study. It was done also to develop the rating scales and to enhance the validity of the questionnaire. The criteria used to judge the physical unit was also researched and re-applied. Feedback from those involved in the pilot study was used to refine a sampling strategy, data collection procedures, and procedures for data management

## 3.10 TRUSTWORTHINESS OF THE STUDY

It is imperative in any study that trustworthiness is established. Guba and Lincoln's model, cited in Krefting (1996) was employed in this study to ensure trustworthiness. This model includes criteria such as truth-value, transferability, applicability, dependability and neutrality. Within this model, creditability, or truth-value, refers to whether the researcher has established confidence in the credibility of the research findings. Transferability is the extent of applicability of the research findings in another context. In this study transferability implies that the elicited strategies and tools in managing the safety could be applied to all academic departments that use chemicals.

The aspects of credibility and transferability are analogous to internal and external validity. Dependability refers to whether the research findings would be consistent if the study was repeated with similar research subjects in a similar context. Dependability was ensured by the objective stance of the researcher and the type of the research approach. Neutrality is the degree to which the research findings would be confirmed by another researcher (Krefting, 1996; De Vos, 1998).

## 3.11 ETHICAL CONSIDERATIONS OF THE RESEARCH

Every effort was made to ensure that the study conformed to the ethical principles of the University of Limpopo as well as ensuring that the respondents remain anonymous (researcher's normal role as a government Health and Safety Inspector remained uncompromised). An ethics proposal was prepared by the researcher and approved by the ethics committee before commencing with the study (see appendix C). Companies were informed about the researcher's part in the study at the outset and told that they were under no obligation to participate

### 3.11.1 Informed Consent

Involvement in the research project will be through invited participation, and workers will not be coerced into taking part. Participants, via their employing organisations, will be notified of their right to obtain a copy of the report summary and will be given contact details to address any queries. Participants will also be advised that if they would prefer not to answer a particular question, they are free to choose not to.  Anonymity and confidentiality will be assured on two levels. Firstly, third parties will not have access to copies of the questionnaires; these will be used purely by the researcher.  Secondly, there is no requirement or need for any names to be included on the questionnaires.

### 3.11.2 Deception

There are no hidden objectives to the research.  Participants will be informed that the information provided will be analysed to identify any relationships between safety climate and job satisfaction.

### 3.11.3 Debriefing

Participating companies will be given contact details so that they can obtain a summary of the research on completion if they wish.

### 3.11.4 Withdrawal from Investigation

Participants will be informed that they are free to withdraw from the study at any time and that prior to the pooling of data; the information they give will be withdrawn and destroyed.

### 3.11.5 Confidentiality

The researcher will give his best endeavours to protect the anonymity and confidentiality of participants.  Personal details such as name and job title are not required, however, age, tenure and personal accident rate are asked for due to the purposes of the study.  Nevertheless, the information is to be merged together as part of the overall findings and anything that could be used to identify specific individuals will therefore remain anonymous.

Participants will be assured that the information given will only be used in relation to the aims of the study and will not be associated with any individual. On completion of the questionnaires, the participant will be asked to seal them into envelopes provided by the researcher. The envelopes will then be collected by the researcher in person or returned by post in pre-paid business envelopes. All returned questionnaires and records will be kept in a secure and locked environment.

### 3.11.6 Protection of Participants

***Emotional consideration:*** potential participants will be advised of the nature of the research in advance and given the opportunity to self-deselect if the subject matter is likely to cause distress or produce any negative consequences.

***Environmental consideration:*** participants will be allowed time by their employers to complete the questionnaire surveys during working hours and away from their immediate work environment if this is likely to cause a problem. Participants' risk of harm will be no greater than in their routine undertaking of everyday tasks.

### 3.11.7 Professional Conduct

The researcher will act with courtesy, politeness and objectivity at all times during any interactions with participants and their respective employers. The researcher will ensure that individuals are not cajoled into involvement with the research project, showing respect and courtesy to those who do not wish to participate or who wish to withdraw from the study.

## 3.12 SUMMARY

Qualitative methods play an important role in safety intervention evaluation. Although in most situations, numbers are necessary to prove effectiveness; qualitative methods can yield information with a breadth and depth not possible with quantitative approaches. In this chapter the research design and method have been discussed in depth together with measures to ensure trustworthiness and ethical measures.

# CHAPTER 4

# RESEARCH FINDINGS AND DISCUSSION

## 4.1 INTRODUCTION

The process of data analysis involves analysing participant information, and researchers typically employ the analysis steps found within a specific strategy of inquiry (Cresswell, 2003). More generic steps include organizing and preparing the data, an initial reading through the information, coding the data, developing from the codes a description and thematic analysis, and representing the findings in tables, graphs, and figures. It also involves interpreting the data in the light of personal lessons learned, comparing the findings with past literature and theory, raising questions, and/or advancing an agenda for reform. Although data collection and analysis are similar in qualitative methods, the way the findings are reported is diverse (Lofland, 1974).

## 4.2 DATA COLLECTION

Data collection was executed through questionnaires (**Appendix A**) and observation check list (**Appendix B**). These were conducted to get data on the safety climate and safe behaviour of employees working in the departments within the Faculty of Science and Agriculture. Thirty (30) copies of questionnaires were distributed among employees in five (5) departments that use chemicals, who were purposively chosen. No prior notification about the contents of the questionnaire was made. Employees were asked to complete the questionnaires, with honesty as a requirement.

Data collected through the questionnaires was then processed qualitatively. A Score was calculated for each safety climate measure (dimension) using each of the statement in the questionnaire. This then led to the development of the dimension score tables (Tables 4.3 to 4.7) followed by graphing of the collected data. The scores computed from the safety climate measures were then plotted to provide a graphical representation of each dimension and an overall picture of the state of the Faculty and the individual departments (Figures 4.6 to 4.15). A radar plot was done for each department and a comparative plot which was also done for the five departments were used to represent the collected data and to aid the analysis and interpretation thereof, which is purposed to produce meaningful information.

Observations were used to gather information on the behaviour aspects of chemical safety. Behaviour-data was collected from only one department. The observer was unobtrusive, collecting data while walking slowly through laboratories and storerooms, and stopping only after receiving the required information. Information gathered through observations (Table 21) aided in determining the validity of the survey questionnaire used to determine the management practices. This also aided in making recommendations to improve workplace safety of the study area concerned and employee attitudes towards safety.

## 4.3 PARTICIPANTS' DATA ANALYSIS

The sample frame for this study consisted of employees working with chemical in academic department of Limpopo. The participants comprised 25 personnel that work with chemicals in the Faculty of Science and Agriculture. The participants sample comprised the full population base from **Department 1** (*12 participants*) as the major department using chemicals within the university, and the purposively selected sample from **Department 2** (*03 participants*)**, Department 3** (*04 participants*)**, Department 4** (*03 participants*)**, Department 5** (*03 participants*) as minor users of chemicals.

### 4.3.1 Response Rate

Table 4.1 shows two types of response rates from the purposive sample that was used. Of the six departments targeted in the Faculty of Science and Agriculture, response rates varied from 0% to 100%, although the actual sampling rate ranges from 10% to 40%. The twenty five (25) survey questionnaire respondents represent a response rate of 83%. All the twenty five (25) completed safety culture questionnaires were valid.

**Table 4.1: Number of Respondents in Each Department**

| | SURVEYS SENT | | SURVEYS COMPLETED | | RESPONSE RATE |
|---|---|---|---|---|---|
| **Department** | **Number** | **Percentage** | **Number** | **Percentage** | **Percentage** |
| **1** | 12 | 40% | 12 | 48% | 100% |
| **2** | 3 | 10% | 3 | 12% | 100% |
| **3** | 6 | 20% | 4 | 16% | 67% |
| **4** | 3 | 10% | 3 | 12% | 100% |
| **5** | 3 | 10% | 3 | 12% | 100% |
| **6** | 3 | 10% | 0 | 0% | 0% |
| **Total** | **30** | **100%** | **25** | **100%** | **83%** |

There were no surveys returned from Department 6, hence the department is excluded from further analysis. The possible reasons for this lack of response relate to the unwillingness of the personnel to participate.

### 4.3.2 Population Sample

Table 4.2 shows the demographics of the respondents. The values were used to in the tables were used to plot graphs to illustrate the extent of demographic variations of the respondents and the demographic distributions of the study sample.

**Table 4.2: Demographics of the respondents**

| | | Dept. 1 | Dept. 2 | Dept. 3 | Dept. 4 | Dept. 5 | Total | % |
|---|---|---|---|---|---|---|---|---|
| ***Gender*** | Female | 4 | 2 | 3 | 0 | 3 | **12** | **48%** |
| | Male | 8 | 1 | 1 | 3 | 0 | **13** | **52%** |
| ***Age*** | Below 30 | 2 | 0 | 0 | 1 | 0 | **3** | **12%** |
| | 30 – 34 | 2 | 1 | 1 | 1 | 2 | **7** | **28%** |
| | 35 – 39 | 3 | 2 | 2 | | 1 | **8** | **32%** |
| | 40 – 44 | 3 | 0 | 0 | 1 | 0 | **4** | **16%** |
| | 45 or above | 2 | 0 | 1 | 0 | 0 | **3** | **12%** |
| ***Exp. With Dept.*** | Less than 1 year | 0 | 1 | 0 | 0 | 0 | **1** | **4%** |
| | 1 – 2 years | 0 | 0 | 0 | 2 | 0 | **2** | **8%** |
| | 3 – 7 years | 4 | 2 | 3 | 0 | 3 | **12** | **48%** |
| | 8 – 12 years | 2 | 0 | 1 | 0 | 0 | **3** | **12%** |
| | 13 – 20 years | 6 | 0 | 0 | 1 | 0 | **7** | **28%** |
| | 21 years or above | 0 | 0 | 0 | 0 | 0 | **0** | **0%** |
| ***Job Title*** | Management | 1 | 0 | 0 | 0 | 0 | **1** | **4%** |
| | Teaching Staff | 6 | 0 | 0 | 0 | 0 | **6** | **24%** |
| | Laboratory Staff | 5 | 3 | 4 | 3 | 3 | **18** | **72%** |
| ***Exp. In Current Position*** | Less than 1 year | 0 | 1 | 0 | 1 | 0 | **2** | **8%** |
| | 1 – 2 years | 0 | 0 | 0 | 1 | 0 | **1** | **4%** |
| | 3 – 7 years | 6 | 0 | 0 | 0 | 3 | **9** | **36%** |
| | 8 – 12 years | 2 | 2 | 3 | 0 | 0 | **7** | **28%** |
| | 13 – 20 years | 4 | 0 | 1 | 1 | 0 | **6** | **24%** |
| | 21 years or above | 0 | 0 | 0 | 0 | 0 | **0** | **0%** |
| ***Exp. In Accident*** | Yes | 9 | 0 | 1 | 1 | 0 | **11** | **44%** |
| | No | 3 | 3 | 3 | 2 | 3 | **14** | **56%** |
| ***Safety Training*** | Yes | 6 | 0 | 3 | 1 | 2 | **12** | **48%** |
| | No | 6 | 3 | 1 | 2 | 1 | **13** | **52%** |
| **Total Respondents** | | **12** | **3** | **4** | **3** | **3** | **25** | |

## Gender Distributions

As illustrated in Figure 4.1 below, there is no much disparity between the number of respondents in terms of gender. Forty eight percent (48%) of the respondents are females and fifty two percent (52%) are males.

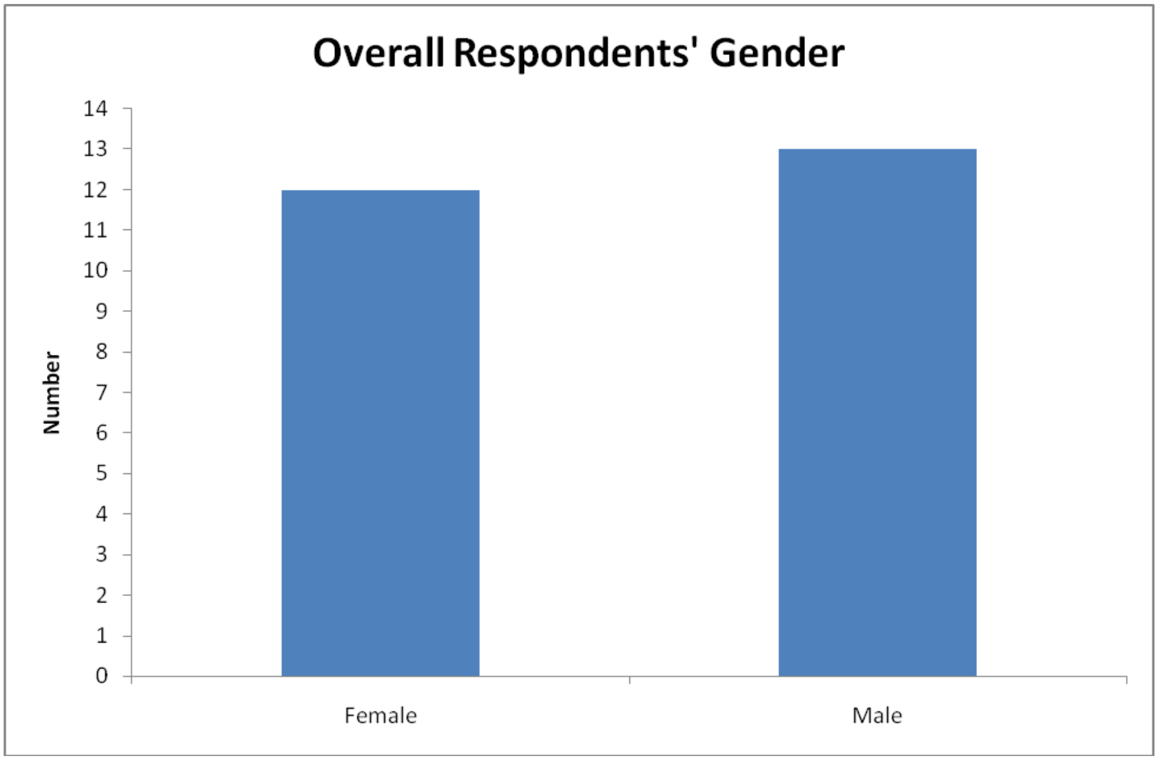


**Figure 4.1: Overall gender distribution of the study sample**

Figure 4.2 illustrates the gender distributions amongst the respondents in the five departments. ***Department 1*** has more males (67%) than females (33%). Whereas ***Department 4*** comprised 100% male respondents, ***Department 5*** comprised 100% of female respondents. This has a gender balancing effect. ***Department 2*** and ***Department 3*** have more females than males. The overall percentage of male respondents is slightly higher than that of female respondents.

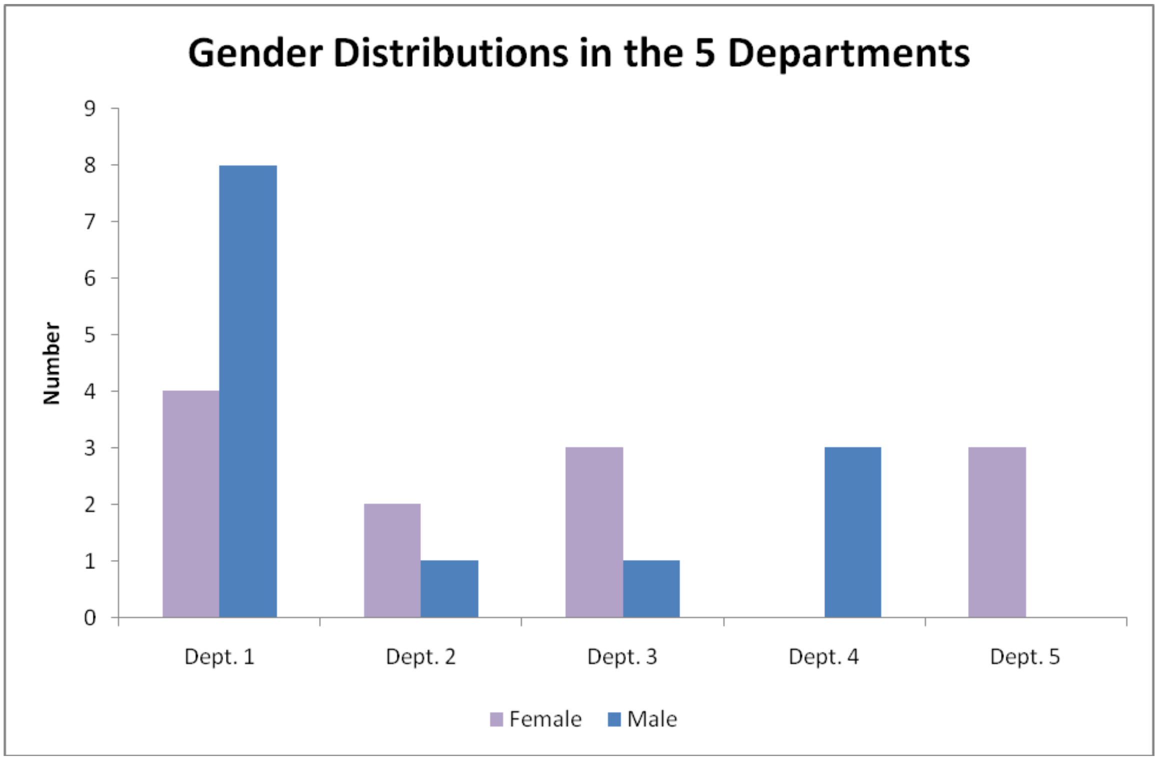


**Figure 4.2: Comparative gender distributions in the 5 departments**

The above figure illustrates that Department 1 has more male respondents. Department 2 and Department 3 have more female respondents. Department 4 has only male respondents and Department 5 has only female respondents.

**Age and Tenure**

The age and tenure was acquired to enable the relative impact of participant's experience to be established during data analysis previous studies have shown that exposure to cultural influences become embedded over significant time periods to foster durable thought patterns (Johnson, 1991). Simpson and Wiggins (1999) found a significant relationship between personal experience and increased positive attitudes towards safety.

Other researchers assert that culture manifests as the result of experiences that occur primarily during the formative years of a human life, comprising those years spent within a family, throughout schooling and the first phases of a person's career. Beyond these years, cultural messages are merely perpetuated. However, Kern asserts that whilst personal experiences in aviation clearly increase over time, the experiences themselves may not provide the right attitudes towards safety. Collecting data on employee experience will enable the impact of age and employment duration to be analysed.

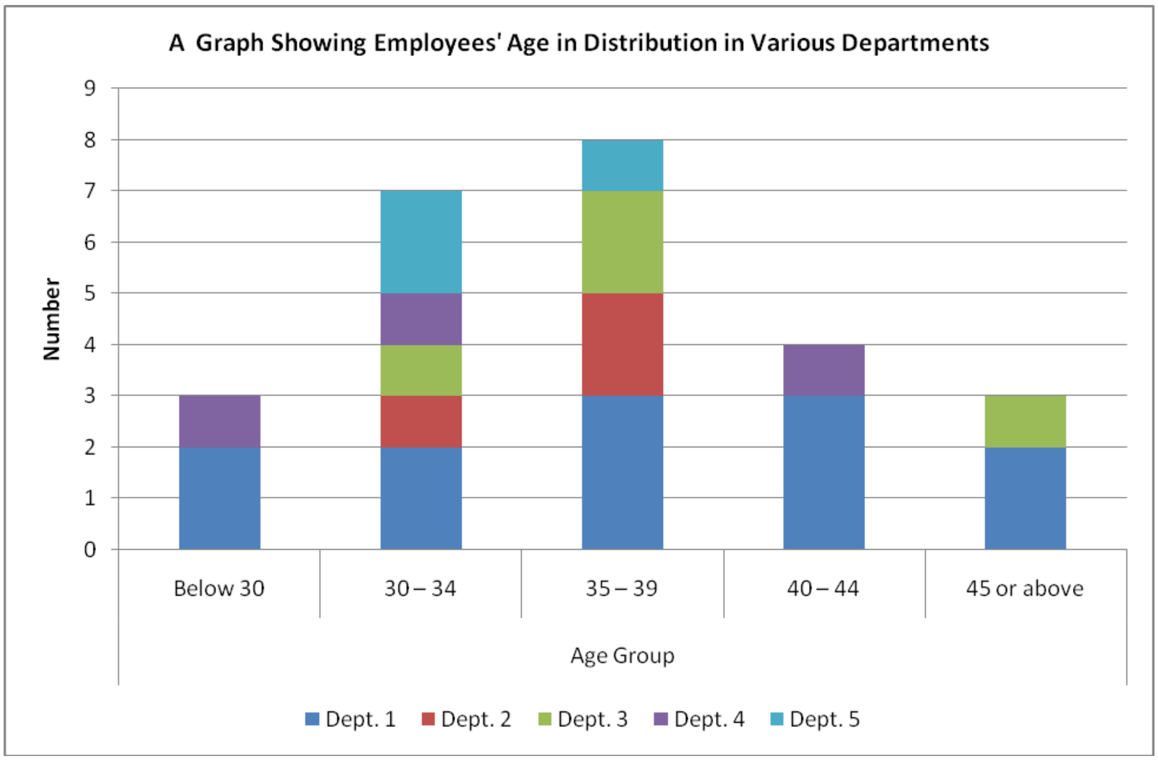


**Figure 4.3: A graphical representation of employees' age distribution**

As shown in Figure 4.3 above, the sample included respondents varying in age from below 30 years old to above 45 years old. The highest percentage (32%) of respondents is between the age group 35 – 39 years, followed by an age group of 30 – 34 years at twenty eight percent (28%).

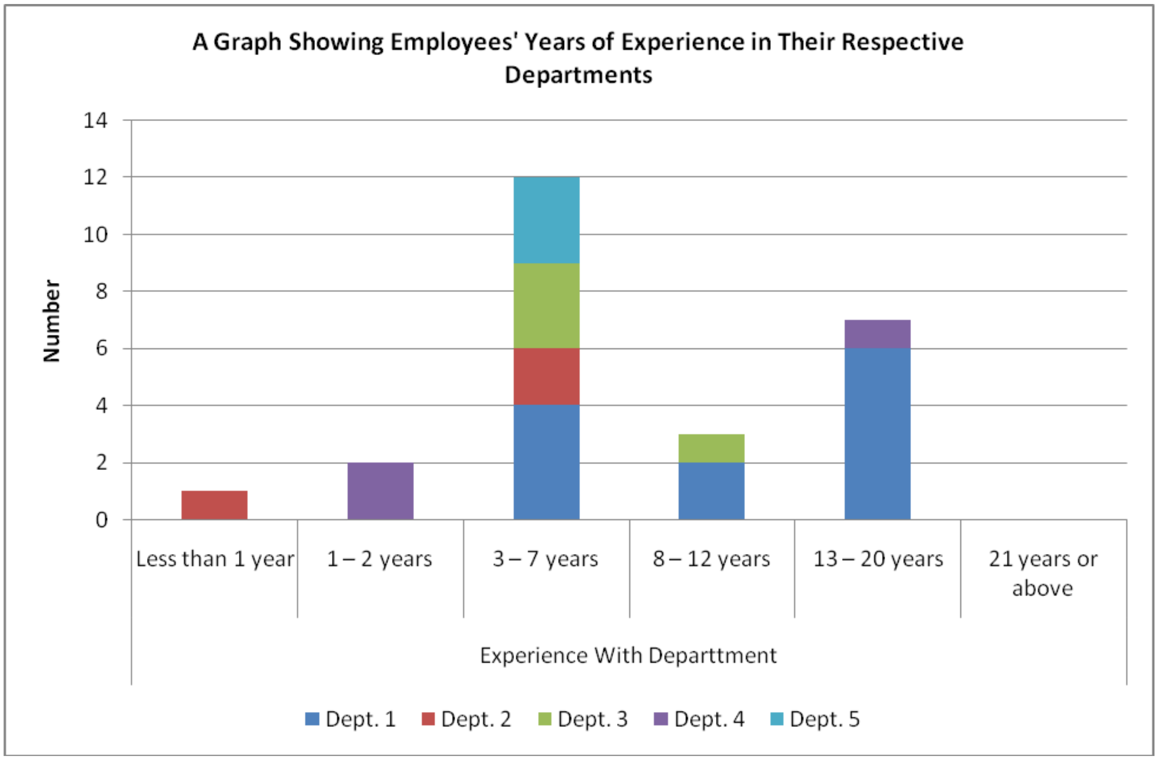


**Figure 4.4: Graphical representation of employees' years of experience working in their departments**

Figure 4.4 indicates that the duration of participants' employment within the departments also varied greatly; with respondents reporting employment duration between one year and 20 years. The highest percentage (48%) of respondents have experience ranging from 3 to 7 years, followed by experience ranging from 13 to 20 years at 28%, and then followed by 8 to 12 years experience at 12%.

**Job Occupation**

The current occupation of respondents was acquired to enable the grouping and comparison of attitudes based upon occupation. The majority (72%) of the respondents work in the laboratories. This is due to the fact that the sample was purposively selected to include employees who work directly with chemicals.

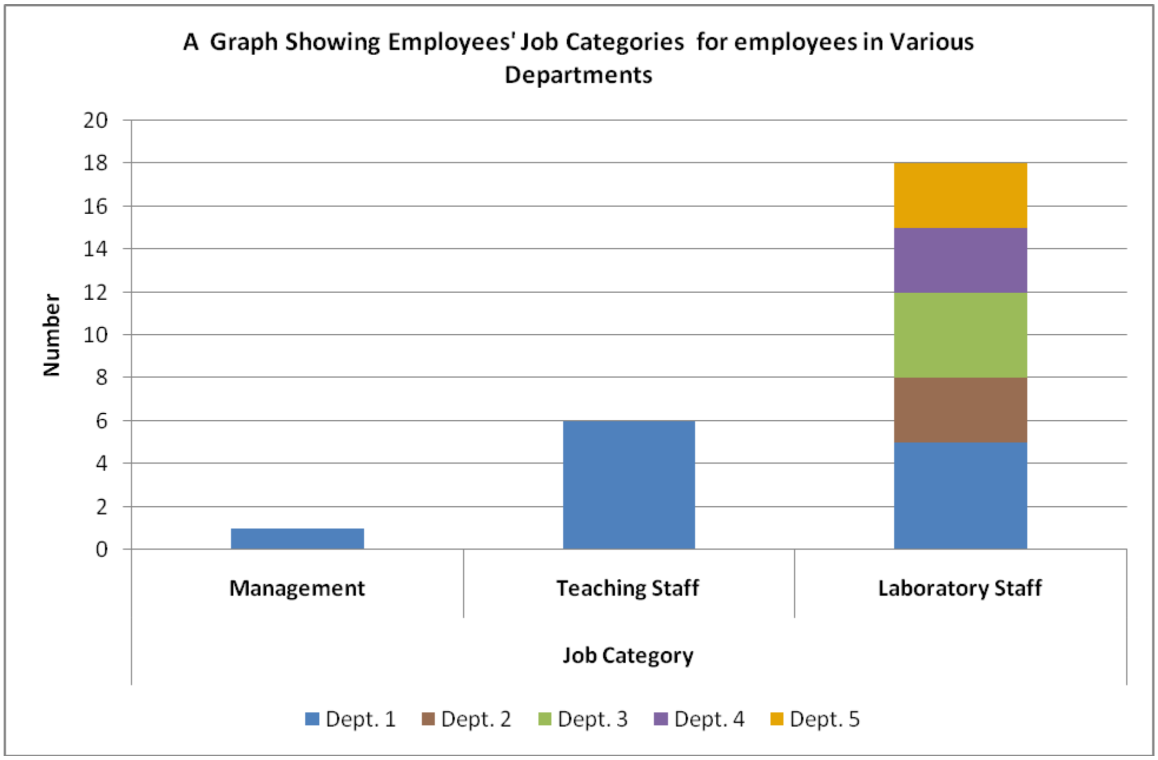


**Figure 4.5: A graphical representation of employees' job category**

Figure 4.5 illustrates the different job categories held by the respondents in the five departments. Twenty four percent (24%) of respondents reported occupational field within the academic category (lecturing staff – Junior/Senior Lecturer), seventy two percent (72%) reported occupational field in the technical category (laboratory staff – Senior Laboratory Assistant/Technician, and Research Assistant), and four percent (4%) reported occupational field in the management category.

## 4.4 SAFETY CLIMATE DATA ANALYSIS

Each item Section 2 of the survey questionnaire was scored by giving a value of 5 to the ‘strongly agree’ category, 4 to the ‘agree’ response, 3 to the ‘indifferent or Neutral’ category, 2 to the ‘disagree’ response, and 1 to the ‘strongly disagree’ category. The scores for the negatively worded items in the questionnaire were reversed by subtracting the individual item score from 6. The resulting individual scores were then averaged for each item, across the whole group. These average item scores were then used to calculate dimension scores. All the Dimensions in the questionnaire had three items except for the ‘Supportive Environment’ dimension which had two dimensions. Because of this reason, the scores needed to be standardised before plotting and comparing these dimensions. The scores were converted to a 1 to 10 scale for standardization. This was achieved by dividing the average score by the total possible score and then multiplying by 10.

### 4.4.1 Safety Climate Results for the Five Departments

Tables and graphs were used to show the responses to each of the dimensions as they were measured for each of the five departments. The tables shows the dimensional scores for each department assessed and the resulting scores are plotted on a radar plot and a bar graph to show the positive and negative responses in each of the dimensions. This information simply gives a picture of the overall levels of positive and negative safety perceptions. Tables 4.3 to 4.7 show how the dimension scores were calculated from the questionnaire items, for each of the nine dimensions and the final score for each safety dimension for all the five departments. Figures 4.6 to 4.15 show graphical representations of the levels of employees’ perceptions on each safety dimension for each of the five departments. The tables and graphs are provided and discussed in below for each department.

***SAFETY CLIMATE RESULTS FOR DEPARTMENT 1***

To calculate the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.3 below.

**Table 4.3: Calculating Dimension Scores for Department 1**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Management Commitment** | Item 1 + Item 2 + Item 3 | 15 | 10 | 8.0 |
| **Communication** | Item 4 + Item 5 + Item 6 | 15 | 10 | 7.5 |
| **Priority of Safety** | Item 7 + Item 8 + Item 9 | 15 | 10 | 7.6 |
| **Safety Rules and Procedures** | (6 - Item 10) + (6 - Item 11) + (6 - Item 12) | 15 | 10 | 4.4 |
| **Supportive Environment** | (6 - Item 13) + Item 14 | 10 | 10 | 6.0 |
| **Involvement** | Item 15 + Item 16 + (6 - Item 17) | 15 | 10 | 5.3 |
| **Personal Priorities and Need for Safety** | Item 18 + (6 - Item 19) + Item 20 | 15 | 10 | 3.0 |
| **Personal Appreciation of Risk** | (6 - Item 21) + (6 - Item 22) + Item 23 | 15 | 10 | 7.0 |
| **Work Environment** | (6 - Item 24) + (6 - Item 25) + (6 - Item 26) | 15 | 10 | 8.0 |

The resulting final scores were used to plot the bar graph (Figure 4.6) and the radar plot (Figure 4.7) to illustrate the overall safety culture for Department 1. Lower scores (below 5) represent a positive safety climate and higher scores (above 5) represent a negative safety climate. Department 1 shows a highly positive climate for Personal Priorities and Need for Safety and a moderately positive climate for Safety Rules and for Procedures.

Department 1 has a highly negative perception for Management Commitment, Communication, Physical Work Environment, and Priority of Safety. The department also shows a moderately to slightly negative perception on Personal Appreciation of Risk, Supportive Environment, and Involvement.

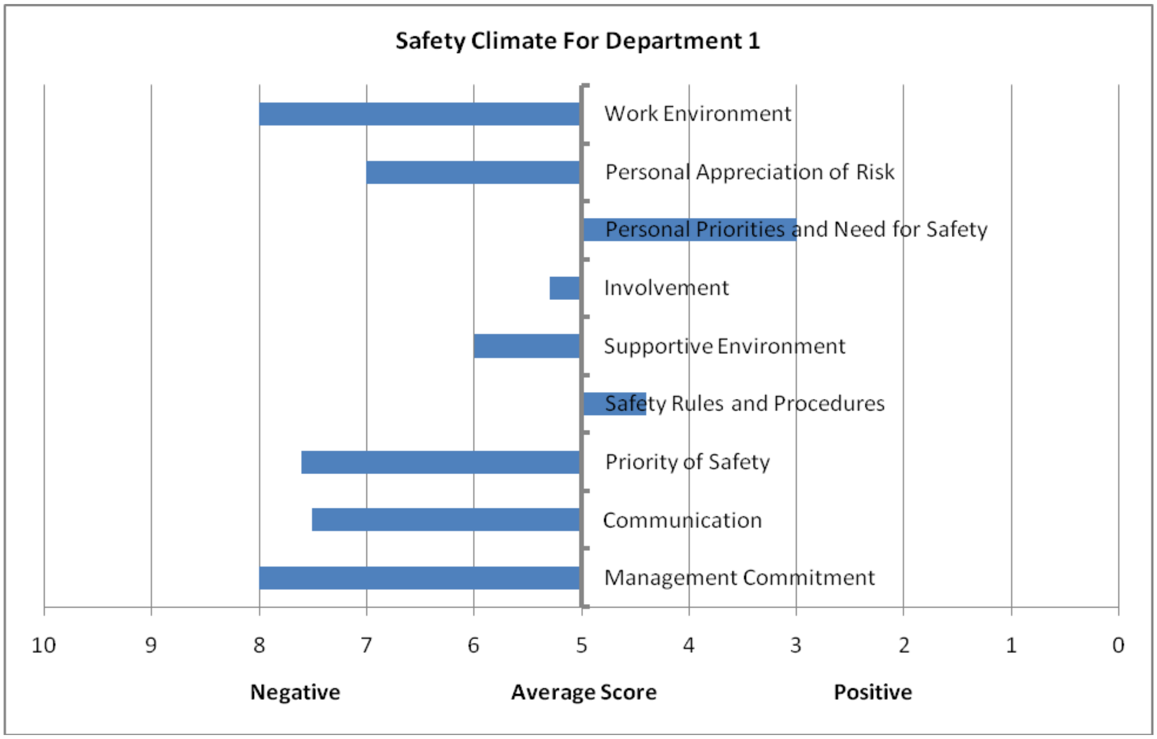


**Figure 4.6: A graph representing the responses to each of the dimensions and showing the levels of negative and positive perceptions**

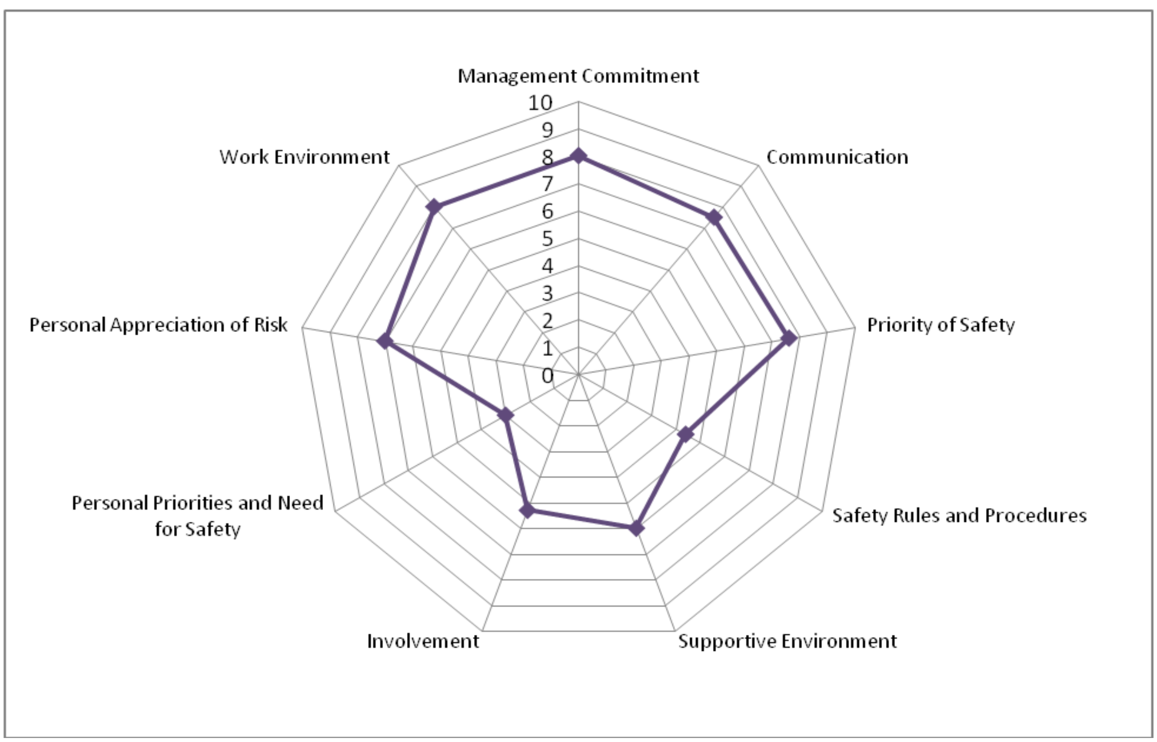


**Figure 4.7: Radar plot of each dimension showing an overall picture of the current state of Department 1**

***SAFETY CLIMATE RESULTS FOR DEPARTMENT 2***

To calculate the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.4 below.

**Table 4.4: Calculating Dimension Scores for Department 2**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Management Commitment** | Item 1 + Item 2 + Item 3 | 15 | 10 | 6.9 |
| **Communication** | Item 4 + Item 5 + Item 6 | 15 | 10 | 6.0 |
| **Priority of Safety** | Item 7 + Item 8 + Item 9 | 15 | 10 | 5.6 |
| **Safety Rules and Procedures** | (6 - Item 10) + (6 - Item 11) + (6 - Item 12) | 15 | 10 | 2.9 |
| **Supportive Environment** | (6 - Item 13) + Item 14 | 10 | 10 | 4.7 |
| **Involvement** | Item 15 + Item 16 + (6 - Item 17) | 15 | 10 | 5.3 |
| **Personal Priorities and Need for Safety** | Item 18 + (6 - Item 19) + Item 20 | 15 | 10 | 2.4 |
| **Personal Appreciation of Risk** | (6 - Item 21) + (6 - Item 22) + Item 23 | 15 | 10 | 5.3 |
| **Work Environment** | (6 - Item 24) + (6 - Item 25) + (6 - Item 26) | 15 | 10 | 6.7 |

The resulting final scores were used to plot the bar graph (Figure 4.8) and the radar plot (Figure 4.9) to illustrate the overall safety culture for Department 2. Lower scores (below 5) represent a positive safety climate and higher scores (above 5) represent a negative safety climate. Department 2 shows a highly positive climate for Personal Priorities and Need for Safety as well as for Safety Rules and Procedures. The department also shows a slightly positive perception on Supportive Environment.

Department 2 has a highly to moderately negative perception for Management Commitment, Communication, Physical Work Environment, and Priority of Safety. The department also shows a slightly negative perception on Involvement, and Personal Appreciation of Risk.

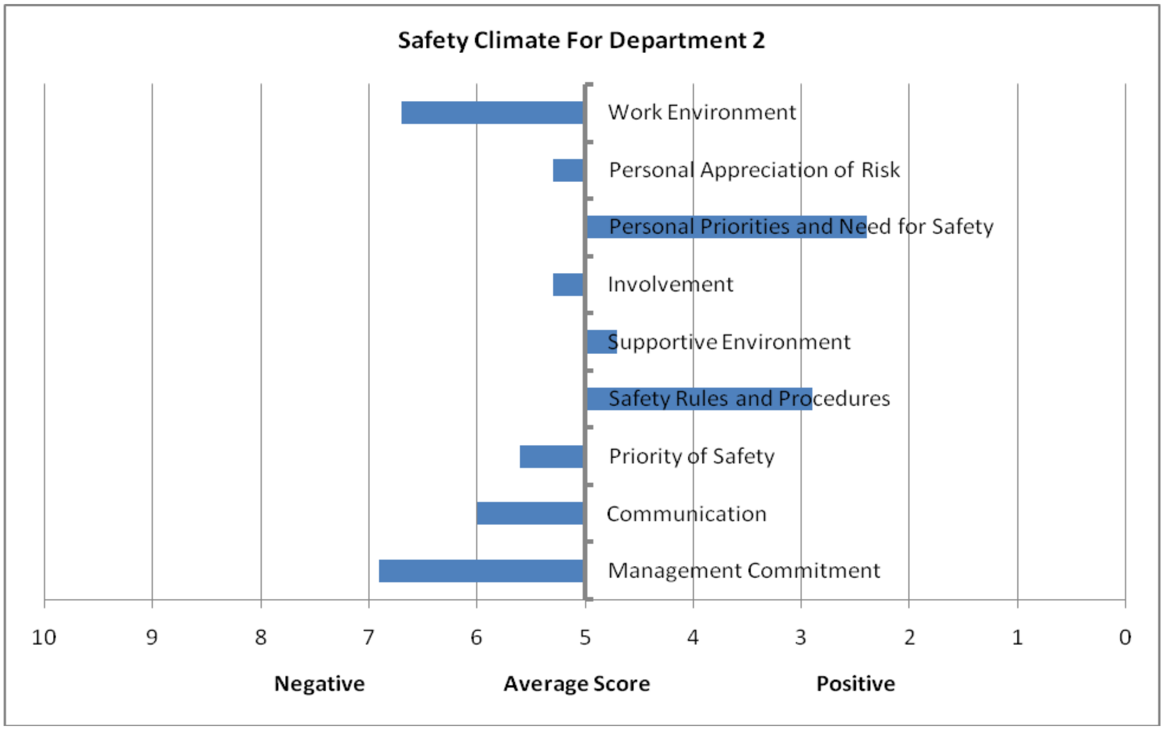


**Figure 4.8: A graph representing the responses to each of the dimensions and showing the levels of negative and positive perceptions**

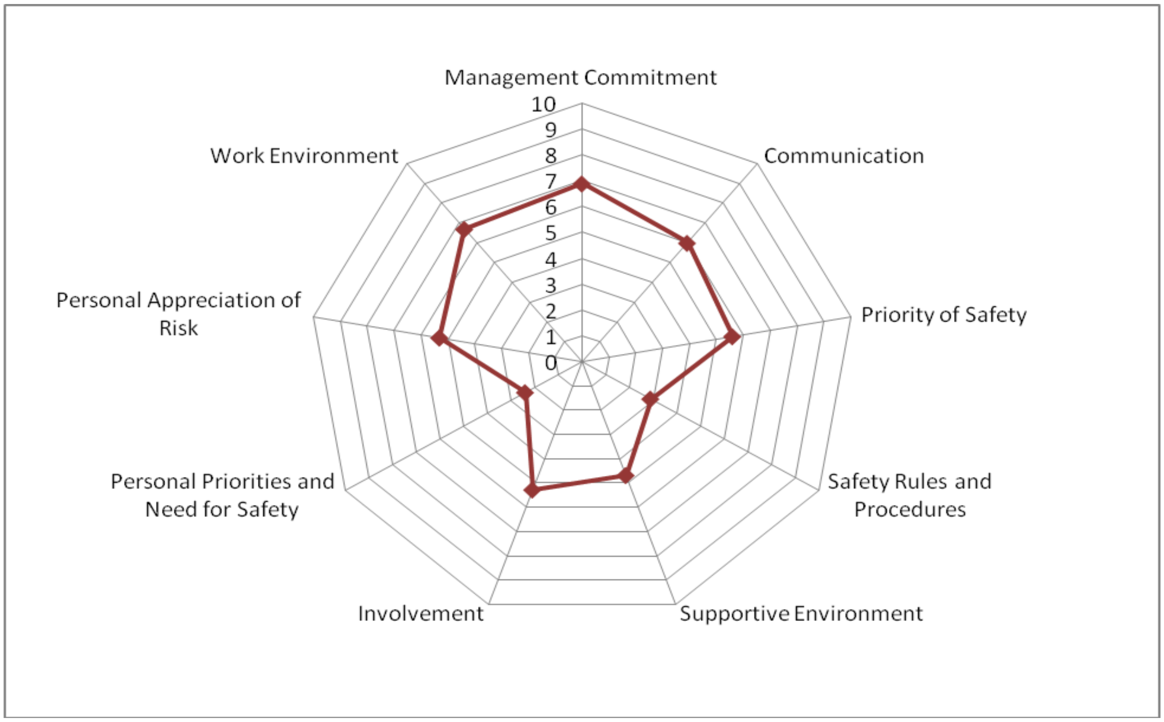


**Figure 4.9: Radar plot of each dimension showing an overall picture of the current state of Department 2**

***SAFETY CLIMATE RESULTS FOR DEPARTMENT 3***

To calculate the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.5 below.

**Table 4.5: Calculating Dimension Scores for Department 3**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Management Commitment** | Item 1 + Item 2 + Item 3 | 15 | 10 | 9.0 |
| **Communication** | Item 4 + Item 5 + Item 6 | 15 | 10 | 8.7 |
| **Priority of Safety** | Item 7 + Item 8 + Item 9 | 15 | 10 | 8.8 |
| **Safety Rules and Procedures** | (6 - Item 10) + (6 - Item 11) + (6 - Item 12) | 15 | 10 | 3.2 |
| **Supportive Environment** | (6 - Item 13) + Item 14 | 10 | 10 | 5.3 |
| **Involvement** | Item 15 + Item 16 + (6 - Item 17) | 15 | 10 | 4.2 |
| **Personal Priorities and Need for Safety** | Item 18 + (6 - Item 19) + Item 20 | 15 | 10 | 3.0 |
| **Personal Appreciation of Risk** | (6 - Item 21) + (6 - Item 22) + Item 23 | 15 | 10 | 7.3 |
| **Work Environment** | (6 - Item 24) + (6 - Item 25) + (6 - Item 26) | 15 | 10 | 9.2 |

The resulting final scores were used to plot the bar graph (Figure 4.10) and the radar plot (Figure 4.11) to illustrate the overall safety culture for Department 3. Lower scores (below 5) represent a positive safety climate and higher scores (above 5) represent a negative safety climate. Department 3 shows a highly positive climate for Personal Priorities and Need for Safety as well as for Safety Rules and Procedures. The department also shows a moderately positive perception on Involvement.

Department 3 has a highly to moderately negative perception for Management Commitment, Communication, Physical Work Environment, Priority of Safety, and Personal Appreciation of Risk. The department also shows a slightly negative perception on Supportive Environment.

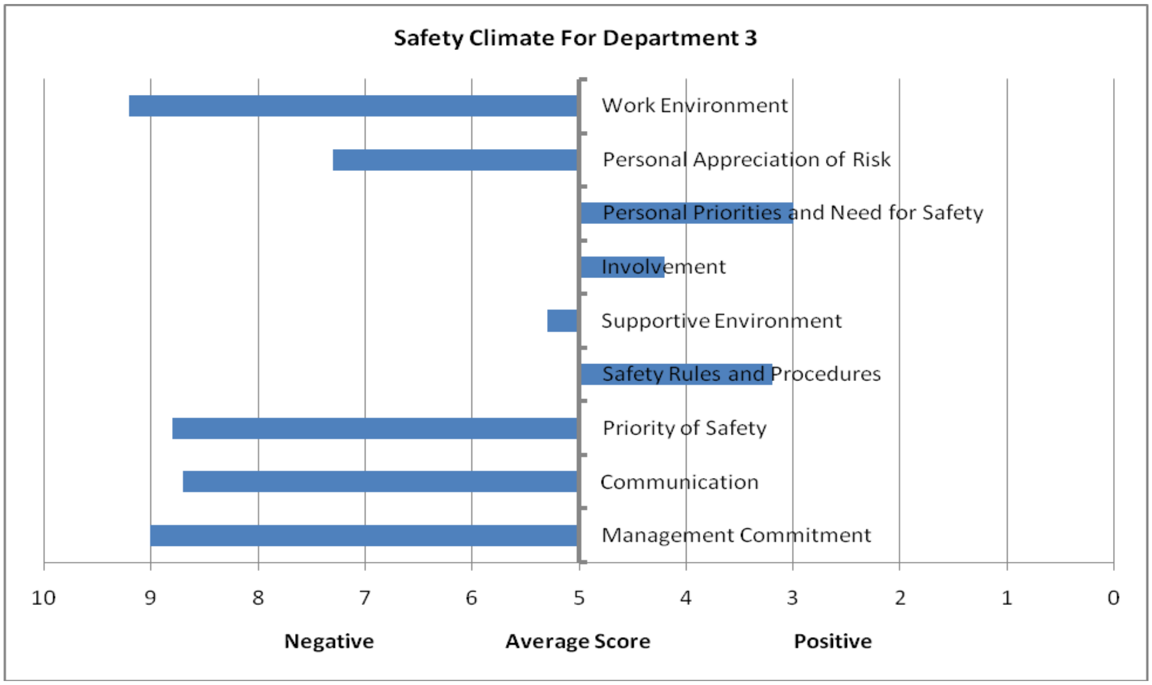


**Figure 4.10: A graph representing the responses to each of the dimensions and showing the levels of negative and positive perceptions**

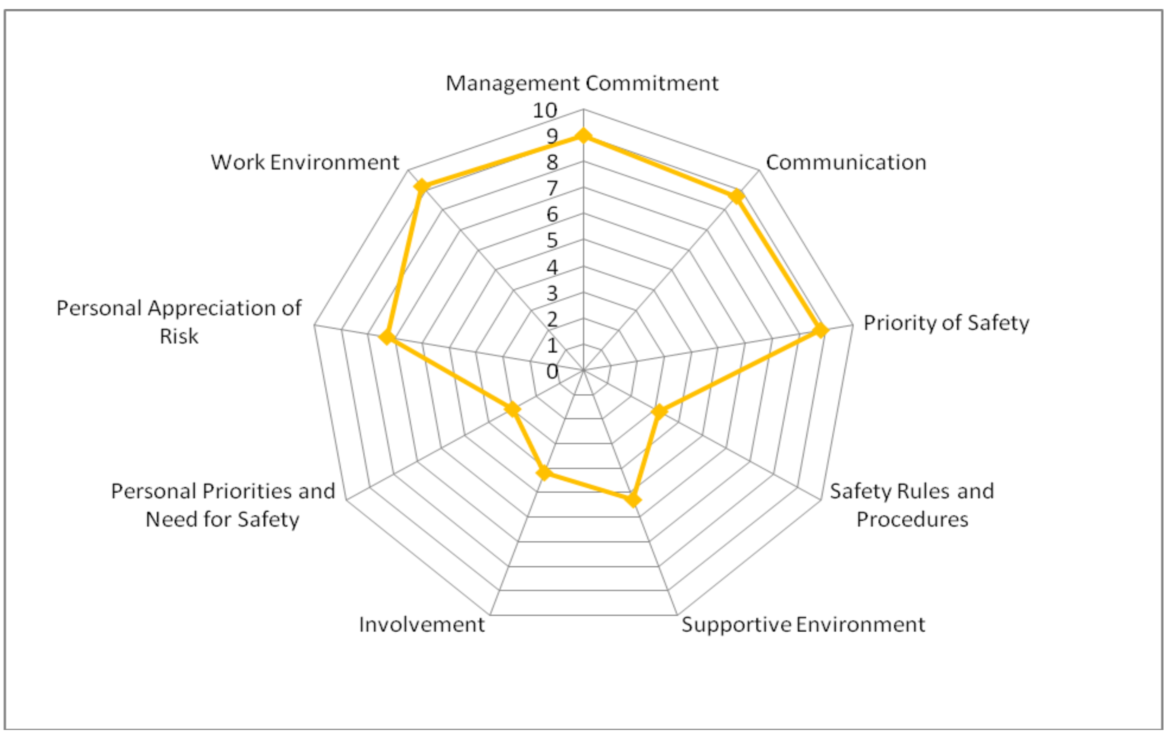


**Figure 4.11: Radar plot of each dimension showing an overall picture of the current state of Department 3**

***SAFETY CLIMATE RESULTS FOR DEPARTMENT 4***

To calculate the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.6 below.

**Table 4.6: Calculating Dimension Scores for Department 4**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Management Commitment** | Item 1 + Item 2 + Item 3 | 15 | 10 | 6.9 |
| **Communication** | Item 4 + Item 5 + Item 6 | 15 | 10 | 6.4 |
| **Priority of Safety** | Item 7 + Item 8 + Item 9 | 15 | 10 | 6.2 |
| **Safety Rules and Procedures** | (6 - Item 10) + (6 - Item 11) + (6 - Item 12) | 15 | 10 | 3.8 |
| **Supportive Environment** | (6 - Item 13) + Item 14 | 10 | 10 | 5.3 |
| **Involvement** | Item 15 + Item 16 + (6 - Item 17) | 15 | 10 | 4.9 |
| **Personal Priorities and Need for Safety** | Item 18 + (6 - Item 19) + Item 20 | 15 | 10 | 3.1 |
| **Personal Appreciation of Risk** | (6 - Item 21) + (6 - Item 22) + Item 23 | 15 | 10 | 5.3 |
| **Work Environment** | (6 - Item 24) + (6 - Item 25) + (6 - Item 26) | 15 | 10 | 7.3 |

The resulting final scores were used to plot the bar graph (Figure 4.12) and the radar plot (Figure 4.13) to illustrate the overall safety culture for Department 4. Lower scores (below 5) represent a positive safety climate and higher scores (above 5) represent a negative safety climate. Department 4 shows a highly positive climate for Personal Priorities and Need for Safety as well as for Safety Rules and Procedures. The department also shows a slightly positive perception on Involvement.

Department 4 has a highly negative perception for Management Commitment, Communication, Physical Work Environment, and Priority of Safety. The department also shows a slightly negative perception on Personal Appreciation of Risk, and Supportive Environment.

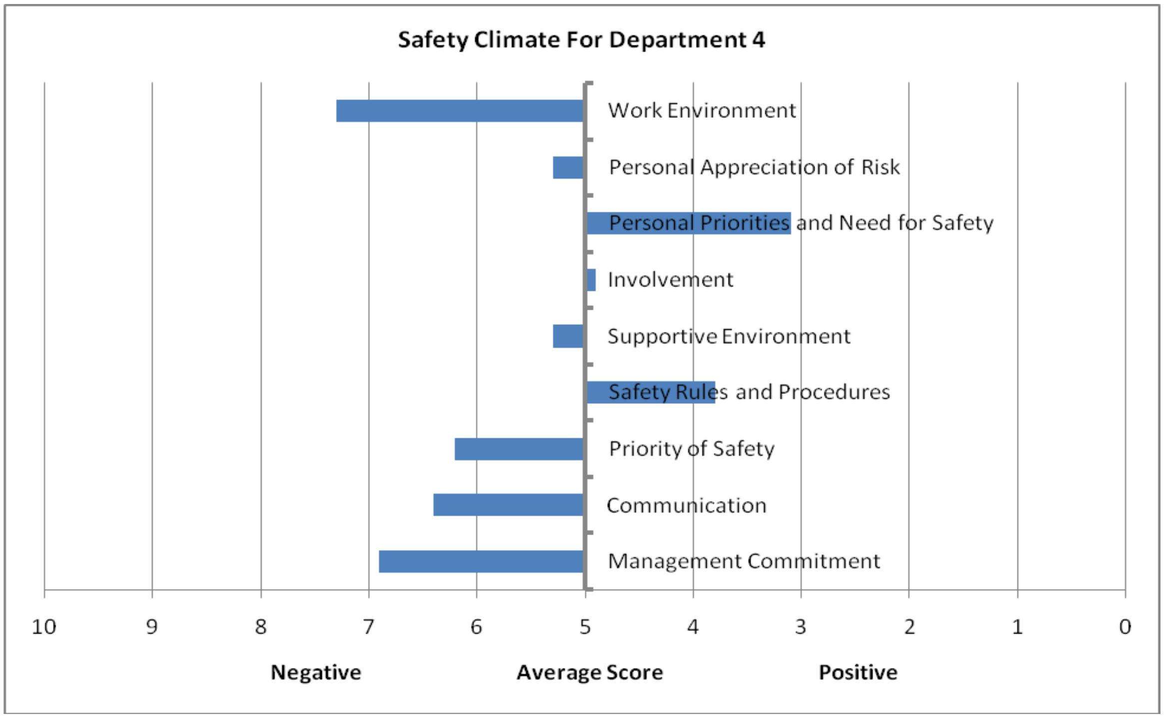


**Figure 4.12: A graph representing the responses to each of the dimensions and showing the levels of negative and positive perceptions**

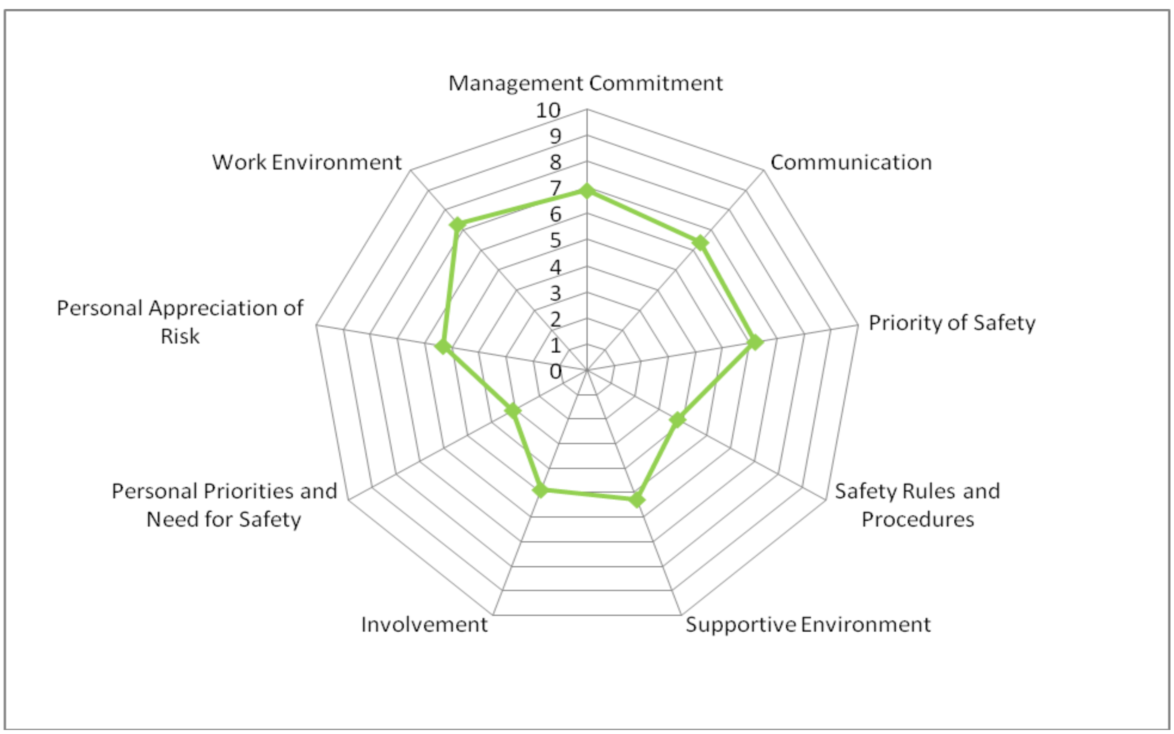


**Figure 4.13: Radar plot of each dimension showing an overall picture of the current state of Department 4**

## ***RESULTS FOR DEPARTMENT 5***

To calculate the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.7 below.

**Table 4.7: Calculating Dimension Scores for Department 5**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Management Commitment** | Item 1 + Item 2 + Item 3 | 15 | 10 | 7.8 |
| **Communication** | Item 4 + Item 5 + Item 6 | 15 | 10 | 6.9 |
| **Priority of Safety** | Item 7 + Item 8 + Item 9 | 15 | 10 | 7.1 |
| **Safety Rules and Procedures** | (6 - Item 10) + (6 - Item 11) + (6 - Item 12) | 15 | 10 | 4.2 |
| **Supportive Environment** | (6 - Item 13) + Item 14 | 10 | 10 | 6.0 |
| **Involvement** | Item 15 + Item 16 + (6 - Item 17) | 15 | 10 | 5.1 |
| **Personal Priorities and Need for Safety** | Item 18 + (6 - Item 19) + Item 20 | 15 | 10 | 3.1 |
| **Personal Appreciation of Risk** | (6 - Item 21) + (6 - Item 22) + Item 23 | 15 | 10 | 6.2 |
| **Work Environment** | (6 - Item 24) + (6 - Item 25) + (6 - Item 26) | 15 | 10 | 7.6 |

The resulting final scores were used to plot the bar graph (Figure 4.14) and the radar plot (Figure 4.15) to illustrate the overall safety culture for Department 5. Lower scores (below 5) represent a positive safety climate and higher scores (above 5) represent a negative safety climate. Department 5 shows a positive climate for Personal Priorities and Need for Safety as well as for Safety Rules and Procedures. The department shows a highly negative perception for Management Commitment, Communication, Physical Work Environment, and Priority of Safety. The department also shows a moderately negative perception on Personal Appreciation of Risk, and Supportive Environment. Department 5 has a slightly negative perception on Involvement.

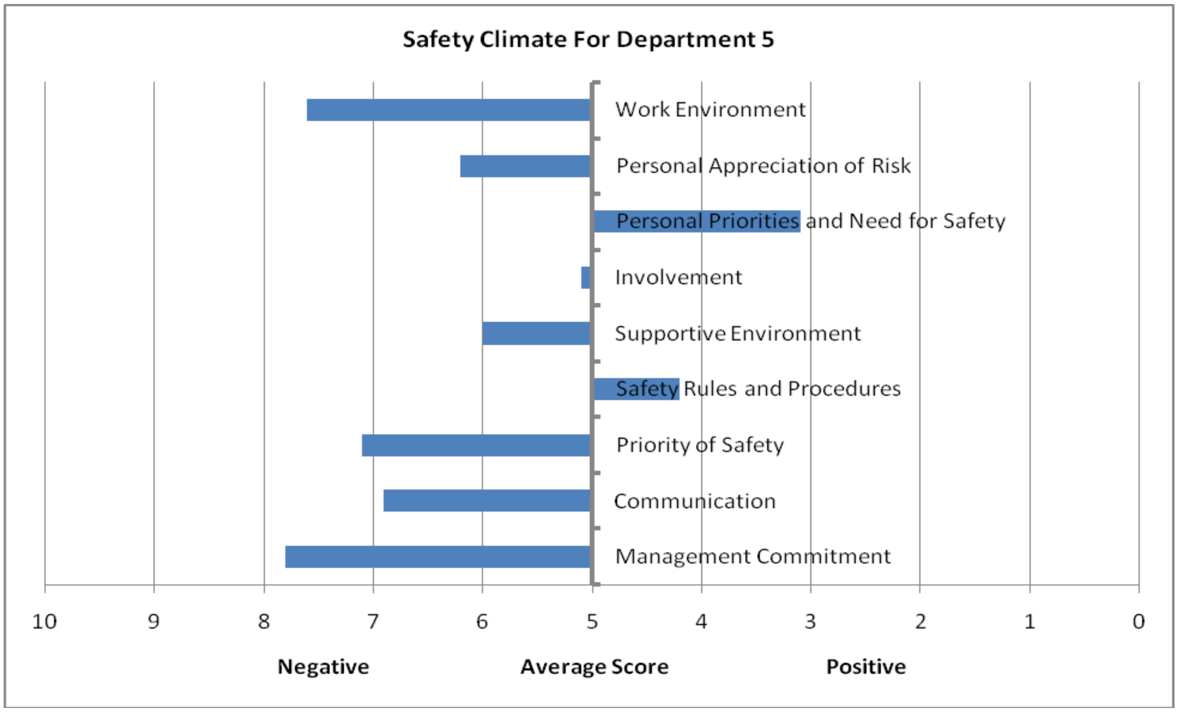


**Figure 4.14: A graph representing the responses to each of the dimensions and showing the levels of negative and positive perceptions**

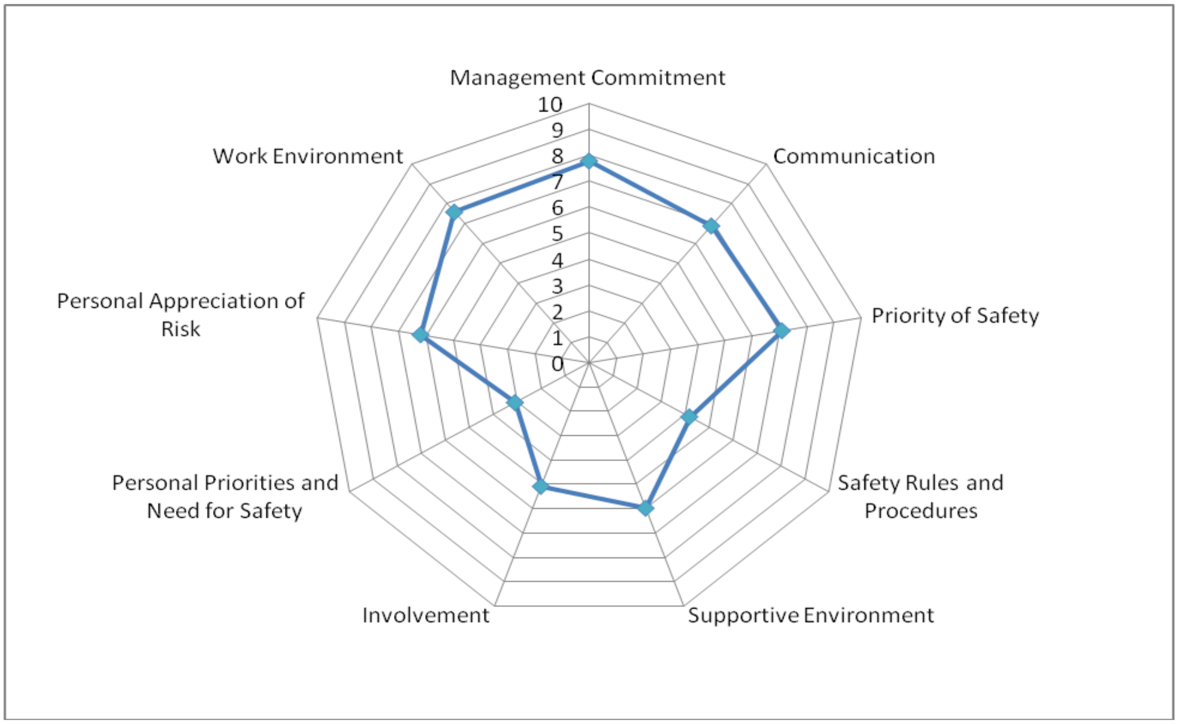


**Figure 4.15: Radar plot of each dimension showing an overall picture of the current state of Department 5**

***RESULTS SUMMARY OF THE SAFETY CLIMATE ASSESSMENT FOR THE FIVE DEPARTMENTS***

The table below shows a safety climate assessment matrix completed using the results for all the five departments assessed. The table gives an illustration of the positive climate (strengths) and the negative climate (weaknesses) in each of the dimensions.

**Table 4.8: Safety Climate Matrix showing positive attitudes and the negative attitudes for the 5 departments**

| | **DEPARTMENT 1** | **DEPARTMENT 2** | **DEPARTMENT 3** | **DEPARTMENT 4** | **DEPARTMENT 5** |
|---|---|---|---|---|---|
| **Management Commitment** | *Negative* | *Negative* | *Negative* | *Negative* | *Negative* |
| **Communication** | *Negative* | *Negative* | *Negative* | *Negative* | *Negative* |
| **Priority of Safety** | *Negative* | *Negative* | *Negative* | *Negative* | *Negative* |
| **Safety Rules and Procedures** | *Positive* | *Positive* | *Positive* | *Positive* | *Positive* |
| **Supportive Environment** | *Negative* | *Positive* | *Negative* | *Negative* | *Negative* |
| **Involvement** | *Negative* | *Negative* | *Positive* | *Positive* | *Negative* |
| **Personal Priorities and Need for Safety** | *Positive* | *Positive* | *Positive* | *Positive* | *Positive* |
| **Personal Appreciation of Risk** | *Negative* | *Negative* | *Negative* | *Negative* | *Negative* |
| **Work Environment** | *Negative* | *Negative* | *Negative* | *Negative* | *Negative* |

### 4.4.1 Comparative Safety Climate

Comparisons were made between the five departments to show how the safety climate varies between departments. Comparisons were also made between male and female respondents in each department to show how the safety climate varies between male and female respondents within the same department group. Departments 4 and 5 are excluded from this analysis since all the respondents in Department 4 are Female and all respondents in Department 5 are Males.

***DEPARTMENT BASED COMPARATIVE ANALYSIS***

***Comparative Safety Climate between the Five Departments***

**Table 4.9: Comparative Safety Dimension Scores between the Five Departments in the Faculty**

| | SAFETY CLIMATE SCORE | | | | |
|---|---|---|---|---|---|
| DIMENSION | DEPT. 1 | DEPT. 2 | DEPT. 3 | DEPT. 4 | DEPT. 5 |
| Management Commitment | 8.0 | 6.9 | 9.0 | 6.9 | 7.8 |
| Communication | 7.5 | 6 | 8.7 | 6.4 | 6.9 |
| Priority of Safety | 7.6 | 5.6 | 8.8 | 6.2 | 7.1 |
| Safety Rules and Procedures | 4.4 | 2.9 | 3.2 | 3.8 | 4.2 |
| Supportive Environment | 6.0 | 4.7 | 5.3 | 5.3 | 6.0 |
| Involvement | 5.3 | 5.3 | 4.2 | 4.9 | 5.1 |
| Personal Priorities and Need for Safety | 3.0 | 2.4 | 3.0 | 3.1 | 3.1 |
| Personal Appreciation of Risk | 7.0 | 5.3 | 7.3 | 5.3 | 6.2 |
| Work Environment | 8.0 | 6.7 | 9.2 | 7.3 | 7.6 |

The safety climate scores in the table above were used to plot the bar graph (Figure 4.16) and the radar plot (Figure 4.17) to illustrate the differences in organisation's Safety Climate that exists between the five departments.

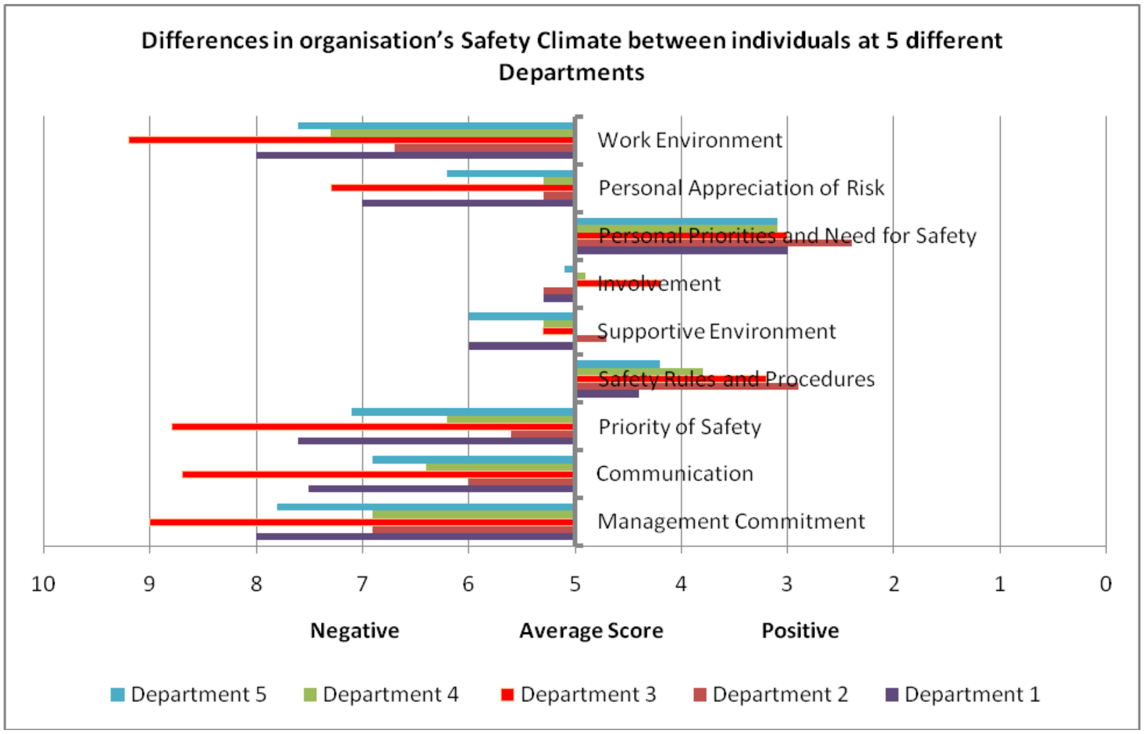


**Figure 4.16: Safety Culture Comparison of 5 different Departments**

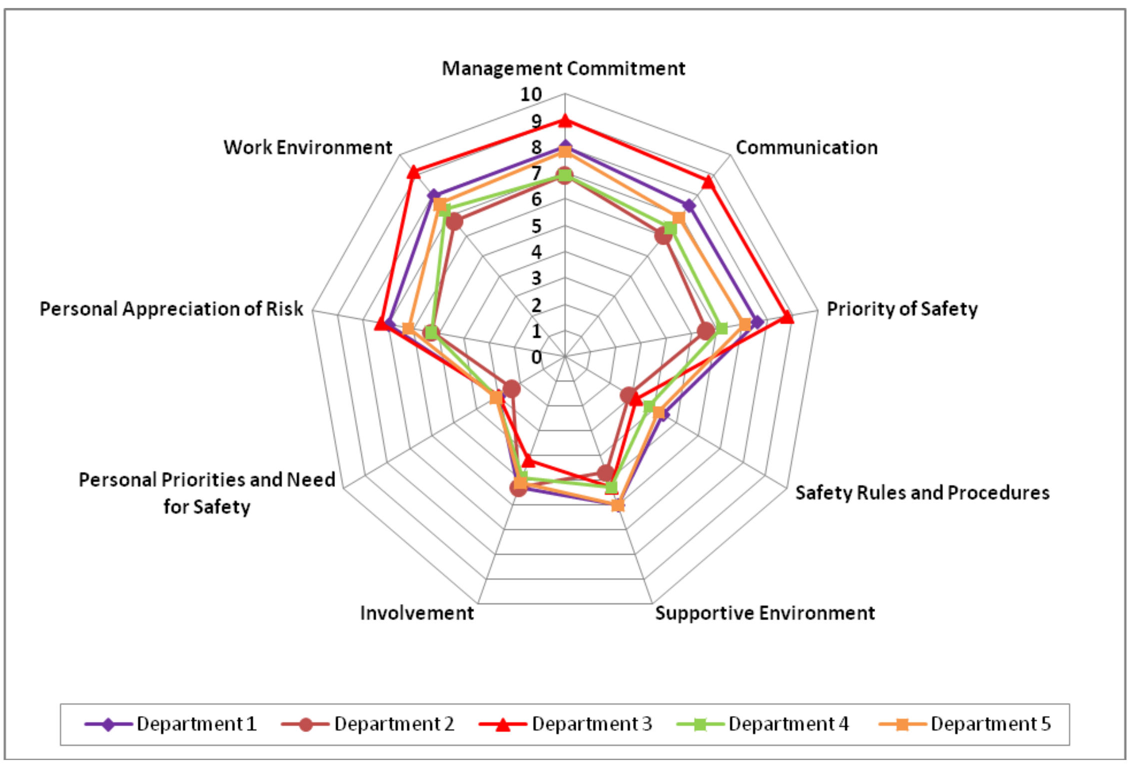


**Figure 4.17: A plot showing a comparative safety climate in 5 Departments**

The departments show a consistent pattern for positive and negative. All the departments have negative perceptions towards Management commitment, Communication, Priority for Safety, Personal Appreciation of Risk and the Physical Work Environment. Department 3 rated the highest levels (more negatives) of these dimension, followed by Department 1, then Department 4 and then Department 5, and lastly Department 2. This implies that all of the five departments have a high level of risks associated with the operations carried out in those departments and the physical work environment within those departments is viewed as highly unsafe. These responses also give an indication that communication about safety issues amongst employees at various levels is insufficient and that the quality of communication within the organisation and between divisions concerning safety initiatives is poor. Management is not committed to addressing safety concerns.

Employees in all the five department also showed consistencies in terms of the attitudes held for Safety Rules and Procedures as well as Personal Priorities and Need for Safety. These attitudes are positive for all the departments, which imply that employees are aware of safety rules and procedures at work and are willing to act in a safe manner. This also implies that individual employees need to feel safe in their work areas and view their personal safety as highly important.

In terms of Supportive Environment, only Department 2 had a slightly positive perception. Department 1, Department 3, department 4 and Department 5 showed negative attitudes toward Supportive Environment. Department 1 and Department 5 rated the same level of safety measure which is the highest, and department 3 and Department 4 rated the same level which is also the second highest. The negative safety climate gives an indication that the nature of the social environment at work does not encourage safe working practices. This probably means that management and supervisors are not encouraging a safe working practice/environment amongst employees. This can be attributed to factors such as the unavailability and maintenance of safety equipment; the unavailability of safety instructions; and the lack of procedural safety information. In terms of Involvement, two departments had a moderately to slightly positive perception.

Department 1, Department 2, Department 4, and Department 5 rated the level of Involvement in safety initiatives to be negative. Department 2 and Department 1 rated the same level. The negative level of involvement gives an indication that employees are generally not involved in safety issues and are not encouraged to take responsibility for safety within the organisation. This indicates that managers and supervisors probably exclude employees in decision making for safety management. Only one department, Department 3, rated positive for involvement, which suggests some degree of employee participation in safety initiatives.

It can be stated that the overall results regarding the organizational context of safety across all department groups were negative. *Management Commitment* gives an indication of perceptions of management's overt commitment to safety issues. Overall results indicated that management is perceived as not being committed to safety issues. *Communication* gives an indication of the nature and efficiency of health and safety communications within the organization. The results generally indicated that there is poor or ineffective communications on safety matters within the departments. *Priority of Safety* gives an indication of the relative status of safety issues within the organization. Overall results indicated that, in comparison to other factors, safety is not a main priority within the departments. *Safety Rules and Procedures* gives an indication of views on the efficacy and necessity of rules and procedures. This is the second most positively ranked factor. This suggests that employees have good values towards safety rules and procedures, and understand their usefulness in preventing accidents. Employees put their safety values to practice in the work team setting.

The overall results regarding the social environment of safety across all groups were slightly negative. *Supportive Environment* gives an indication of the nature of the social environment at work, and the support derived from it. The results for supportive environment were slightly negative for all groups. This suggests that even though employees have good general values towards safety and understand their need for safety, they may not be putting their safety values to practice in the work team setting. *Involvement* gives an indication of the extent to which safety is a focus for everyone and all are involved. Overall results indicated a neutral involvement, which imply a sufficient focus and involvement in safety mattes in the departments. Department 3 and 4 reported a slightly positive involvement which implies that everyone in these departments is involved in safety matters. Departments 1, 2 and 5 reported slightly negative results implying that not everyone in these departments focus on safety mattes.

The overall results regarding the Individual Appreciation of safety across all groups were positive for Personal Priorities and Need for Safety and negative for Personal Appreciation of Risk. *Personal Priorities and Need for Safety* gives an indication of the individual's view of their own safety management and need to feel safe. Employees rated their own safety management and need to feel safe positive. This implies that employees value their own safety and need to feel safe in their work environment. *Personal Appreciation of Risk* gives an indication of how individuals view the risk associated with work. Employees rated personal appreciation of risk negative, which indicates that they are aware that risks associated with their work are high.

The overall results regarding the Work Environment were negative across all groups. *Physical Work Environment* gives an indication of perceptions of the nature of the physical environment. Employees rated the physical environment as particularly negative with regard to safety. This implies that the physical work environment is not safe as viewed by the employees.

## ***GENDER BASED COMPARATIVE ANALYSIS***

A comparative analysis was done for each department based on the respondents' gender. The analysis was conducted for three departments (Department 1, Department 2, and Department 3) for the simply reason that they are the only departments that had both males and females respondents. Department 4 and Department 5 were only included in the overall gender differentiated analysis.

### ***Gender Differentiated Results for Department 1***

**Table 4.10: Comparative Safety Dimension Scores between the Males and Females in Department 1**

| DIMENSION | DEPARTMENT 1 | |
|---|---|---|
| | **Female** | **Male** |
| **Management Commitment** | 7.2 | 8.4 |
| **Communication** | 7.3 | 7.6 |
| **Priority of Safety** | 7 | 7.8 |
| **Safety Rules and Procedures** | 4 | 4.6 |
| **Supportive Environment** | 5.5 | 6.3 |
| **Involvement** | 4.7 | 5.6 |
| **Personal Priorities and Need for Safety** | 2.8 | 3.1 |
| **Personal Appreciation of Risk** | 7 | 7 |
| **Work Environment** | 6.3 | 8.8 |

The safety climate scores in the table above were used to plot the bar graph (Figure 4.18) to illustrate the differences in organisation's Safety Climate that exists between the males and females in Department 1.

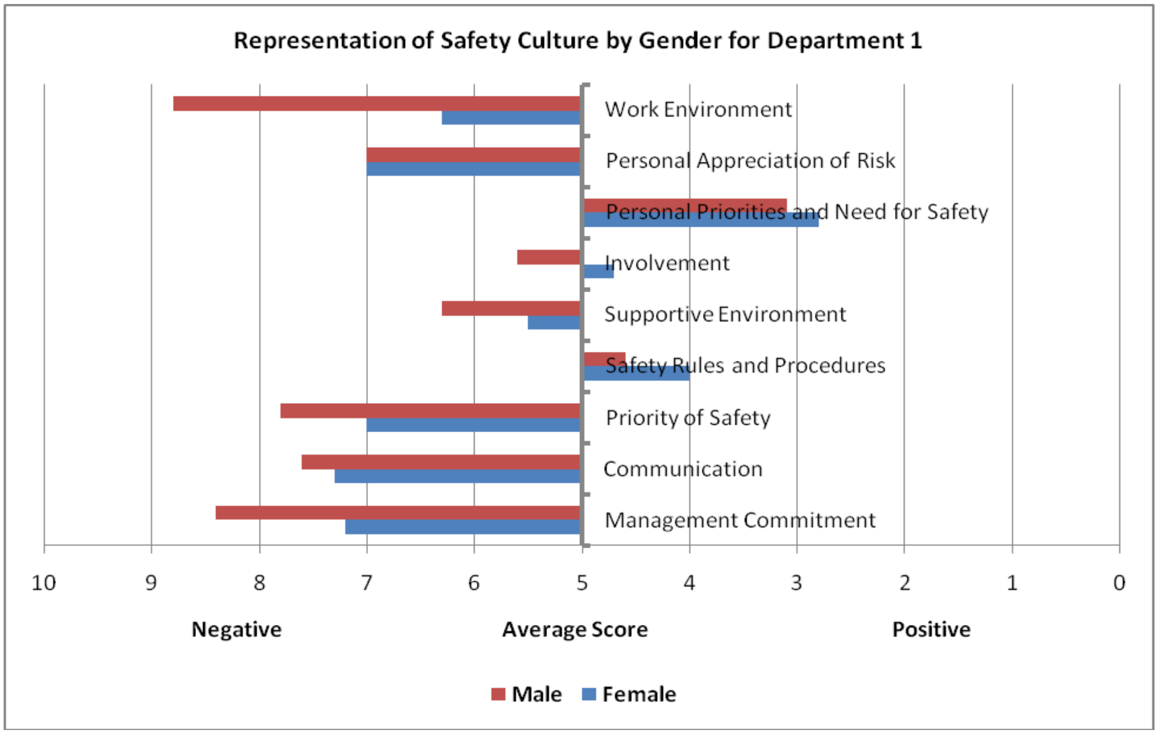


**Figure 4.18: Safety Culture, differentiating between males and females in Department 1**

In Department 1, males rated more negatively than females. Females almost consistently rated less negatively (for negatively rated dimensions, i.e. below a score of 5) and more positively (for positively rated dimensions, i.e. above a score of 5) than males. Females rated the Management Commitment, Work Environment, Communication, Priority of Safety, and Supportive Environment safety dimensions less negatively than males. This implies that males regard the organizational context (management commitment to safety, prioritization of safety issues procedures, environment and communication) and the environment aspects (physical work environment and the social environment) of safety management as insufficient.

Females also rated the Safety Rules and Procedures and Personal Priorities and Need for Safety dimensions more positively than males. This suggests that females are more aware of safety rules and procedures at work and are more willing to act in a safe manner than male do. It also means that females have a strong need to feel safe in their work areas and view their personal safety more important than males do. Both males and females rated fairly equal for personal appreciation for risk, suggesting that both males and females are aware of the risks associated with their work areas and that the risk levels are high in those areas. Whereas males rated Involvement dimension negatively, it was rated positively by females.

In terms of Involvement, females rated slightly positive and males rated slightly negative. This gives an indication that unlike females, males feel that they are generally not involved in safety issues and that they are not encouraged taking responsibility for safety within the organisation. This indicates that managers and supervisors show less concern towards males and exclude them in planning and decision making for safety.

***<u>Gender Differentiated Results for Department 2</u>***

**Table 4.11: Comparative Safety Dimension Scores between the Males and Females in Department 2**

| DIMENSION | DEPARTMENT 2 | |
|---|---|---|
| | **Female** | **Male** |
| **Management Commitment** | 6.3 | 8 |
| **Communication** | 5.7 | 6.7 |
| **Priority of Safety** | 4.3 | 8 |
| **Safety Rules and Procedures** | 3.3 | 2 |
| **Supportive Environment** | 4.5 | 5 |
| **Involvement** | 5.7 | 4.7 |
| **Personal Priorities and Need for Safety** | 2.3 | 2.7 |
| **Personal Appreciation of Risk** | 5 | 6 |
| **Work Environment** | 6.3 | 7.3 |

The safety climate scores in the table above were used to plot the bar graph (Figure 4.19) to illustrate the differences in organisation's Safety Climate that exists between the males and females in Department 2.

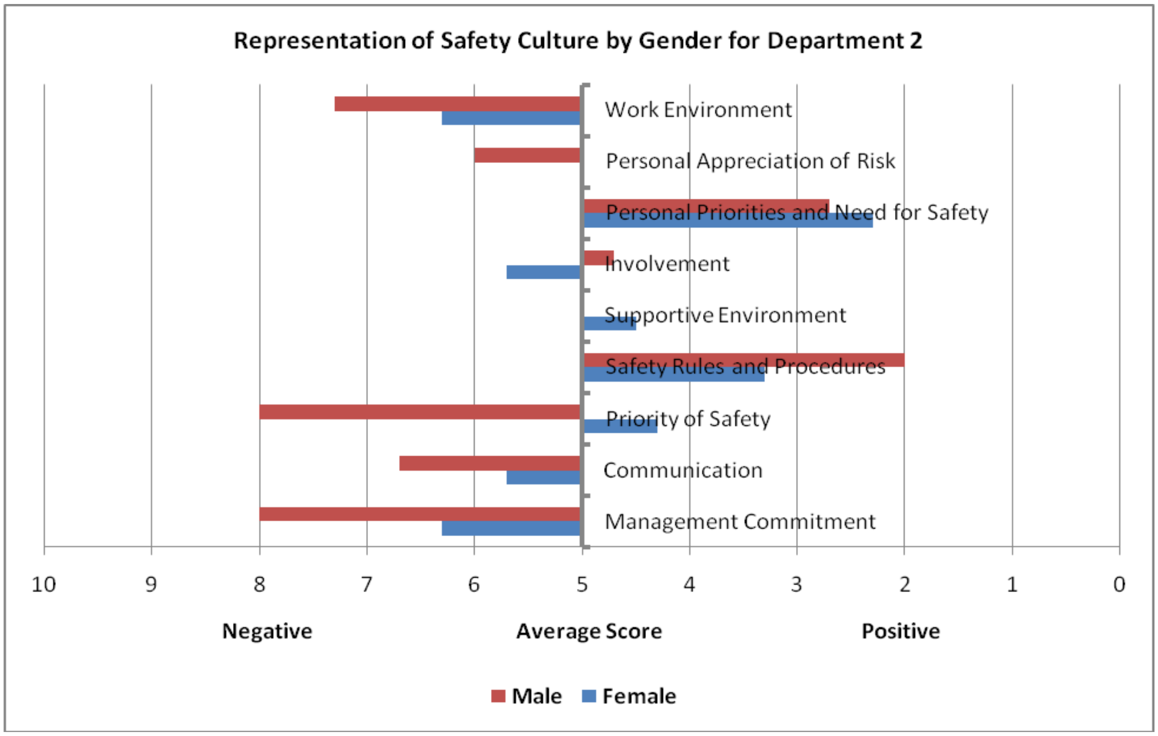


**Figure 4.19: Safety Culture, differentiating between males and females in Department 2**

The results indicate that male respondents have more negative attitudes than females. Males rated the Management Commitment, Work Environment, Communication, Priority of Safety, and Personal Appreciation of Risk dimensions more negatively than females. This implies that males regard the organizational context (management commitment to safety, prioritization of safety issues procedures, environment and communication) and the environment aspects (physical work environment) of safety management as insufficient.

Female respondents expressed a neutral attitude towards personal appreciation of risk whereas male respondents expressed a neutral attitude towards supportive environment. Female respondents showed a more positive level of personal priorities and need for safety which means that females have a strong need to feel safe in their work areas and view their personal safety more important than males do. Male respondents showed a more positive attitude towards safety rules and procedures. This suggests that males are more aware of safety rules and procedures at work and are more willing to act in a safe manner than females.

In terms of Involvement, males rated slightly positive and females rated slightly negative. This is not consistent with the other departments (1 and 3). The results gives an indication that unlike males, in Department 2 females feel that they are generally not involved in safety issues and that they are not encouraged taking responsibility for safety within the organisation. This indicates that managers and supervisors show less concern or are biased towards females and exclude them in planning and decision making for safety.

***Gender Differentiated Results for Department 3***

**Table 4.12: Comparative Safety Dimension Scores between the Males and Females in Department 3**

| DIMENSION | DEPARTMENT 3 | |
|---|---|---|
| | **Female** | **Male** |
| **Management Commitment** | 9.1 | 8.7 |
| **Communication** | 8.4 | 9.3 |
| **Priority of Safety** | 8.7 | 9.3 |
| **Safety Rules and Procedures** | 2.9 | 4 |
| **Supportive Environment** | 5.3 | 5 |
| **Involvement** | 4.4 | 3.3 |
| **Personal Priorities and Need for Safety** | 2.9 | 3.3 |
| **Personal Appreciation of Risk** | 7.3 | 7.3 |
| **Work Environment** | 9.1 | 9.3 |

The safety climate scores in the table above were used to plot the bar graph (Figure 4.20) to illustrate the differences in organisation's Safety Climate that exists between the males and females in Department 3.

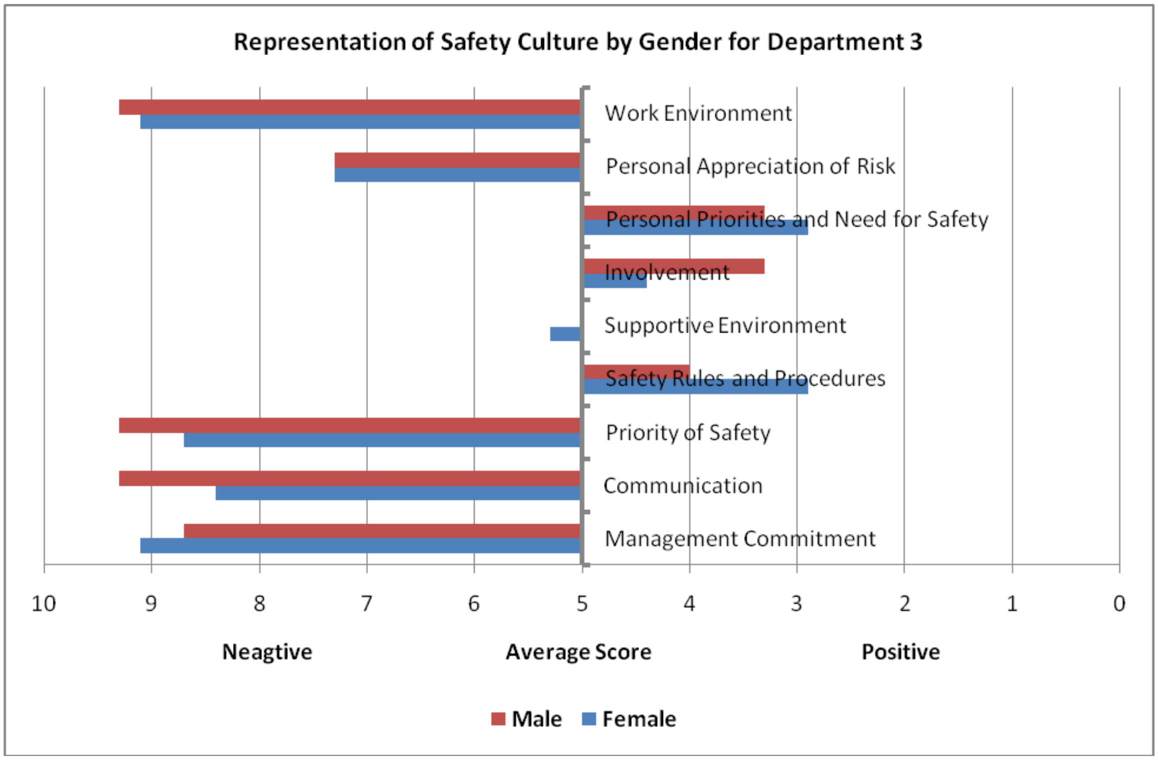


**Figure 4.20: Safety Culture, differentiating between males and females in Department 3**

The results for department 3 are less consistent with the results for Department 2 and Department 3 in terms of negative and positive safety ratings. Males rated the Work Environment, Communication, and Priority of Safety, dimensions more negatively than females. This implies that males regard the prioritization of safety issues procedures, the physical work environment and communication as insufficient more than females do. On the dimension Personal Appreciation of Risk, both males and females reported fairly equal results, suggesting that both males and females are aware of the risks associated with their work areas and that the risk levels are high in those areas.

Female respondents showed a more positive level of Personal Priorities and Need for Safety and Safety Rules and Procedures which means that females have a strong need to feel safe in their work areas and view their personal safety more important are more aware of safety rules and procedures at work and are more willing to act in a safe manner than males.

Male respondents expressed a neutral attitude towards supportive environment whereas females expressed a slightly negative attitude. This means that females believe that the social environment at work, and the support derived from it is does not support safety values, suggesting that even though females have good general values towards safety and understand their need for safety, they may not be putting their safety values to practice in the work team setting.

Male respondents showed a more positive attitude towards Involvement than females. This gives an indication that females feel that they are generally less involved in safety issues than males and that they are not encouraged taking responsibility for safety within the organisation. This implies that managers and supervisors show less concern or are biased towards females and exclude them in planning and decision making for safety.

***Overall Gender Differentiated Results for the 5 Departments***

**Table 4.13: Comparative Safety Dimension Scores between the Males and Females in the Five Departments**

| DIMENSION | DEPARTMENT 1 | | DEPARTMENT 2 | | DEPARTMENT 3 | |
|---|---|---|---|---|---|---|
| | Female | Male | Female | Male | Female | Male |
| Management Commitment | 7.2 | 8.4 | 6.3 | 8 | 9.1 | 8.7 |
| Communication | 7.3 | 7.6 | 5.7 | 6.7 | 8.4 | 9.3 |
| Priority of Safety | 7 | 7.8 | 4.3 | 8 | 8.7 | 9.3 |
| Safety Rules and Procedures | 4 | 4.6 | 3.3 | 2 | 2.9 | 4 |
| Supportive Environment | 5.5 | 6.3 | 4.5 | 5 | 5.3 | 5 |
| Involvement | 4.7 | 5.6 | 5.7 | 4.7 | 4.4 | 3.3 |
| Personal Priorities and Need for Safety | 2.8 | 3.1 | 2.3 | 2.7 | 2.9 | 3.3 |
| Personal Appreciation of Risk | 7 | 7 | 5 | 6 | 7.3 | 7.3 |
| Work Environment | 6.3 | 8.8 | 6.3 | 7.3 | 9.1 | 9.3 |

The safety climate scores in the table above were used to plot the bar graph (Figure 4.21) to illustrate the differences in organisation's Safety Climate that exists between males and females in the five departments.

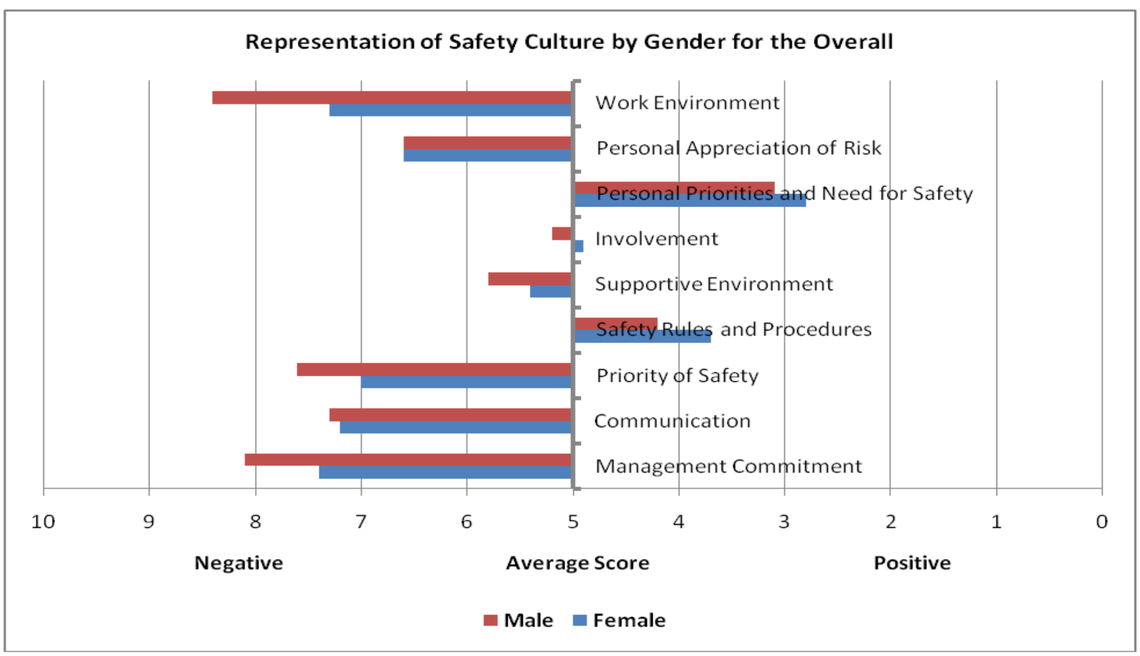


**Figure 4.21: Safety Culture, differentiating between males and females averaged across all departments**

The overall results displayed in Figure 4.21 display some consistencies with the results obtained for Department 1 as illustrated in Figure 4.18. Results on the differences between males and females in terms of safety culture revealed that females almost consistently reported a less negative (for negatively rated dimensions, i.e. below a score of 5) or more positive (for positively rated dimensions, i.e. above a score of 5) as compared to males on all safety culture dimensions. This implies that males regard management commitment to safety, prioritization of safety issues procedures, physical and social environment, and communication of safety issues between employees and departments as insufficient.

Females also rated the Safety Rules and Procedures and Personal Priorities and Need for Safety dimensions more positively than males. This suggests that females are more aware of safety rules and procedures at work and are more willing to act in a safe manner than male do. It also means that females have a strong need to feel safe in their work areas and view their personal safety more important than males do. Both males and females rated fairly equal for personal appreciation for risk, suggesting that both males and females are aware of the risks associated with their work areas and that the risk levels are high in those areas. Whereas males rated Involvement dimension negatively, it was rated positively by females.

In terms of Involvement, females rated slightly positive and males rated slightly negative. This gives an indication that unlike females, males feel that they are generally not involved in safety issues and that they are not encouraged taking responsibility for safety within the organisation. This indicates that managers and supervisors show less concern towards males and exclude them in planning and decision making for safety.

## 4.5 CHEMICAL MANAGEMENT PRACTICES DATA ANALYSIS

Each item on Section 3 of the survey questionnaire was scored by giving a value of 5 to the ‘strongly agree’ category, 4 to the ‘agree’ response, 3 to the ‘indifferent or Neutral’ category, 2 to the ‘disagree’ response, and 1 to the ‘strongly disagree’ category. The scores for the negatively worded items in the questionnaire were reversed by subtracting the individual item score from 6. The resulting individual scores were then averaged for each item, across the whole group. These average item scores were then used to calculate dimension scores. Chemical Management Practices indicator had 11 items, Emergency Planning 4 items, and Chemical Safety Records Management indicator had 4 items. Because these indicators had unequal number of items, the scores needed to be standardised before plotting and comparing these dimensions. The scores were converted to a 1 to 10 scale for standardization. This was achieved by dividing the average score by the total possible score and then multiplying by 10.

### 4.5.1 Behavioural Results for the Five Departments

Tables and graphs were used to show the responses to each of the behaviour indicators as they were measured for each of the five departments. The tables shows the indicator scores for each department assessed and the resulting scores are plotted on a bar graph to show the positive and negative responses in each of the indicators. This information simply illustrates a picture of the overall levels of positive and negative safety perceptions. Tables 4.14 to 4.18 show how the indicator scores were calculated from the questionnaire items, for each of the three dimensions and the final score for each safety dimension for all the five departments. Figures 4.22 to 4.26 show graphical representations of the levels of employees’ behaviours as they perceive in each of the five departments. The tables and graphs are provided and discussed in below for each department.

## ***BEHAVIOURAL RESULTS FOR DEPARTMENT 1***

To calculate of the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.14 below.

**Table 4.14: Calculating Behavioural Indicator Scores for Department 1**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Chemical Management Practices** | Item 1 + Item 2 + Item 3 + Item 4 + (6 - Item 5) + Item 6 + Item 7 + Item 8 + Item 9 + Item 10 + Item 11 | 55 | 10 | 6.2 |
| **Emergency Planning** | Item 12 + Item 13 + Item 14 + Item 15 | 20 | 10 | 6.6 |
| **Chemical Safety Records Management** | Item 16 + Item 17 + Item 18 + Item 19 | 20 | 10 | 4.6 |

The resulting final scores were used to plot the bar graph (Figure 4.22) to illustrate the overall safety behaviour for Department 1. Lower scores (below 5) represent safe behaviours and higher scores (above 5) represent unsafe behaviours.

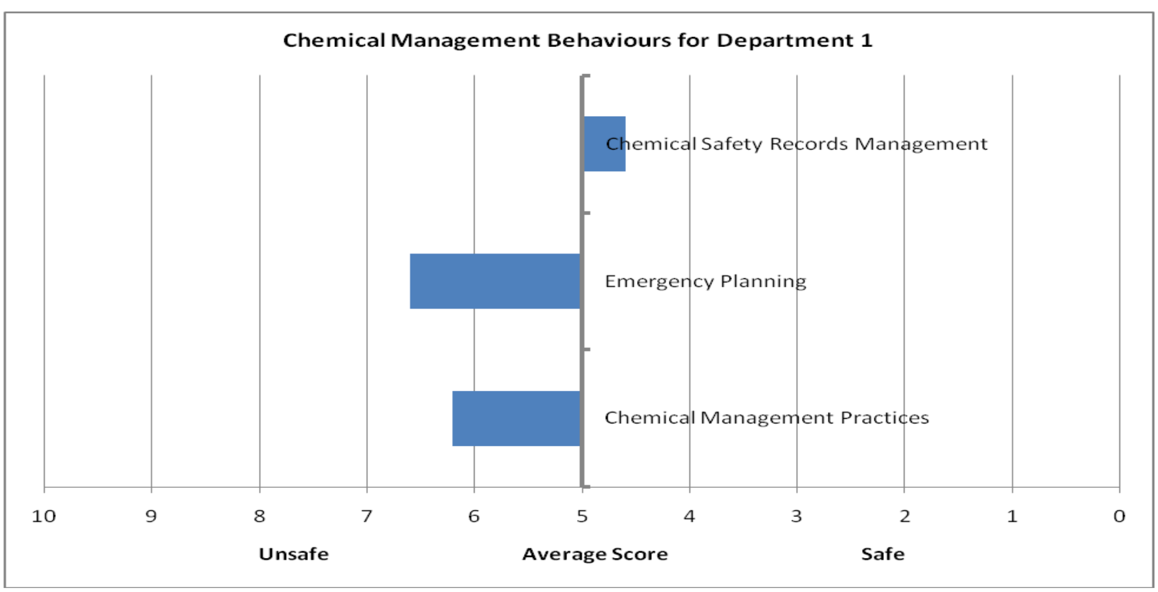


**Figure 4.22: Chemical management behaviour safety level for Department 1**

For Department 1, Behaviours in terms of Chemical management practices is rated moderately negative, Chemical Safety Records Management is rated slightly positive, and Emergency Planning is rated considerably negative. The above results show that employees' behaviours toward chemical management practices and emergency planning is generally unsafe. The unsafe behaviour for emergency planning may be an indication that the work areas are not equipped with emergency equipment, employees are unfamiliar with the locations of the emergency equipment, or employees have not been trained in the use of the emergency equipment. The unsafe Chemical Management Procedure may be an indication that chemical procurement, distribution, handling, and storage is conducted in a sound/prudent manner. The slighly positive results obtained for chemical records managemnt might be an indication that safety information and records are managed in a fairly good manner.

***BEHAVIOURAL RESULTS FOR DEPARTMENT 2***

To calculate of the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.15 below.

**Table 4.15: Calculating Behavioural Indicator Scores for Department 2**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Chemical Management Practices** | Item 1 + Item 2 + Item 3 + Item 4 + (6 - Item 5) + Item 6 + Item 7 + Item 8 + Item 9 + Item 10 + Item 11 | 55 | 10 | 6.8 |
| **Emergency Planning** | Item 12 + Item 13 + Item 14 + Item 15 | 20 | 10 | 8.2 |
| **Chemical Safety Records Management** | Item 16 + Item 17 + Item 18 + Item 19 | 20 | 10 | 4.5 |

The resulting final scores were used to plot the bar graph (Figure 4.23) to illustrate the overall safety behaviour for Department 2. The results obtained bears a resemblance to the results obtained for Department 1. Lower scores (below 5) represent safe behaviours and higher scores (above 5) represent unsafe behaviours.

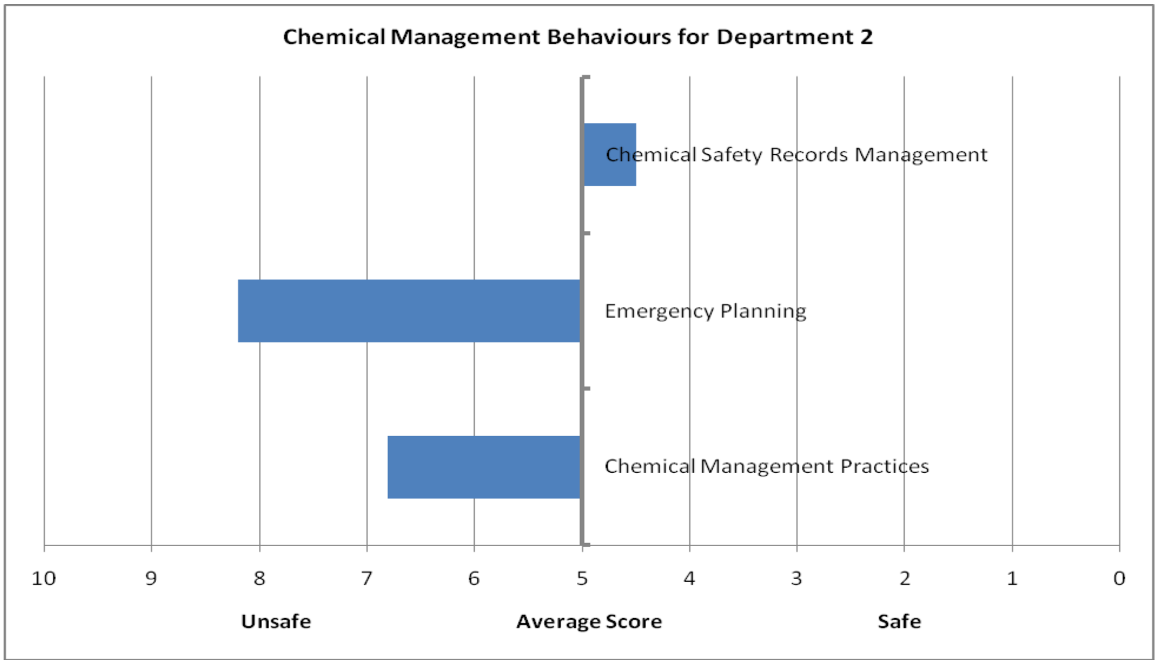


**Figure 4.23: Chemical management behaviour safety level for Department 2**

For Department 2, Behaviours in terms of Chemical management practices is rated moderately negative, Chemical Safety Records Management is rated slightly positive, and Emergency Planning is rated considerably negative. The above results show that employees' behaviours toward chemical management practices and emergency planning is generally unsafe. The unsafe behaviour for emergency planning may be an indication that the work areas are not equipped with emergency equipment, employees are unfamiliar with the locations of the emergency equipment, or employees have not been trained in the use of the emergency equipment. The unsafe Chemical Management Procedure may be an indication that chemical procurement, distribution, handling, and storage is conducted in a sound/prudent manner. The slighly positive results obtained for chemical records managemnt might be an indication that safety information and records are managed in a fairly good manner.

***BEHAVIOURAL RESULTS FOR DEPARTMENT 3***

To calculate of the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.16 below.

**Table 4.16: Calculating Behavioural Indicator Scores for Department 3**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Chemical Management Practices** | Item 1 + Item 2 + Item 3 + Item 4 + (6 - Item 5) + Item 6 + Item 7 + Item 8 + Item 9 + Item 10 + Item 11 | 55 | 10 | 8.4 |
| **Emergency Planning** | Item 12 + Item 13 + Item 14 + Item 15 | 20 | 10 | 7.9 |
| **Chemical Safety Records Management** | Item 16 + Item 17 + Item 18 + Item 19 | 20 | 10 | 7.6 |

The resulting final scores were used to plot the bar graph (Figure 4.24) to illustrate the overall safety behaviour for Department 3. Lower scores (below 5) represent safe behaviours and higher scores (above 5) represent unsafe behaviours.

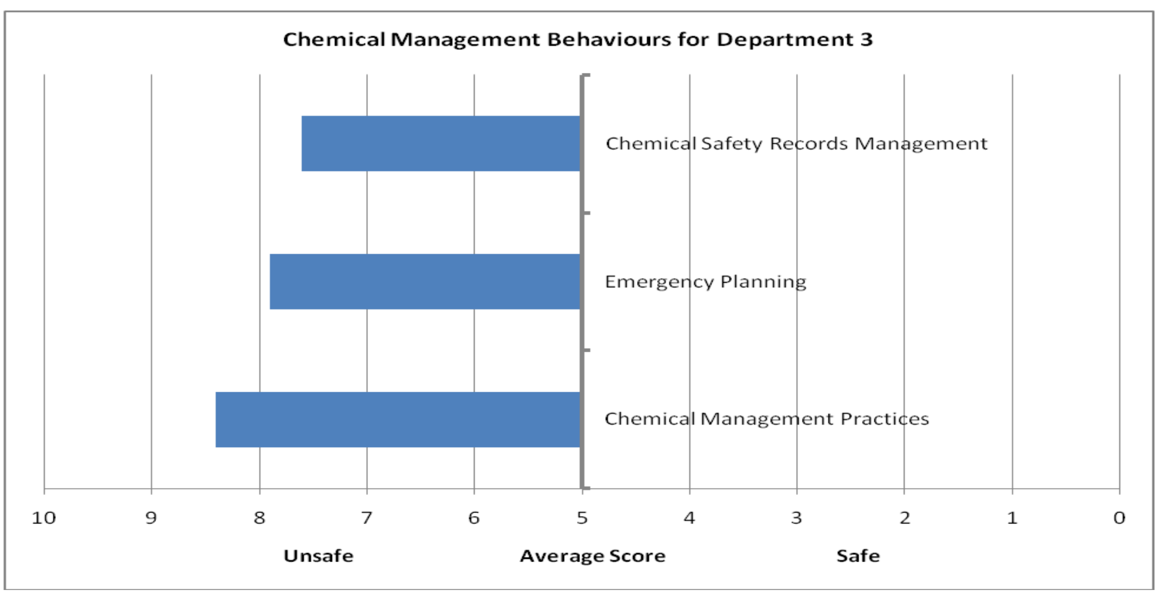


**Figure 4.24: Chemical management behaviour safety level for Department 3**

For Department 3, Behaviours in terms of Chemical management practices, Chemical Safety Records Management, and Emergency Planning are unsafe.

For Department 3, all the behavioural indicators have rated considerably negative. The above results show that employees' behaviours toward chemical management practices and emergency planning is generally unsafe. The unsafe behaviour for emergency planning may be an indication that the work areas are not equipped with emergency equipment, employees are unfamiliar with the locations of the emergency equipment, or employees have not been trained in the use of the emergency equipment. The unsafe Chemical Management Procedures may be an indication that chemical procurement, distribution, handling, and storage is conducted in a sound/prudent manner. The negative results obtained for chemical records managemnt might be an indication that there is no chemical safety information on that is properly managed or readily.

***<u>BEHAVIOURAL RESULTS FOR DEPARTMENT 4</u>***

To calculate of the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.17 below.

**Table 4.17: Calculating Behavioural Indicator Scores for Department 4**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Chemical Management Practices** | Item 1 + Item 2 + Item 3 + Item 4 + (6 - Item 5) + Item 6 + Item 7 + Item 8 + Item 9 + Item 10 + Item 11 | 55 | 10 | 6.1 |
| **Emergency Planning** | Item 12 + Item 13 + Item 14 + Item 15 | 20 | 10 | 7.7 |
| **Chemical Safety Records Management** | Item 16 + Item 17 + Item 18 + Item 19 | 20 | 10 | 5.2 |

The resulting final scores were used to plot the bar graph (Figure 4.25) to illustrate the overall safety behaviour for Department 4. Lower scores (below 5) represent safe behaviours and higher scores (above 5) represent unsafe behaviours.

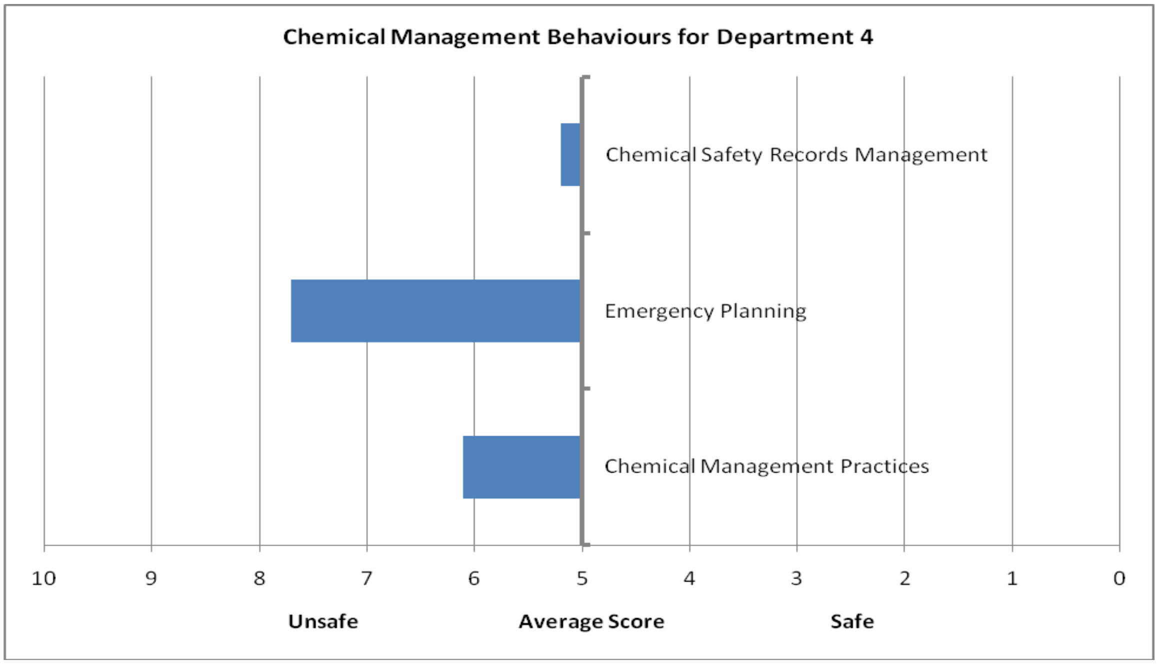


**Figure 4.25: Chemical management behaviour safety level for Department 4**

For Department 4, Behaviours in terms of Chemical management practices is rated moderately negative, Chemical Safety Records Management is rated slightly negative, and Emergency Planning is rated considerably negative. The above results show that employees' behaviours toward chemical management practices and emergency planning is generally unsafe. The unsafe behaviour for emergency planning may be an indication that the work areas are not equipped with emergency equipment, employees are unfamiliar with the locations of the emergency equipment, or employees have not been trained in the use of the emergency equipment. The unsafe Chemical Management Procedure may be an indication that chemical procurement, distribution, handling, and storage is conducted in a sound/prudent manner. The slighly negative results obtained for chemical records managemnt might be an indication that some information might be available to a little extent.

***BEHAVIOURAL RESULTS FOR DEPARTMENT 5***

To calculate of the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.18 below.

**Table 4.18: Calculating Behavioural Indicator Scores for Department 5**

| DIMENSION | ADD | DIVIDE BY | MULTIPLY BY | FINAL SCORE |
|---|---|---|---|---|
| **Chemical Management Practices** | Item 1 + Item 2 + Item 3 + Item 4 + (6 - Item 5) + Item 6 + Item 7 + Item 8 + Item 9 + Item 10 + Item 11 | 55 | 10 | 5.6 |
| **Emergency Planning** | Item 12 + Item 13 + Item 14 + Item 15 | 20 | 10 | 6.8 |
| **Chemical Safety Records Management** | Item 16 + Item 17 + Item 18 + Item 19 | 20 | 10 | 5.2 |

The resulting final scores were used to plot the bar graph (Figure 4.26) to illustrate the overall safety behaviour for Department 5. Lower scores (below 5) represent safe behaviours and higher scores (above 5) represent unsafe behaviours.

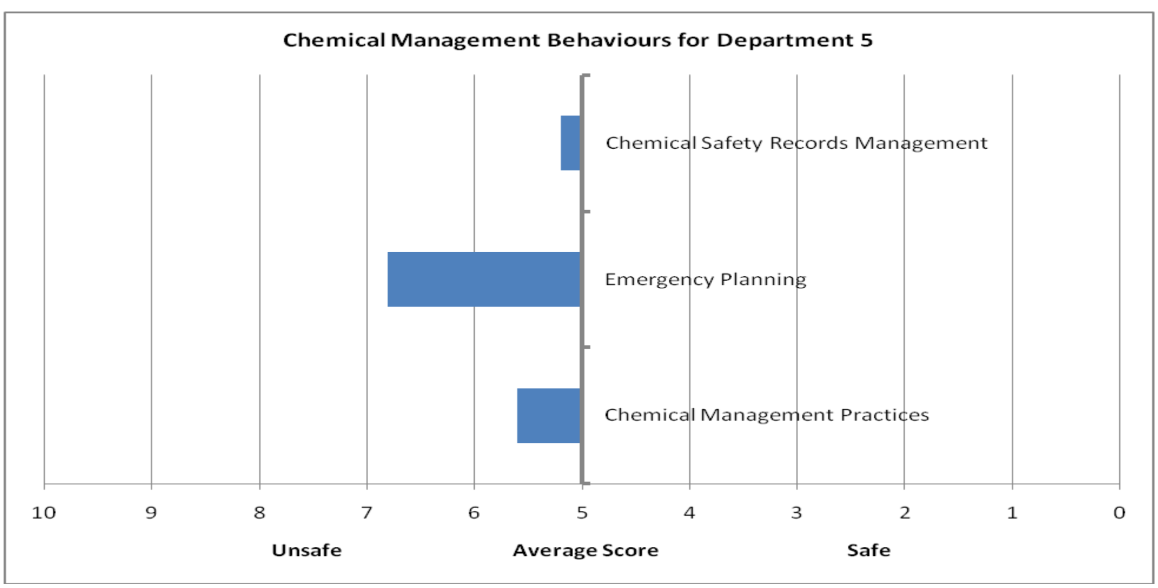


**Figure 4.26: Chemical management safety behaviour level for Department 5**

For Department 5, Behaviours in terms of Chemical management practices is rated moderately negative, Chemical Safety Records Management is rated slightly negative, and Emergency Planning is rated considerably negative. The above results show that employees' behaviours toward chemical management practices and emergency planning is generally unsafe. The unsafe behaviour for emergency planning may be an indication that the work areas are not equipped with emergency equipment, employees are unfamiliar with the locations of the emergency equipment, or employees have not been trained in the use of the emergency equipment. The unsafe Chemical Management Procedure may be an indication that chemical procurement, distribution, handling, and storage is conducted in a sound/prudent manner. The slighly negative results obtained for chemical records managemnt might be an indication that some information might be available to a little extent. The results are similar to the ones obtained for Department 1.

***<u>BEHAVIOURAL RESULTS FOR ALL DEPARTMENTS</u>***

To calculate of the final score for each safety dimension, the method outlined in Section 3.8.1 was used. This is summarized in Table 4.19 below.

**Table 4.19: Comparative Behavioural Indicators Scores between the Five Departments**

| | SAFETY CLIMATE SCORE | | | | |
|---|---|---|---|---|---|
| **DIMENSION** | **DEPT. 1** | **DEPT. 2** | **DEPT. 3** | **DEPT. 4** | **DEPT. 5** |
| Chemical Management Practices | 6.2 | 6.8 | 8.4 | 6.1 | 5.6 |
| Emergency Planning | 6.6 | 8.2 | 7.9 | 7.7 | 6.8 |
| Chemical Safety Records Management | 4.6 | 4.5 | 7.6 | 5.2 | 5.2 |

The results shows that there is some similarities exhibited in the levels of safe and undafe behaviours between departments 4 and 5, and between departments 1 and 2.  Department 3 shows extremely negative results on all indicators.

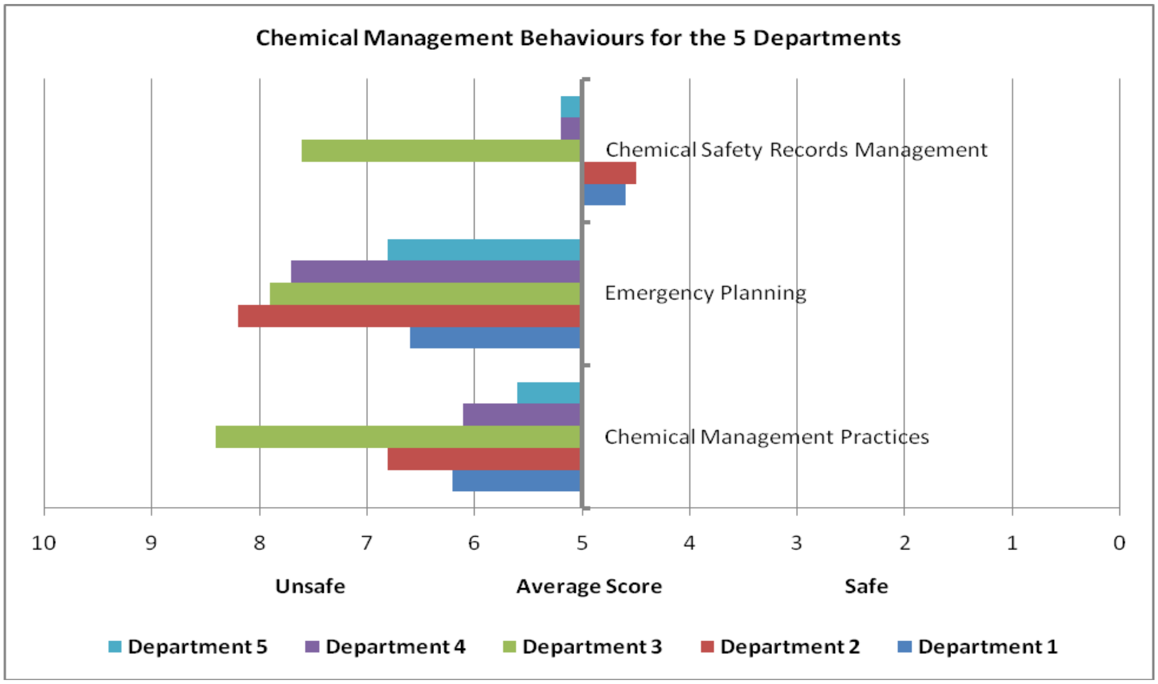


**Figure 4.27: Overall chemical management behaviour safety level**

***RESULTS SUMMARY OF THE BEHAVIOURAL ASSESSMENT FOR THE FIVE DEPARTMENTS***

The table below shows a safety behaviour assessment matrix completed using the results for all the five departments. The table gives an illustration of the safe behaviours (strengths) and the unsafe behaviours (weaknesses) in each of the safety behaviour indicator.

**Table 4.20: Summary of Chemical Mangement Behaviors**

| | **Chemical Management Practices** | **Emergency Planning** | **Chemical Safety Information Management** |
|---|---|---|---|
| **Department 1** | *Unsafe* | *Unsafe* | *Safe* |
| **Department 2** | *Unsafe* | *Unsafe* | *Safe* |
| **Department 3** | *Unsafe* | *Unsafe* | *Unsafe* |
| **Department 4** | *Unsafe* | *Unsafe* | *Unsafe* |
| **Department 5** | *Unsafe* | *Unsafe* | *Unsafe* |

There is consistency with regard to Chemical Management Practices and Emergency Planning for all the five departments. The above results show that employees' behaviours toward chemical management practices and emergency planning is generally unsafe. The unsafe behaviour for emergency planning may be an indication that the work areas are not equipped with emergency equipment, employees are unfamiliar with the locations of the emergency equipment, or employees have not been trained in the use of the emergency equipment. The unsafe Chemical Management Procedure may be an indication that chemical procurement, distribution, handling, and storage is conducted in a sound/prudent manner.

These results are in agreement with the 'Supportive Environment' safety climate measure, were eighty percent (80%) of the departments had a negative attitude towards. giving an indication that the nature of the social environment that does not encourage safe working practices. This usually results when management and supervisors do not encourage a safe working practice/environment amongst employees due to factors such as the unavailability and maintenance of safety equipment; the unavailability of safety instructions; and the lack of procedural safety information. This probably means that, even though employees value their personal safety and have a high need to feel safe as measured by the safety climate measure ‘Personal Priorities and Need for Safety’, they are discouraged and driven to unsafe behaviours by unsupportive environment and management’s lack of commitment towards safety.

In terms of safety information management activities, the results do not show any consistent trend. Safety information management behaviours rated safe for Department 1 and Department 2. This means that sources of information for chemical safety and chemical incidents are kept and maitained in these two departments. This type of information is useful in ensuring employee safety when hazardous materials are stored or used in the workplace. Responses from these two departments contradict the safety climate indication of insufficient communication about safety issues amongst employees at various levels and the poor quality of communication within the organisation and between divisions concerning safety initiatives.

The reason for this type of outcome could be attributed to the fact that there is a high level of risks associated with operations carried out in departments and the physical work environment within those departments is viewed as highly unsafe. Another reason could be that because employees hold positive attitudes for Safety Rules and Procedures, they are merely abiding by the rules and procedures to manage the chemical safety information and records.

## 4.5 OBSERVATIONAL DATA ANALYSIS

Observational data was collected from direct observation of individual behaviour using a behavioural checklist (Appendix C). Six (6) behavioural indicators were developed and used in a checklist. Behavioural indicators refer to a set of performance indicators which give some idea of how the organisation is behaving. The behavioural indicators used in this study included Housekeeping, Personal Protective equipment, Chemical and Gas cylinder Storage, Signs and Labels, Chemical waste handling, and Emergency safety equipment.

It is not important to measure behaviours as it is assumed that attitudes measured through survey are enacted as behaviours. The behavioural indicators of safety climate will not only augment the overall picture built up by the safety climate measures described in Section 4.4. They will also help in identifying the major factors in chemical management as well as providing another avenue for continuous improvement.

Observations were conducted in Department 1 only due to time limitations. Behavioural indicators in Department 1 environments was derived from Direct Observation of safe and unsafe acts regarding chemicals management using a behavioural checklist for critical tasks. The indicators included and the results from observations are shown in the Table 4.21.

The housekeeping in Department 1 was evaluated as unsafe because chemical odours are detected as one enters the building. Laboratory workers use noxious-smelling chemicals on the bench top. Chemical spills a left unattended on floors and bench tops. Employees were observed working with chemicals without wearing appropriate PPE. Though they had their laboratory coats on, they did not put their safety goggles, safety gloves and protective shoes while working with dangerous chemicals. In some instances the laboratory coats were not fastened.

**Table 4.21: The outcomes for observation of Department 1**

| TASKS | BEHAVIOUR | SAFE | UNSAFE | NOT SEEN |
|---|---|---|---|---|
| Housekeeping | Chemical storerooms, Laboratories and chemical preparation rooms are kept Clean | | *Unsafe* | |
| Personal Protective equipment | Employees wear appropriate PPE when carrying out tasks (i.e. safety goggles, laboratory coats, gloves and safety shoes) | | *Unsafe* | |
| Chemical and Gas cylinder Storage | Chemicals are stored under safe conditions, in properly labelled containers, appropriate to their properties | | *Unsafe* | |
| | Cylinders securely fastened to the wall or other supportive device | | *Unsafe* | |
| Signs and Labels | Safety Shower, eyewash station, fire extinguisher, and fire blanket in labs are clearly visible and marked with signs | | *Unsafe* | |
| | Secondary chemical containers properly labelled | *Safe* | | |
| Chemical waste handling | Chemical waste are handled of in an environmentally friendly manner | | *Unsafe* | |
| Emergency safety equipment | Dates of inspections of the fire extinguisher, safety shower and eyewash station are recorded | *Safe* | | |

The conditions under which chemicals are stored is not safe in that they are placed in alphabetical order without any consideration of chemical compatibility.

Some chemicals are randomly stored in the laboratory cupboards. Some chemicals stored in the storeroom are not properly labelled as the labels or containers are corroded. It looked like some of the chemicals have long been standing on the shelves, which contributed accumulation of expired chemicals and gives an indication of poor chemical inventory management. Secondary chemical containers of prepared solutions were properly labelled as to their contents on white stickers. Gas cylinders (filled and empty) are not securely fastened to the wall or other supportive device. Some cylinders are freely standing in the laboratories and in the passages.

Safety Showers are not marked with signs. Eyewash kits are shelved in the offices and not in areas where chemicals are kept. There are no signs marking areas where fire extinguishers are. Fire blanket were not observed. Chemical waste generated in the laboratories is not handled in an environmentally friendly way. The Waste disposal procedures must also comply with the environmental management legislations. In Department 1 employees pour the chemical waste down the drain. There was an accumulation of unlabelled containers of chemical waste. Dates of inspections of the fire extinguisher were observed, dates of inspections of the safety shower and eyewash station were not observed.

***RESULTS SUMMARY OF THE DIRECT OBSERVATION OF THE DEPARTMENT 1***

Table 4.22 below, shows a safety behaviour assessment matrix completed using the results for all the five departments. The table gives an illustration of the safe behaviours (strengths) and the unsafe behaviours (weaknesses) in each of the safety behaviour indicator and compares them with the results obtained through the survey questionnaire.

**Table 4.22: Comparison of Behavioural Dimension Observation Results and Safety Climate Survey Measurement Results**

| BEHAVIORAL MEASUREMENTS | | SAFETY CLIMATE MEASUREMENTS | |
|---|---|---|---|
| **Housekeeping** | *Unsafe* | *Negative* | **Work Environment (Section 1, Items 24 - 26)** |
| **Personal Protective equipment** | *Unsafe* | *Negative* | **Personal Appreciation of Risk (Section 1, Items 21 - 23)** |
| **Chemical and Gas cylinder Storage** | *Unsafe* | *Negative* | **Chemical Management Practices (Section 2, Items 1 - 11)** |
| **Signs and Labels** | *Safe* | *Positive* | **Chemical Safety Information (Section 2, Items 16 - 9)** |
| **Chemical waste handling** | *Unsafe* | *Negative* | **Chemical Management Practices (Section 2, Items 1 - 11)** |
| **Emergency safety equipment** | *Safe* | *Negative* | **Emergency Planning (Section 2, Items 12 – 15)** |

The above table illustrates the behavioural measurements positively validated against safety attitudes measures. All the dimensions measured through observations agree with the dimensions measured through the safety climate survey questionnaire, with the exception of emergency safety equipment / emergency planning dimension.

## 4.6 SUMMARY

As shown in Table 10, the five departments are generally consistent with the perceptions they hold for safety. All the departments have negative perceptions towards Management commitment, Communication, Priority for Safety, Personal Appreciation of Risk and the Physical Work Environment. This implies that all of the five departments have a high level of risks associated with the operations carried out in those departments and the physical work environment within those departments is viewed as highly unsafe. These responses also give an indication that communication about safety issues amongst employees at various levels is insufficient and that the quality of communication within the organisation and between divisions concerning safety initiatives is poor. Management is not committed to addressing safety concerns. All five department also showed consistencies in terms of the attitudes held for Safety Rules and Procedures as well as Personal Priorities and Need for Safety. These attitudes are positive for all the departments, which imply that employees are aware of safety rules and procedures at work and are willing to act in a safe manner. This also implies that individual employees need to feel safe in their work areas and view their personal safety as highly important.

In terms of Supportive Environment, only one department had a slightly positive perception. Eighty percent (80%) of the departments showed negative attitudes toward Supportive Environment, which gives an indication that the nature of the social environment at work does not encourage safe working practices. This probably means that management and supervisors are not encouraging a safe working practice/environment amongst employees which could be attributed to factors such as the unavailability and maintenance of safety equipment; the unavailability of safety instructions; and the lack of procedural safety information. In terms of Involvement, two departments had a moderately to slightly positive perception. Sixty percent (60%) of the department showed a negative attitude towards Involvement, which gives an indication that employees are generally not involved in safety issues and that employees are not encouraged to take responsibility for safety within the organisation. This indicates that managers and supervisors probably exclude employees in decision making for safety management.

Behavioural/observations measurements positively validated against safety attitudes measures (survey questionnaire). All the dimensions measured through observations agree with the dimensions measured through the safety climate survey questionnaire, with the exception of emergency safety equipment / emergency planning dimension. Safety attitude as displayed in the different department are consistent with the unsafe behaviours of employees within those departments. This concurs with the theory of attitudes and behaviours which predicts that attitudes predict/determine behaviours. If employees hold negative attitudes towards safety they are deemed to behave in an unsafe manner. The generally negative scores indicates that employees often fail to take into consideration the safety of themselves and others when carrying out activities at work; and that even when employees are generally aware of the safety rules and procedures and value their own safety, they do not abide by those safety rules. Management is not putting much priority to safety issues and safety communication within the departments is insufficient. The physical work environment requires some improvement to make it safer.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 INTRODUCTION

A review of literature on chemicals management, safety management and safety climate in Chapter 2 provided a framework for the research methods in Chapter 3. Chapter 4 presented the analysis of the data and the results in detail. This chapter (Chapter 5) outlines the findings from the research. It begins by summarizing the key outputs of the work presented in each chapter. It then outlines the implications of the work for the academic departments and also suggests a number of possible directions for future research.

## 5.2 CONCLUSIONS

The main aim of this study was to explore safety attitudes and perceptions, and their contribution to the management of chemical operations within a university department. Three central research questions have been asked about the perceptions and attitudes of employees towards chemical safety within a university department, the chemicals management practices within the department, and the contribution of employees' safety attitudes towards chemicals management practices. To answer those questions, several objectives were identified as important and listed in Chapter 1.

The objectives have successfully been achieved. Chapter 2 presented a review of literature on sound/prudent management of chemicals. Chapter 4 presented the results of all the data analysis so as to achieve the rest of the objectives. A safety climate measure questionnaire was administered in order to investigate employees' perceptions and attitudes regarding chemical safety, and their awareness of the hazards and risks associated with chemicals used in the workplace and also to investigate the current chemical management practices. The results revealed that employees had good degree risk awareness and a relatively high degree of safety awareness. The results also revealed that employees chemical management practices is influenced by their perception of risk. Observations were conducted to validate the behaviours questionnaire.

In conclusion, it can be stated that, *"safety is attitude and can be affected by many things which influence a person's behavior".* The safety of the workplace is influenced by a number of factors such as the organisational environment, management attitude and commitment, the nature of the job or task, and the personal attributes of the individual. Workers' safety climate assessed with the questionnaire developed in this study turned out to be significantly associated with chemical management behaviours. There are no significant variations between groups.

There are a number of important considerations which are apparent from this study in regard to safety climate. To create and maintain an effective safety climate, it is important to ensure that employees have access to relevant safety information and have sufficient opportunity to voice their safety concerns. There also appears to be a corollary between the recognised effective elements of a safety management program and safety culture. In short, a well designed safety management program is the process by which a positive safety climate may be fostered.

## 5.3 RECOMMENDATIONS

The results of the survey identified areas in which employees' attitudes towards were not positive. Some groups gave an indication that the organisation's general approach to safety is ineffective and that communication between themselves and their Managers/Supervisors is insufficient. Some groups also indicated that the physical working environment (including maintenance, equipment etc.) does not support the safety. This type of results gives decision-makers within the departments the opportunity for safety climate and behaviours improvements. The recommendations provided focus on specific issues and findings in the survey in no order of priority.

The following are recommendations to consider when working towards improving the safety climate in the academic departments:

1. Increase employee participation in safety initiatives to increase ownership and encourage more personal responsibility
2. Introducing more safety training for employees to ensure competence in safety related issues.
3. Implement and encourage employee input on safety initiatives to increase their ownership and feeling of involvement in the process, and encourage feedback from all employees on workplace safety.
4. Encourage Management to set an example in safety initiatives and ensure that safety rules and procedures are enforced.
5. Ensure that Managers and Supervisors are effectively communicating safety initiatives and are encouraging feedback. It may be that the initiatives do exist and could be effective but are not readily seen by other employees.
6. Ensure safety equipment is supplied and maintained regularly, that safety instructions are readily available and that the work environment is continually monitored for safety. This may be particularly important for high risk positions departments (such as Departments 1 and 3).

## 5.4 LIMITATIONS

The researcher accepts that the current study is far from conclusive, but it does show quite clearly that the perceptions of safety climate are associated with chemical management behaviours for this study. Nevertheless, it is still recognised that this study is not without its limitations. There are several limitations associated with this research.

The first limitation of this study is the timeframe for completion. The scope of the research was very wide. Studying safety climate and chemicals management behaviours was a demanding task. This type of research is highly complex and requires several studies because in one study only some results can be obtained. The validation of results is important so that it can be determined whether the results are in line with other studies in the field. The second limitation is that the research used a case study (whole population in one department) and a purposively selected samples of a population four other departments. The problem with this approach is that selection of the samples in the four departments influences the results somehow. It is difficult to say whether the samples represent their respective departments.

The third limitation is that this study only addressed the behavioural variables within the workplace and the researcher acknowledges that management systems will undoubtedly impact on both behavioural aspects and perceptions of safety climate. The fourth limitation is that the study was designed to use self-reported questionnaires in order to record perceptions of safety climate and chemicals management behaviours. It is acknowledged that the use of self-reported measures may result in biased responses especially when they are made anonymously.

## 5.5 SUGGESTIONS FOR FURTHER RESEARCH

The findings reported in this study represent an exploratory analysis of the data collected. As a result, a number of research avenues remain open for investigation. This study focused on the safety climate and the behavioural aspects of chemicals management. It would be valuable to explore the safety management systems and whether they had any influence on safety climate and safety behaviours. This line of enquiry may have implications for the strategies used in the development and implementation of safety policies, safety systems and processes, safety structures, and safety reports.

Further research can be recommended on safety climate measurements that would include employees at various levels of management for their safety attitudes and perceptions and then compare the results of perceptions and attitudes of employees at operational level. Another approach would be a study that concentrated on an entire organization over a long period of time. This would be useful in respect to following the progress of various organizational changes over time and sampling their affect on safety behaviours and safety climate.

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# APPENDICES

## APPENDIX A: SURVEY QUESTIONNAIRE

# MANAGING CHEMICALS AT THE UNIVERSITY OF LIMPOPO:

# A SAFETY PERSPECTIVE

**SURVEY QUESTIONNAIRE**

**November 2008**

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*University Department*

*Chemical Safety Management Survey*

*November 2008*

Dear Respondent,

I am currently studying for a Masters Degree in Business Administration (MBA), at the University of Limpopo. As part of my completion it is required of me to do research on any business or management issue. I have chosen to focus on management practices and staff perceptions on chemical safety in an academic department. Part of this analysis involves the completion of a questionnaire by employees in a university department. By completing this questionnaire, you will thus have the opportunity to tell what you think of chemical safety and management practices in your work area.

Please answer all of the questions as honestly as possible. The questionnaire is anonymous and so please do not write your name anywhere on it. I am interested in broad trends of opinions and not in individual replies. The data collected as part of this research will be used for academic purposes only. No personal details will be disclosed to anyone and the information that you supply will in no way be linked to you or your department.

I would be grateful if you could set aside a few minutes of your time to complete the questionnaire. Your participation is voluntary. Should you wish not to answer any specific question, please feel free to leave that question blank. I would like to encourage you though to answer all questions as this will assist me in obtaining a more representative sample. Should you have any questions or need some more clarification, you can contact me on 082 776 2896

I wish to thank you in advance for your participation.

________________________

PO Thivhafuni

## SAFETY QUESTIONNAIRE

The questionnaire three sections: Sample Profile (biographical details), Safety Climate and Chemical Management Operation/Behaviour.

### 1. PROFILE OF THE SAMPLE

This section (**SECTION 1**) is designed to determine the profile of the respondents being surveyed. This approach will assist in determining whether the sample is representative of the department and to determine any correlations between the profile and the other dimensions.

***Indicate your response to the questions in Section 1 by marking a cross 'x' in the box adjacent to your reply.***

### 2. SAFETY CLIMATE AND SAFE BEHAVIOUR MEASUREMENT

**SECTIONS 2 and 3** are designed to measure safety climate, based on the safety attitude dimensions, and behavioural aspects of safety based on the chemical management operations, respectively. These measures give some indication of how people view their work and work environments, value safer working practices, and the extent to which they work safely or unsafely; that is, to what degree certain views and beliefs are shared among the workforce.

***Indicate your level of agreement or disagreement with each of the statements in SECTIONS 2 and 3. Respond to the statements in by marking a cross 'X' in the box below your chosen response. For example, if you agreed with the following statement you would tick under the 'Agree' category, thus:***

| | Strongly Agree | Agree | Indifferent | Disagree | Strongly Disagree | Don't Know |
|---|---|---|---|---|---|---|
| 1. Identified safety concerns are addressed in a timely manner | | x | | | | |

## SECTION 1: SAMPLE PROFILE

***Please indicate your response to the following questions by marking a cross 'x' in the box adjacent to your reply. Mark one box only for each question***

1. What is your gender?

☐ Female ☐ Male

2. What is your age?

☐ Below 30 ☐ 30 to 34
☐ 35 to 39 ☐ 40 to 44
☐ 45 or above

3. How long have you been working for this department?

☐ Less than 1 year ☐ 1 to 2 years
☐ 3 to 7 years ☐ 8 to 12 years
☐ 13 to 20 years ☐ 21 years or over

4. What is your present job title?

☐ Management (Head of Department / Director of School)
☐ Senior Lecturer
☐ Junior Lecturer
☐ Principal Laboratory Technician
☐ Chief Laboratory Technician
☐ Senior Laboratory Technician / Assistant
☐ Laboratory Technician / Assistant
☐ Other, please specify: ________________________

5. How long have you been working in your current position?

☐ Less than 1 year ☐ 1 to 2 years
☐ 3 to 7 years ☐ 8 to 12 years
☐ 13 to 20 years ☐ 21 years or over

6. Have you experienced a chemical accident in your work area?

☐ Yes ☐ No

7. Have you received any chemical safety training?

☐ Yes ☐ No

## SECTION 2: SAFETY CLIMATE QUESTIONNAIRE

***Please mark your chosen response to each of the following statements by marking a cross 'x' in the box adjacent to your reply. Please mark only one box for each reply.***

| STATEMENTS | Strongly Agree | Agree | Indifferent / Neutral | Disagree | Strongly Disagree | Don't Know / (N/A) |
|---|---|---|---|---|---|---|
| 1. Management acts decisively when a safety concern has been raised | | | | | | |
| 2. In my workplace management acts quickly to correct safety problems | | | | | | |
| 3. Managers and supervisors express concern if safety procedures are not adhered to | | | | | | |
| 4. Safety information is always brought to my attention by my manager | | | | | | |
| 5. There is good communication here about safety issues which affect me | | | | | | |
| 6. Management operates an open door policy on safety issues | | | | | | |
| 7. Management clearly considers the safety of employees of great importance | | | | | | |
| 8. I believe safety issues are assigned a high priority | | | | | | |
| 9. Safety rules and procedures are carefully followed | | | | | | |
| 10. Some safety rules and procedures do not need to be followed to get the job done safely | | | | | | |
| 11. Some safety rules are not really practical | | | | | | |
| 12. Employees are not encouraged to raise safety concerns | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. When people ignore safety procedures, I feel it is none of my business | | | | | | |
| 14. I am strongly encouraged to report unsafe conditions | | | | | | |
| 15. I am involved in informing management of important safety issues | | | | | | |
| 16. I am involved with safety issues at work | | | | | | |
| 17. I am never involved in the ongoing review of safety | | | | | | |
| 18. Safety is the number one priority in my mind when completing a job | | | | | | |
| 19. I feel that safety issues are not the most important aspect of my job | | | | | | |
| 20. A safe place to work has a lot of personal meaning to me | | | | | | |
| 21. I am sure it is only a matter of time before I am involved in an accident | | | | | | |
| 22. In my workplace the chances of being involved in an accident are quite high | | | | | | |
| 23. I am clear about what my responsibilities are for health and safety | | | | | | |
| 24. I cannot always get the equipment I need to do the job safely | | | | | | |
| 25. Sometimes conditions here hinder my ability to work safely | | | | | | |
| 26. Sometimes I am not given enough time to get the job done safely | | | | | | |

## SECTION 3: CHEMICAL OPERATIONS QUESTIONNAIRE

***Please mark your chosen response to each of the following statements by marking a cross 'x' in the box adjacent to your reply. Please mark only one box for each reply.***

| STATEMENTS | Strongly Agree | Agree | Indifferent / Neutral | Disagree | Strongly Disagree | Don't Know / (N/A) |
|---|---|---|---|---|---|---|
| 1. The department implements management procedures to ensure safe handling and storage of chemicals | | | | | | |
| 2. Personnel are trained for handling and use of chemicals | | | | | | |
| 3. The chemical inventory inspection is conducted regularly | | | | | | |
| 4. Less hazardous or environmentally friendly chemical substitutions are considered when purchasing chemicals | | | | | | |
| 5. Chemicals are purchased in bulk | | | | | | |
| 6. The department keeps an updated inventory list of the chemicals used and stored | | | | | | |
| 7. The department has a designated chemical storage area | | | | | | |
| 8. The chemical storeroom is identified with a sign as a chemical storeroom | | | | | | |
| 9. The storeroom is kept under lock and key, and is entered by authorized personnel only | | | | | | |
| 10. The chemical storeroom has shelving units fastened to the wall or floor | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 11. Chemicals are stored based on compatibility and not in alphabetical or random order | | | | | | |
| 12. First aid supplies are available in each room where chemicals are used or stored | | | | | | |
| 13. Fire extinguishers are available at appropriate areas in the department | | | | | | |
| 14. Employees are trained in how to utilize fire extinguishers | | | | | | |
| 15. Emergency telephone numbers are posted in each room where chemicals are used or stored | | | | | | |
| 16. Stored chemicals are clearly identified by the label as to their contents | | | | | | |
| 17. The labels are readable and tightly secured onto all chemical containers | | | | | | |
| 18. Material Safety Data Sheets (MSDS) are readily available for all chemicals used | | | | | | |
| 19. Records of all incidents involving chemicals are collected and maintained | | | | | | |

***Thank you for completing the survey. Your time and participation are greatly appreciated.***

## APPENDIX B: BEHAVIOURAL CHECKLIST

| TASKS | BEHAVIOUR | SAFE | UNSAFE | NOT SEEN |
|---|---|---|---|---|
| Housekeeping | Chemical storerooms, Laboratories and chemical preparation rooms are kept Clean | | | |
| Personal Protective equipment | Employees wear appropriate PPE when carrying out tasks (i.e. safety goggles, laboratory coats, gloves and safety boots) | | | |
| Chemical and Gas cylinder Storage | Chemicals are stored under safe conditions, in properly labelled containers, appropriate to their properties | | | |
| | Cylinders securely fastened to the wall or other supportive device | | | |
| Signs and Labels | Safety Shower, eyewash station, fire extinguisher, and fire blanket in labs clearly visible and marked with signs | | | |
| | Secondary containers properly labelled | | | |
| Chemical waste handling | Chemical waste are handled of in an environmentally friendly manner | | | |
| Emergency safety equipment | Dates of inspections of the fire extinguisher, safety shower and eyewash station are recorded | | | |

## APPENDIX C: INDIVIDUALS' SCORES FOR SAFETY CLIMATE DIMENSIONS

| **Statement** | **Individuals' Scores** | | | | | | | | | | | | | | | | | | | | | | | | | **Avg.** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Management acts decisively when a safety concern has been raised | 5 | 5 | 4 | 4 | 2 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 3 | 5 | 4 | 5 | 5 | 4 | 5 | 3 | 4 | 5 | 0 | 5 | 5 | 4.4 | | |
| 2. In my workplace management acts quickly to correct safety problems | 5 | 4 | 2 | 4 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 3 | 4 | 3 | 5 | 5 | 5 | 4 | 2 | 5 | 4 | 4 | 5 | 4 | 4.2 | | |
| 3. Managers and supervisors express concern if safety procedures are not adhered to | 4 | 2 | 2 | 4 | 4 | 2 | 3 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 2 | 3 | 3 | 2 | 2 | 3 | 3.2 | | |
| **Dimension -Management Commitment Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **11.8** | **7.9** |
| 4. Safety information is always brought to my attention by my line manager | 4 | 2 | 2 | 4 | 4 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 5 | 4 | 4 | 5 | 2 | 3 | 4 | 2 | 3 | 3 | 3.1 | | |
| 5. There is good communication here about safety issues which affect me | 5 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 2 | 5 | 4 | 5 | 5 | 2 | 4 | 4 | 3 | 4 | 4 | 3.8 | | |
| 6. Management operates an open door policy on safety issues | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 5 | 4 | 5 | 5 | 3 | 4 | 4 | 4 | 3 | 4 | 4 | 2 | 4 | 3 | 3 | 4 | 5 | 4.0 | | |
| **Dimension -Communication Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **10.9** | **7.3** |
| 7. Management clearly considers the safety of employees to be of great importance | 4 | 4 | 2 | 2 | 4 | 5 | 4 | 4 | 5 | 3 | 3 | 4 | 3 | 4 | 3 | 5 | 4 | 4 | 5 | 2 | 3 | 3 | 3 | 4 | 4 | 3.6 | | |
| 8. I believe safety issues are assigned a high priority | 5 | 5 | 1 | 4 | 4 | 5 | 5 | 4 | 5 | 4 | 4 | 5 | 1 | 4 | 2 | 5 | 5 | 4 | 4 | 2 | 4 | 3 | 3 | 4 | 5 | 3.9 | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9. Safety rules and procedures are carefully followed | 4 | 4 | 1 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 4 | 2 | 4 | 2 | 4 | 4 | 4 | 5 | 3 | 4 | 4 | 3 | 3 | 3 | 3.4 | | |
| **Dimension -Priority of Safety Total Score** | | | | | | | | | | | | | | | | | | | | | | | | | | | **11.0** | **7.3** |
| 10. Some safety rules and procedures do not need to be followed to get the job done safely | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 4 | 2 | 1 | 4 | 2 | 1 | 2.0 | | |
| 11. Some safety rules are not really practical | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 1 | 3 | 1 | 1 | 1.8 | | |
| 12. Employees are not encouraged to raise safety concerns | 1 | 2 | 4 | 4 | 3 | 4 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 3 | 2 | 2 | 2.1 | | |
| **Dimension - Safety Rules and Procedures Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **5.9** | **3.9** |
| 13. When people ignore safety procedures here, I feel it is none of my business | 4 | 1 | 4 | 4 | 2 | 2 | 3 | 2 | 3 | 3 | 4 | 4 | 1 | 2 | 3 | 1 | 1 | 3 | 1 | 1 | 4 | 2 | 3 | 2 | 3 | 2.5 | | |
| 14. I am strongly encouraged to report unsafe conditions | 4 | 2 | 1 | 2 | 4 | 3 | 2 | 4 | 3 | 4 | 4 | 3 | 2 | 3 | 3 | 4 | 3 | 4 | 4 | 2 | 4 | 3 | 4 | 3 | 3 | 3.1 | | |
| **Dimension - Supportive Environment Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **5.6** | **5.6** |
| 15. I am involved in informing management of important safety issues | 2 | 2 | 1 | 2 | 2 | 5 | 2 | 1 | 2 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2.2 | | |
| 16. I am involved with safety issues at work | 2 | 1 | 1 | 2 | 4 | 2 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 2 | 1 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 2.0 | | |
| 17. I am never involved in the ongoing review of safety | 3 | 1 | 5 | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 5 | 3 | 3 | 3 | 4 | 1 | 2 | 3 | 1 | 2 | 3 | 3 | 4 | 3 | 2 | 3.1 | | |
| **Dimension - Involvement Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **7.6** | **5.0** |
| 18. Safety is the number one priority in my mind when completing a job | 3 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 3 | 2 | 3 | 1 | 2 | 3 | 2 | 1 | 1.9 | | |
| 19. I feel that safety issues are not the most important aspect of my job | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1.3 | | |
| 20. A safe place to work has a lot of personal meaning to me | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1.3 | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dimension - Personal Priorities and Need for Safety Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **4.4** | **3.0** |
| 21. I am sure it is only a matter of time before I am involved in an accident | 5 | 5 | 4 | 2 | 4 | 4 | 4 | 5 | 4 | 5 | 4 | 4 | 1 | 3 | 3 | 5 | 5 | 4 | 5 | 2 | 3 | 3 | 2 | 4 | 5 | 3.8 | | |
| 22. In my workplace the chances of being involved in an accident are quite high | 5 | 5 | 4 | 4 | 3 | 4 | 4 | 5 | 5 | 5 | 4 | 4 | 2 | 4 | 4 | 5 | 5 | 4 | 5 | 2 | 3 | 3 | 2 | 5 | 4 | 4.0 | | |
| 23. I am clear about what my responsibilities are for health and safety | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 4 | 2 | 2 | 2 | 2 | 2 | 2.0 | | |
| **Dimension - Personal Appreciation of Risk Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **9.8** | **6.6** |
| 24. I cannot always get the equipment I need to do the job safely | 4 | 5 | 1 | 4 | 4 | 5 | 4 | 5 | 5 | 4 | 4 | 5 | 3 | 4 | 3 | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 2 | 5 | 5 | 4.2 | | |
| 25. Sometimes conditions here hinder my ability to work safely | 5 | 5 | 1 | 4 | 4 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 3 | 4 | 4 | 5 | 5 | 4 | 5 | 3 | 4 | 5 | 2 | 5 | 5 | 4.3 | | |
| 26. Sometimes I am not given enough time to get the job done safely | 4 | 1 | 1 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 5 | 5 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 1 | 3 | 4 | 2 | 4 | 4 | 3.4 | | |
| **Dimension - Work Environment Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **11.8** | **7.9** |

**DEPARTMENT 5** **DEPARTMENT 4** **DEPARTMENT 3** **DEPARTMENT 2** **DEPARTMENT 1**

## APPENDIX D: SAFETY DIMENSIONS SCORES FOR DEPARTMENT 1

Department 1

| Statement | Individuals' Scores | | | | | | | | | | | | Average | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Management acts decisively when a safety concern has been raised | 5 | 5 | 4 | 4 | 2 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 4.4 | | |
| 2. In my workplace management acts quickly to correct safety problems | 5 | 4 | 2 | 4 | 4 | 5 | 5 | 4 | 5 | 5 | 5 | 4 | 4.3 | | |
| 3. Managers and supervisors express concern if safety procedures are not adhered to | 4 | 2 | 2 | 4 | 4 | 2 | 3 | 3 | 4 | 4 | 3 | 4 | 3.3 | | |
| **Dimension -Management Commitment Total Score:** | | | | | | | | | | | | | | **12** | **8.0** |
| 4. Safety information is always brought to my attention by my line manager | 4 | 2 | 2 | 4 | 4 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2.9 | | |
| 5. There is good communication here about safety issues which affect me | 5 | 4 | 1 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3.8 | | |
| 6. Management operates an open door policy on safety issues | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 5 | 4 | 5 | 5 | 4.5 | | |
| **Dimension -Communication Total Score:** | | | | | | | | | | | | | | **11.25** | **7.5** |
| 7. Management clearly considers the safety of employees to be of great importance | 4 | 4 | 2 | 2 | 4 | 5 | 4 | 4 | 5 | 3 | 3 | 4 | 3.7 | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8. I believe safety issues are assigned a high priority | 5 | 5 | 1 | 4 | 4 | 5 | 5 | 4 | 5 | 4 | 4 | 5 | 4.3 | | |
| 9. Safety rules and procedures are carefully followed | 4 | 4 | 1 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 4 | 4 | 3.4 | | |
| **Dimension -Priority of Safety Total Score** | | | | | | | | | | | | | | **11.3** | **7.6** |
| 10. Some safety rules and procedures do not need to be followed to get the job done safely | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 2 | 2.2 | | |
| 11. Some safety rules are not really practical | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 1.9 | | |
| 12. Employees are not encouraged to raise safety concerns | 1 | 2 | 4 | 4 | 3 | 4 | 2 | 3 | 1 | 2 | 3 | 1 | 2.5 | | |
| **Dimension - Safety Rules and Procedures Total Score:** | | | | | | | | | | | | | | **6.6** | **4.4** |
| 13. When people ignore safety procedures here, I feel it is none of my business | 4 | 1 | 4 | 4 | 2 | 2 | 3 | 2 | 3 | 3 | 4 | 4 | 3.0 | | |
| 14. I am strongly encouraged to report unsafe conditions | 4 | 2 | 1 | 2 | 4 | 3 | 2 | 4 | 3 | 4 | 4 | 3 | 3.0 | | |
| **Dimension - Supportive Environment Total Score:** | | | | | | | | | | | | | | **6.0** | **6.0** |
| 15. I am involved in informing management of important safety issues | 2 | 2 | 1 | 2 | 2 | 5 | 2 | 1 | 2 | 2 | 2 | 1 | 2.0 | | |
| 16. I am involved with safety issues at work | 2 | 1 | 1 | 2 | 4 | 2 | 3 | 2 | 2 | 1 | 3 | 3 | 2.2 | | |
| 17. I am never involved in the ongoing review of safety | 3 | 1 | 5 | 4 | 4 | 5 | 4 | 4 | 4 | 3 | 5 | 3 | 3.8 | | |
| **Dimension - Involvement Total Score:** | | | | | | | | | | | | | | **7.9** | **5.3** |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18. Safety is the number one priority in my mind when completing a job | 3 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 1.8 | | |
| 19. I feel that safety issues are not the most important aspect of my job | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1.2 | | |
| 20. A safe place to work has a lot of personal meaning to me | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1.5 | | |
| **Dimension - Personal Priorities and Need for Safety Total Score:** | | | | | | | | | | | | | | **4.5** | **3.0** |
| 21. I am sure it is only a matter of time before I am involved in an accident | 5 | 5 | 4 | 2 | 4 | 4 | 4 | 5 | 4 | 5 | 4 | 4 | 4.2 | | |
| 22. In my workplace the chances of being involved in an accident are quite high | 5 | 5 | 4 | 4 | 3 | 4 | 4 | 5 | 5 | 5 | 4 | 4 | 4.3 | | |
| 23. I am clear about what my responsibilities are for health and safety | 2 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.0 | | |
| **Dimension - Personal Appreciation of Risk Total Score:** | | | | | | | | | | | | | | **10.5** | **7.0** |
| 24. I cannot always get the equipment I need to do the job safely | 4 | 5 | 1 | 4 | 4 | 5 | 4 | 5 | 5 | 4 | 4 | 5 | 4.2 | | |
| 25. Sometimes conditions here hinder my ability to work safely | 5 | 5 | 1 | 4 | 4 | 5 | 5 | 5 | 4 | 5 | 5 | 5 | 4.4 | | |
| 26. Sometimes I am not given enough time to get the job done safely | 4 | 1 | 1 | 4 | 3 | 3 | 4 | 4 | 4 | 3 | 5 | 5 | 3.4 | | |
| **Dimension - Work Environment Total Score:** | | | | | | | | | | | | | | **12.0** | **8.0** |

## APPENDIX E: SAFETY DIMENSIONS SCORES FOR DEPARTMENT 2

Department 2

| Statement | Individuals' Scores | | | Average | | |
|---|---|---|---|---|---|---|
| 1. Management acts decisively when a safety concern has been raised | 3 | 5 | 4 | 4.0 | | |
| 2. In my workplace management acts quickly to correct safety problems | 3 | 4 | 3 | 3.3 | | |
| 3. Managers and supervisors express concern if safety procedures are not adhered to | 3 | 3 | 3 | 3.0 | | |
| **Dimension -Management Commitment Total Score:** | | | | | **10.3333** | **6.9** |
| 4. Safety information is always brought to my attention by my line manager | 3 | 2 | 2 | 2.3 | | |
| 5. There is good communication here about safety issues which affect me | 3 | 4 | 2 | 3.0 | | |
| 6. Management operates an open door policy on safety issues | 3 | 4 | 4 | 3.7 | | |
| **Dimension -Communication Total Score:** | | | | | **9** | **6.0** |
| 7. Management clearly considers the safety of employees to be of great importance | 3 | 4 | 3 | 3.3 | | |
| 8. I believe safety issues are assigned a high priority | 1 | 4 | 2 | 2.3 | | |
| 9. Safety rules and procedures are carefully followed | 2 | 4 | 2 | 2.7 | | |
| **Dimension -Priority of Safety Total Score** | | | | | **8.3** | **5.6** |
| 10. Some safety rules and procedures do not need to be followed to get the job done safely | 1 | 1 | 2 | 1.3 | | |
| 11. Some safety rules are not really practical | 1 | 1 | 2 | 1.3 | | |
| 12. Employees are not encouraged to raise safety concerns | 2 | 1 | 2 | 1.7 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Dimension - Safety Rules and Procedures Total Score:** | | | | | **4.3** | **2.9** |
| 13. When people ignore safety procedures here, I feel it is none of my business | 1 | 2 | 3 | 2.0 | | |
| 14. I am strongly encouraged to report unsafe conditions | 2 | 3 | 3 | 2.7 | | |
| **Dimension - Supportive Environment Total Score:** | | | | | **4.7** | **4.7** |
| 15. I am involved in informing management of important safety issues | 3 | 2 | 3 | 2.7 | | |
| 16. I am involved with safety issues at work | 2 | 2 | 2 | 2.0 | | |
| 17. I am never involved in the ongoing review of safety | 3 | 3 | 4 | 3.3 | | |
| **Dimension - Involvement Total Score:** | | | | | **8.0** | **5.3** |
| 18. Safety is the number one priority in my mind when completing a job | 1 | 2 | 2 | 1.7 | | |
| 19. I feel that safety issues are not the most important aspect of my job | 1 | 1 | 1 | 1.0 | | |
| 20. A safe place to work has a lot of personal meaning to me | 1 | 1 | 1 | 1.0 | | |
| **Dimension - Personal Priorities and Need for Safety Total Score:** | | | | | **3.7** | **2.4** |
| 21. I am sure it is only a matter of time before I am involved in an accident | 1 | 3 | 3 | 2.3 | | |
| 22. In my workplace the chances of being involved in an accident are quite high | 2 | 4 | 4 | 3.3 | | |
| 23. I am clear about what my responsibilities are for health and safety | 3 | 2 | 2 | 2.3 | | |
| **Dimension - Personal Appreciation of Risk Total Score:** | | | | | **8.0** | **5.3** |
| 24. I cannot always get the equipment I need to do the job safely | 3 | 4 | 3 | 3.3 | | |
| 25. Sometimes conditions here hinder my ability to work safely | 3 | 4 | 4 | 3.7 | | |
| 26. Sometimes I am not given enough time to get the job done safely | 3 | 3 | 3 | 3.0 | | |
| **Dimension - Work Environment Total Score:** | | | | | **10.0** | **6.7** |

## APPENDIX F: SAFETY DIMENSIONS SCORES FOR DEPARTMENT 3

Department 3

| Statement | Individuals' Scores | | | | Average | | |
|---|---|---|---|---|---|---|---|
| 1. Management acts decisively when a safety concern has been raised | 5 | 5 | 4 | 5 | 4.8 | | |
| 2. In my workplace management acts quickly to correct safety problems | 5 | 5 | 5 | 4 | 4.8 | | |
| 3. Managers and supervisors express concern if safety procedures are not adhered to | 4 | 4 | 4 | 4 | 4.0 | | |
| **Dimension -Management Commitment Total Score:** | | | | | | **13.5** | **9.0** |
| 4. Safety information is always brought to my attention by my line manager | 5 | 4 | 4 | 5 | 4.5 | | |
| 5. There is good communication here about safety issues which affect me | 5 | 4 | 5 | 5 | 4.8 | | |
| 6. Management operates an open door policy on safety issues | 4 | 3 | 4 | 4 | 3.8 | | |
| **Dimension -Communication Total Score:** | | | | | | **13** | **8.7** |
| 7. Management clearly considers the safety of employees to be of great importance | 5 | 4 | 4 | 5 | 4.5 | | |
| 8. I believe safety issues are assigned a high priority | 5 | 5 | 4 | 4 | 4.5 | | |
| 9. Safety rules and procedures are carefully followed | 4 | 4 | 4 | 5 | 4.3 | | |
| **Dimension -Priority of Safety Total Score** | | | | | | **13.3** | **8.8** |
| 10. Some safety rules and procedures do not need to be followed to get the job done safely | 1 | 2 | 1 | 2 | 1.5 | | |
| 11. Some safety rules are not really practical | 1 | 2 | 2 | 2 | 1.8 | | |
| 12. Employees are not encouraged to raise safety concerns | 2 | 1 | 1 | 2 | 1.5 | | |
| **Dimension - Safety Rules and Procedures Total Score (Reversed (the total subtracted from 12)):** | | | | | | **4.8** | **3.2** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 13. When people ignore safety procedures here, I feel it is none of my business | 1 | 1 | 3 | 1 | 1.5 | | |
| 14. I am strongly encouraged to report unsafe conditions | 4 | 3 | 4 | 4 | 3.8 | | |
| **Dimension - Supportive Environment Total Score:** | | | | | | **5.3** | **5.3** |
| 15. I am involved in informing management of important safety issues | 3 | 2 | 3 | 2 | 2.5 | | |
| 16. I am involved with safety issues at work | 1 | 3 | 2 | 2 | 2.0 | | |
| 17. I am never involved in the ongoing review of safety | 1 | 2 | 3 | 1 | 1.8 | | |
| **Dimension - Involvement Total Score:** | | | | | | **6.3** | **4.2** |
| 18. Safety is the number one priority in my mind when completing a job | 1 | 2 | 3 | 2 | 2.0 | | |
| 19. I feel that safety issues are not the most important aspect of my job | 1 | 1 | 2 | 2 | 1.5 | | |
| 20. A safe place to work has a lot of personal meaning to me | 1 | 1 | 1 | 1 | 1.0 | | |
| **Dimension - Personal Priorities and Need for Safety Total Score:** | | | | | | **4.5** | **3.0** |
| 21. I am sure it is only a matter of time before I am involved in an accident | 5 | 5 | 4 | 5 | 4.8 | | |
| 22. In my workplace the chances of being involved in an accident are quite high | 5 | 5 | 4 | 5 | 4.8 | | |
| 23. I am clear about what my responsibilities are for health and safety | 1 | 2 | 2 | 1 | 1.5 | | |
| **Dimension - Personal Appreciation of Risk Total Score:** | | | | | | **11.0** | **7.3** |
| 24. I cannot always get the equipment I need to do the job safely | 5 | 5 | 5 | 4 | 4.8 | | |
| 25. Sometimes conditions here hinder my ability to work safely | 5 | 5 | 4 | 5 | 4.8 | | |
| 26. Sometimes I am not given enough time to get the job done safely | 4 | 4 | 4 | 5 | 4.3 | | |
| **Dimension - Work Environment Total Score:** | | | | | | **13.8** | **9.2** |

## APPENDIX G: SAFETY DIMENSIONS SCORES FOR DEPARTMENT 4

Department 4

| Statement | Individuals' Scores | | | Average | | |
|---|---|---|---|---|---|---|
| 1. Management acts decisively when a safety concern has been raised | 3 | 4 | 5 | 4.0 | | |
| 2. In my workplace management acts quickly to correct safety problems | 2 | 5 | 4 | 3.7 | | |
| 3. Managers and supervisors express concern if safety procedures are not adhered to | 2 | 3 | 3 | 2.7 | | |
| **Dimension -Management Commitment Total Score:** | | | | | **10.3** | **6.9** |
| 4. Safety information is always brought to my attention by my line manager | 2 | 3 | 4 | 3.0 | | |
| 5. There is good communication here about safety issues which affect me | 2 | 4 | 4 | 3.3 | | |
| 6. Management operates an open door policy on safety issues | 2 | 4 | 3 | 3.0 | | |
| **Dimension -Communication Total Score:** | | | | | **9.3** | **6.2** |
| 7. Management clearly considers the safety of employees to be of great importance | 2 | 3 | 3 | 2.7 | | |
| 8. I believe safety issues are assigned a high priority | 2 | 4 | 3 | 3.0 | | |
| 9. Safety rules and procedures are carefully followed | 3 | 4 | 4 | 3.7 | | |
| **Dimension -Priority of Safety Total Score** | | | | | **9.3** | **6.2** |
| 10. Some safety rules and procedures do not need to be followed to get the job done safely | 4 | 2 | 1 | 2.3 | | |
| 11. Some safety rules are not really practical | 3 | 2 | 1 | 2.0 | | |
| 12. Employees are not encouraged to raise safety concerns | 2 | 1 | 1 | 1.3 | | |
| **Dimension - Safety Rules and Procedures Total Score:** | | | | | **5.7** | **3.8** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. When people ignore safety procedures here, I feel it is none of my business | 1 | 4 | 2 | 2.3 | | |
| 14. I am strongly encouraged to report unsafe conditions | 2 | 4 | 3 | 3.0 | | |
| **Dimension - Supportive Environment Total Score:** | | | | | **5.3** | **5.3** |
| 15. I am involved in informing management of important safety issues | 2 | 2 | 2 | 2.0 | | |
| 16. I am involved with safety issues at work | 3 | 2 | 3 | 2.7 | | |
| 17. I am never involved in the ongoing review of safety | 2 | 3 | 3 | 2.7 | | |
| **Dimension - Involvement Total Score:** | | | | | **7.3** | **4.9** |
| 18. Safety is the number one priority in my mind when completing a job | 3 | 1 | 2 | 2.0 | | |
| 19. I feel that safety issues are not the most important aspect of my job | 2 | 2 | 1 | 1.7 | | |
| 20. A safe place to work has a lot of personal meaning to me | 1 | 1 | 1 | 1.0 | | |
| **Dimension - Personal Priorities and Need for Safety Total Score:** | | | | | **4.7** | **3.1** |
| 21. I am sure it is only a matter of time before I am involved in an accident | 2 | 3 | 3 | 2.7 | | |
| 22. In my workplace the chances of being involved in an accident are quite high | 2 | 3 | 3 | 2.7 | | |
| 23. I am clear about what my responsibilities are for health and safety | 4 | 2 | 2 | 2.7 | | |
| **Dimension - Personal Appreciation of Risk Total Score:** | | | | | **8.0** | **5.3** |
| 24. I cannot always get the equipment I need to do the job safely | 4 | 4 | 5 | 4.3 | | |
| 25. Sometimes conditions here hinder my ability to work safely | 3 | 4 | 5 | 4.0 | | |
| 26. Sometimes I am not given enough time to get the job done safely | 1 | 3 | 4 | 2.7 | | |
| **Dimension - Work Environment Total Score:** | | | | | **11.0** | **7.3** |

## APPENDIX H: SAFETY DIMENSIONS SCORES FOR DEPARTMENT 5

Department 5

| Statement | Individuals' Scores | | | Average | | |
|---|---|---|---|---|---|---|
| 1. Management acts decisively when a safety concern has been raised | 0 | 5 | 5 | 5.0 | | |
| 2. In my workplace management acts quickly to correct safety problems | 4 | 5 | 4 | 4.3 | | |
| 3. Managers and supervisors express concern if safety procedures are not adhered to | 2 | 2 | 3 | 2.3 | | |
| **Dimension -Management Commitment Total Score:** | | | | | **11.7** | **7.8** |
| 4. Safety information is always brought to my attention by my line manager | 2 | 3 | 3 | 2.7 | | |
| 5. There is good communication here about safety issues which affect me | 3 | 4 | 4 | 3.7 | | |
| 6. Management operates an open door policy on safety issues | 3 | 4 | 5 | 4.0 | | |
| **Dimension -Communication Total Score:** | | | | | **10.3** | **6.9** |
| 7. Management clearly considers the safety of employees to be of great importance | 3 | 4 | 4 | 3.7 | | |
| 8. I believe safety issues are assigned a high priority | 3 | 4 | 5 | 4.0 | | |
| 9. Safety rules and procedures are carefully followed | 3 | 3 | 3 | 3.0 | | |
| **Dimension -Priority of Safety Total Score** | | | | | **10.7** | **7.1** |
| 10. Some safety rules and procedures do not need to be followed to get the job done safely | 4 | 2 | 1 | 2.3 | | |
| 11. Some safety rules are not really practical | 3 | 1 | 1 | 1.7 | | |
| 12. Employees are not encouraged to raise safety concerns | 3 | 2 | 2 | 2.3 | | |
| **Dimension - Safety Rules and Procedures Total Score:** | | | | | **6.3** | **4.2** |
| 13. When people ignore safety procedures here, I feel it is none of my business | 3 | 2 | 3 | 2.7 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 14. I am strongly encouraged to report unsafe conditions | 4 | 3 | 3 | 3.3 | | |
| **Dimension - Supportive Environment Total Score:** | | | | | **6.0** | **6.0** |
| 15. I am involved in informing management of important safety issues | 4 | 2 | 2 | 2.7 | | |
| 16. I am involved with safety issues at work | 2 | 2 | 2 | 2.0 | | |
| 17. I am never involved in the ongoing review of safety | 4 | 3 | 2 | 3.0 | | |
| **Dimension - Involvement Total Score:** | | | | | **7.7** | **5.1** |
| 18. Safety is the number one priority in my mind when completing a job | 3 | 2 | 1 | 2.0 | | |
| 19. I feel that safety issues are not the most important aspect of my job | 2 | 1 | 1 | 1.3 | | |
| 20. A safe place to work has a lot of personal meaning to me | 2 | 1 | 1 | 1.3 | | |
| **Dimension - Personal Priorities and Need for Safety Total Score:** | | | | | **4.7** | **3.1** |
| 21. I am sure it is only a matter of time before I am involved in an accident | 2 | 4 | 5 | 3.7 | | |
| 22. In my workplace the chances of being involved in an accident are quite high | 2 | 5 | 4 | 3.7 | | |
| 23. I am clear about what my responsibilities are for health and safety | 2 | 2 | 2 | 2.0 | | |
| **Dimension - Personal Appreciation of Risk Total Score:** | | | | | **9.3** | **6.2** |
| 24. I cannot always get the equipment I need to do the job safely | 2 | 5 | 5 | 4.0 | | |
| 25. Sometimes conditions here hinder my ability to work safely | 2 | 5 | 5 | 4.0 | | |
| 26. Sometimes I am not given enough time to get the job done safely | 2 | 4 | 4 | 3.3 | | |
| **Dimension - Work Environment Total Score:** | | | | | **11.3** | **7.6** |

## APPENDIX I: INDIVIDUALS' SCORES FOR BEHAVIOUR INDICATORS

| **Statement** | **Individuals' Scores** | | | | | | | | | | | | | | | | | | | | | | | | | **Average** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. The department implements management procedures to ensure safe handling and storage of chemicals | 4 | 1 | 4 | 4 | 4 | 2 | 3 | 3 | 4 | 4 | 4 | 3 | 0 | 4 | 4 | 5 | 4 | 4 | 4 | 2 | 3 | 3 | 2 | 4 | 3 | 3.3 |
| 2. Personnel are trained for handling and use of chemicals | 3 | 3 | 2 | 2 | 4 | 5 | 2 | 3 | 4 | 3 | 3 | 3 | 5 | 4 | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 5 | 2 | 2 | 3 | 3.6 |
| 3. The chemical inventory inspection is conducted regularly | 5 | 5 | 2 | 4 | 4 | 2 | 4 | 4 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 5 | 5 | 5 | 4 | 3 | 4 | 4 | 2 | 4 | 3 | 4.0 |
| 4. Less hazardous or environmentally friendly chemical substitutions are considered when purchasing chemicals | 4 | 2 | 2 | 4 | 4 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 2 | 3 | 4 | 4 | 5 | 5 | 4 | 2 | 4 | 5 | 2 | 2 | 2 | 3.3 |
| 5. Chemicals are purchased in bulk | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 5 | 2 | 1 | 1 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 2 | 3.8 |
| 6. The department keeps an updated inventory list of the chemicals used and stored | 5 | 5 | 2 | 4 | 4 | 3 | 4 | 5 | 5 | 4 | 5 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 3 | 2 | 2 | 3 | 2 | 3.6 |
| 7. The department has a designated chemical storage area | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 0 | 3 | 3 | 5 | 3 | 4 | 5 | 2 | 1 | 2 | 2 | 2 | 2 | 2.2 |
| 8. The chemical storeroom is identified with | 5 | 4 | 2 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 0 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 4 | 5 | 5 | 4.4 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a sign as a chemical storeroom | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9. The storeroom is kept under lock and key, and is entered by authorized personnel only | 2 | 1 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 0 | 5 | 5 | 5 | 5 | 5 | 4 | 2 | 2 | 2 | 3 | 4 | 4 | 2.8 | | |
| 10. The chemical storeroom has shelving units fastened to the wall or floor | 2 | 1 | 2 | 4 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 5 | 5 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.2 | | |
| 11. Chemicals are stored based on compatibility and not in alphabetical or random order | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 5 | 5 | 4 | 2 | 3 | 3 | 3 | 4 | 4 | 4.2 | | |
| **Chemical Management Procedures Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **37.28** | **6.8** |
| 12. First aid supplies are available in each room where chemicals are used or stored | 4 | 5 | 2 | 4 | 4 | 5 | 3 | 4 | 5 | 5 | 4 | 4 | 3 | 3 | 3 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 2 | 2 | 3 | 3.8 | | |
| 13. Fire extinguishers are available at appropriate areas in the department | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 5 | 5 | 4 | 1 | 3 | 2 | 1 | 4 | 5 | 4 | 2 | 2 | 2 | 2.7 | | |
| 14. Employees are trained in how to utilize fire extinguishers | 5 | 5 | 1 | 4 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 4 | 5 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 5 | 5 | 4.5 | | |
| 15. Emergency telephone numbers are posted in each room where chemicals are used or stored | 5 | 5 | 1 | 4 | 4 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 5 | 5 | 5 | 4 | 2 | 2 | 2 | 4 | 5 | 5 | 4.2 | | |
| **Emergency Planning Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **15.16** | **7.6** |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16. Stored chemicals are clearly identified by the label as to their contents | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.3 | | |
| 17. The labels are readable and tightly secured onto all chemical containers | 4 | 2 | 1 | 4 | 3 | 1 | 3 | 3 | 4 | 3 | 4 | 4 | 2 | 2 | 2 | 5 | 4 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | | | |
| 18. Material Safety Data Sheets (MSDS) are readily available for all chemicals used | 4 | 2 | 1 | 4 | 4 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 0 | 3 | 2 | 5 | 4 | 4 | 3 | 4 | 3 | 4 | 3 | 3 | 3 | 3.3 | | |
| 19. Records of all incidents involving chemicals are collected and maintained | 5 | 5 | 2 | 4 | 3 | 3 | 4 | 5 | 5 | 5 | 4 | 5 | 0 | 3 | 2 | 5 | 5 | 5 | 4 | 0 | 4 | 4 | 3 | 4 | 3 | 3.7 | | |
| **Information and Records Management Total Score:** | | | | | | | | | | | | | | | | | | | | | | | | | | | **9.3** | **4.7** |

**DEPARTMENT 5** **DEPARTMENT 4** **DEPARTMENT 3** **DEPARTMENT 2** **DEPARTMENT 1**

## APPENDIX J: BEHAVIOURAL SCORES FOR DEAPRTMENT 1

| **Statement** | **Individuals' Scores** | | | | | | | | | | | | **Average** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. The department implements management procedures to ensure safe handling and storage of chemicals | 4 | 1 | 4 | 4 | 4 | 2 | 3 | 3 | 4 | 4 | 4 | 3 | 3.3 | |
| 2. Personnel are trained for handling and use of chemicals | 3 | 3 | 2 | 2 | 4 | 5 | 2 | 3 | 4 | 3 | 3 | 3 | 3.1 | |
| 3. The chemical inventory inspection is conducted regularly | 5 | 5 | 2 | 4 | 4 | 2 | 4 | 4 | 5 | 5 | 5 | 4 | 4.1 | |
| 4. Less hazardous or environmentally friendly chemical substitutions are considered when purchasing chemicals | 4 | 2 | 2 | 4 | 4 | 2 | 2 | 3 | 4 | 4 | 4 | 4 | 3.3 | |
| 5. Chemicals are purchased in bulk | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 5 | 4.6 | |
| 6. The department keeps an updated inventory list of the chemicals used and stored | 5 | 5 | 2 | 4 | 4 | 3 | 4 | 5 | 5 | 4 | 5 | 4 | 4.2 | |
| 7. The department has a designated chemical storage area | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 1.7 | |
| 8. The chemical storeroom is identified with a sign as a chemical storeroom | 5 | 4 | 2 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 4 | 4 | 4.3 | |
| 9. The storeroom is kept under lock and key, and is entered by authorized personnel only | 2 | 1 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2.0 | |
| 10. The chemical storeroom has shelving units fastened to the wall or floor | 2 | 1 | 2 | 4 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2.0 | |
| 11. Chemicals are stored based on compatibility and not in alphabetical or random order | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 4.5 | |
| **Chemical Management Procedures Total Score:** | | | | | | | | | | | | | **37.0** | **6.7** |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12. First aid supplies are available in each room where chemicals are used or stored | 4 | 5 | 2 | 4 | 4 | 5 | 3 | 4 | 5 | 5 | 4 | 4 | 4.0 | | |
| 13. Fire extinguishers are available at appropriate areas in the department | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 1.6 | | |
| 14. Employees are trained in how to utilize fire extinguishers | 5 | 5 | 1 | 4 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 4 | 3.8 | | |
| 15. Emergency telephone numbers are posted in each room where chemicals are used or stored | 5 | 5 | 1 | 4 | 4 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 3.8 | | |
| **Emergency Planning Total Score:** | | | | | | | | | | | | | | **13.2** | **6.6** |
| 16. Stored chemicals are clearly identified by the label as to their contents | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 1.6 | | |
| 17. The labels are readable and tightly secured onto all chemical containers | 4 | 2 | 1 | 4 | 3 | 1 | 3 | 3 | 4 | 3 | 4 | 4 | 2.2 | | |
| 18. Material Safety Data Sheets (MSDS) are readily available for all chemicals used | 4 | 2 | 1 | 4 | 4 | 2 | 3 | 4 | 4 | 4 | 4 | 4 | 2.6 | | |
| 19. Records of all incidents involving chemicals are collected and maintained | 5 | 5 | 2 | 4 | 3 | 3 | 4 | 5 | 5 | 5 | 4 | 5 | 3.4 | | |
| **Information and Records Management Total Score:** | | | | | | | | | | | | | | **9.8** | **4.9** |

## APPENDIX K: BEHAVIOURAL SCORES FOR DEAPRTMENT 2

| Statement | Individuals' Scores | | | Average | |
|---|---|---|---|---|---|
| 1. The department implements management procedures to ensure safe handling and storage of chemicals | 0 | 4 | 4 | 4.0 | |
| 2. Personnel are trained for handling and use of chemicals | 5 | 4 | 5 | 4.7 | |
| 3. The chemical inventory inspection is conducted regularly | 3 | 4 | 4 | 3.7 | |
| 4. Less hazardous or environmentally friendly chemical substitutions are considered when purchasing chemicals | 2 | 3 | 4 | 3.0 | |
| 5. Chemicals are purchased in bulk | 2 | 1 | 1 | 1.3 | |
| 6. The department keeps an updated inventory list of the chemicals used and stored | 3 | 4 | 4 | 3.7 | |
| 7. The department has a designated chemical storage area | 0 | 3 | 3 | 2.0 | |
| 8. The chemical storeroom is identified with a sign as a chemical storeroom | 0 | 5 | 5 | 3.3 | |
| 9. The storeroom is kept under lock and key, and is entered by authorized personnel only | 0 | 5 | 5 | 3.3 | |
| 10. The chemical storeroom has shelving units fastened to the wall or floor | 3 | 5 | 5 | 4.3 | |
| 11. Chemicals are stored based on compatibility and not in alphabetical or random order | 3 | 5 | 5 | 4.3 | |
| **Chemical Management Procedures Total Score:** | | | | **37.7** | **6.8** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12. First aid supplies are available in each room where chemicals are used or stored | 3 | 3 | 3 | 3.0 | | |
| 13. Fire extinguishers are available at appropriate areas in the department | 5 | 5 | 4 | 4.7 | | |
| 14. Employees are trained in how to utilize fire extinguishers | 5 | 4 | 4 | 4.3 | | |
| 15. Emergency telephone numbers are posted in each room where chemicals are used or stored | 5 | 4 | 4 | 4.3 | | |
| **Emergency Planning Total Score:** | | | | | **16.3** | **8.2** |
| 16. Stored chemicals are clearly identified by the label as to their contents | 2 | 2 | 2 | 2.0 | | |
| 17. The labels are readable and tightly secured onto all chemical containers | 2 | 2 | 2 | 2.0 | | |
| 18. Material Safety Data Sheets (MSDS) are readily available for all chemicals used | 0 | 3 | 2 | 2.5 | | |
| 19. Records of all incidents involving chemicals are collected and maintained | 0 | 3 | 2 | 2.5 | | |
| **Information and Records Management Total Score:** | | | | | **9.0** | **4.5** |

## APPENDIX L: BEHAVIOURAL SCORES FOR DEAPRTMENT 3

| **Statement** | **Individuals' Scores** | | | | **Average** | |
|---|---|---|---|---|---|---|
| 1. The department implements management procedures to ensure safe handling and storage of chemicals | 5 | 4 | 4 | 4 | 4.3 | |
| 2. Personnel are trained for handling and use of chemicals | 5 | 4 | 4 | 4 | 4.3 | |
| 3. The chemical inventory inspection is conducted regularly | 5 | 5 | 5 | 4 | 4.8 | |
| 4. Less hazardous or environmentally friendly chemical substitutions are considered when purchasing chemicals | 4 | 5 | 5 | 4 | 4.5 | |
| 5. Chemicals are purchased in bulk | 4 | 5 | 4 | 4 | 4.3 | |
| 6. The department keeps an updated inventory list of the chemicals used and stored | 4 | 4 | 4 | 4 | 4.0 | |
| 7. The department has a designated chemical storage area | 5 | 3 | 4 | 5 | 4.3 | |
| 8. The chemical storeroom is identified with a sign as a chemical storeroom | 5 | 5 | 5 | 5 | 5.0 | |
| 9. The storeroom is kept under lock and key, and is entered by authorized personnel only | 5 | 5 | 5 | 4 | 4.8 | |
| 10. The chemical storeroom has shelving units fastened to the wall or floor | 1 | 1 | 2 | 2 | 1.5 | |
| 11. Chemicals are stored based on compatibility and not in alphabetical or random order | 5 | 5 | 5 | 4 | 4.8 | |
| **Chemical Management Procedures Total Score:** | | | | | **46.3** | **8.4** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12. First aid supplies are available in each room where chemicals are used or stored | 5 | 4 | 4 | 4 | 4.3 | | |
| 13. Fire extinguishers are available at appropriate areas in the department | 1 | 3 | 2 | 1 | 1.8 | | |
| 14. Employees are trained in how to utilize fire extinguishers | 5 | 5 | 5 | 5 | 5.0 | | |
| 15. Emergency telephone numbers are posted in each room where chemicals are used or stored | 5 | 5 | 5 | 4 | 4.8 | | |
| **Emergency Planning Total Score:** | | | | | | **15.75** | **7.9** |
| 16. Stored chemicals are clearly identified by the label as to their contents | 2 | 3 | 3 | 2 | 2.5 | | |
| 17. The labels are readable and tightly secured onto all chemical containers | 5 | 4 | 4 | 3 | 4.0 | | |
| 18. Material Safety Data Sheets (MSDS) are readily available for all chemicals used | 5 | 4 | 4 | 3 | 4.0 | | |
| 19. Records of all incidents involving chemicals are collected and maintained | 5 | 5 | 5 | 4 | 4.8 | | |
| **Information and Records Management Total Score:** | | | | | | **15.3** | **7.6** |

## APPENDIX M: BEHAVIOURAL SCORES FOR DEAPRTMENT 4

| **Statement** | **Individuals' Scores** | | | **Average** | | |
|---|---|---|---|---|---|---|
| 1. The department implements management procedures to ensure safe handling and storage of chemicals | 2 | 3 | 3 | 2.7 | | |
| 2. Personnel are trained for handling and use of chemicals | 4 | 5 | 5 | 4.7 | | |
| 3. The chemical inventory inspection is conducted regularly | 3 | 4 | 4 | 3.7 | | |
| 4. Less hazardous or environmentally friendly chemical substitutions are considered when purchasing chemicals | 2 | 4 | 5 | 3.7 | | |
| 5. Chemicals are purchased in bulk | 4 | 4 | 4 | 4.0 | | |
| 6. The department keeps an updated inventory list of the chemicals used and stored | 2 | 3 | 2 | 2.3 | | |
| 7. The department has a designated chemical storage area | 2 | 1 | 2 | 1.7 | | |
| 8. The chemical storeroom is identified with a sign as a chemical storeroom | 4 | 5 | 4 | 4.3 | | |
| 9. The storeroom is kept under lock and key, and is entered by authorized personnel only | 2 | 2 | 2 | 2.0 | | |
| 10. The chemical storeroom has shelving units fastened to the wall or floor | 2 | 2 | 2 | 2.0 | | |
| 11. Chemicals are stored based on compatibility and not in alphabetical or random order | 2 | 3 | 3 | 2.7 | | |
| **Chemical Management Procedures Total Score:** | | | | | **33.7** | **6.1** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12. First aid supplies are available in each room where chemicals are used or stored | 4 | 5 | 4 | 4.3 | | |
| 13. Fire extinguishers are available at appropriate areas in the department | 4 | 5 | 4 | 4.3 | | |
| 14. Employees are trained in how to utilize fire extinguishers | 5 | 5 | 4 | 4.7 | | |
| 15. Emergency telephone numbers are posted in each room where chemicals are used or stored | 2 | 2 | 2 | 2.0 | | |
| **Emergency Planning Total Score:** | | | | | **15.3** | **7.7** |
| 16. Stored chemicals are clearly identified by the label as to their contents | 2 | 2 | 2 | 2.0 | | |
| 17. The labels are readable and tightly secured onto all chemical containers | 2 | 2 | 2 | 2.0 | | |
| 18. Material Safety Data Sheets (MSDS) are readily available for all chemicals used | 4 | 3 | 4 | 3.7 | | |
| 19. Records of all incidents involving chemicals are collected and maintained | 0 | 4 | 4 | 2.7 | | |
| **Information and Records Management Total Score:** | | | | | **10.3** | **5.2** |

## APPENDIX N: BEHAVIOURAL SCORES FOR DEAPRTMENT 5

| Statement | Individuals' Scores | | | Average | | |
|---|---|---|---|---|---|---|
| 1. The department implements management procedures to ensure safe handling and storage of chemicals | 2 | 4 | 3 | 3.0 | | |
| 2. Personnel are trained for handling and use of chemicals | 2 | 2 | 3 | 2.3 | | |
| 3. The chemical inventory inspection is conducted regularly | 2 | 4 | 3 | 3.0 | | |
| 4. Less hazardous or environmentally friendly chemical substitutions are considered when purchasing chemicals | 2 | 2 | 2 | 2.0 | | |
| 5. Chemicals are purchased in bulk | 3 | 2 | 2 | 2.3 | | |
| 6. The department keeps an updated inventory list of the chemicals used and stored | 2 | 3 | 2 | 2.3 | | |
| 7. The department has a designated chemical storage area | 2 | 2 | 2 | 2.0 | | |
| 8. The chemical storeroom is identified with a sign as a chemical storeroom | 4 | 5 | 5 | 4.7 | | |
| 9. The storeroom is kept under lock and key, and is entered by authorized personnel only | 3 | 4 | 4 | 3.7 | | |
| 10. The chemical storeroom has shelving units fastened to the wall or floor | 2 | 2 | 2 | 2.0 | | |
| 11. Chemicals are stored based on compatibility and not in alphabetical or random order | 3 | 4 | 4 | 3.7 | | |
| **Chemical Management Procedures Total Score:** | | | | | **31.0** | **5.6** |
| 12. First aid supplies are available in each room where chemicals are used or stored | 2 | 2 | 3 | 2.3 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13. Fire extinguishers are available at appropriate areas in the department | 2 | 2 | 2 | 2.0 | | |
| 14. Employees are trained in how to utilize fire extinguishers | 4 | 5 | 5 | 4.7 | | |
| 15. Emergency telephone numbers are posted in each room where chemicals are used or stored | 4 | 5 | 5 | 4.7 | | |
| **Emergency Planning Total Score:** | | | | | **13.7** | **6.8** |
| 16. Stored chemicals are clearly identified by the label as to their contents | 2 | 2 | 2 | 2.0 | | |
| 17. The labels are readable and tightly secured onto all chemical containers | 2 | 2 | 2 | 2.0 | | |
| 18. Material Safety Data Sheets (MSDS) are readily available for all chemicals used | 3 | 3 | 3 | 3.0 | | |
| 19. Records of all incidents involving chemicals are collected and maintained | 3 | 4 | 3 | 3.3 | | |
| **Information and Records Management Total Score:** | | | | | **10.3** | **5.2** |