SHERATON DETROIT

Safety and Operational Risks at a Selected Chemical Company

By

Dan Nayager

Submitted in Partial fulfillment of the requirements for the degree of

Masters in Business Administration

Business studies Unit
In the faculty of Business Administration
At the Durban University of Technology

Supervisor: Dr JP Govender

November 2007

Gods Blessings

I asked for Strength....And God gave me Difficulties to make me strong

I asked for Wisdom....And God gave me Problems to solve

I asked for Prosperity....And God gave me Brain and Brawn to work

I asked for Courage....And God gave me Obstacles to overcome

I asked for Love....And God gave me Troubled people to help

I asked for Favours....And God gave me Opportunities

"I received nothing I wanted.....But I received everything I needed"

Execucao: Leandro Valdir
Traduccion: Fidelia Garcia

Declaration

This dissertation is being submitted in partial fulfillment of the requirements for the degree of Masters in Business Administration. I hereby confirm that all the work herein is my own.

The works of other authors have been acknowledged by citation of references in the text and the list of references in the bibliography.

I HEREBY DECLARE THAT THE ABOVE FACTS ARE CORRECT.

Signed: [redacted]... Date: 12-11-2007

SRJ Nayager (Candidate)

Acknowledgements

All things are possible through God Almighty "Na Ma Si Vaa Ya"

I am deeply grateful and sincerely thank Dr Jeevarathnam Govender, for his time, support, guidance and encouragement from inception to completion of this study. I have proceeded through some trying times, but your unwavering encouragement and motivation has got me to the finishing line. Again, a thousand thanks to you my mentor and champion.

I am also thankful to the Ms Indirani Naidoo from UKZN for the professional analysis of all the research data and the support and assistance from Dr Hari Garbharran, Mr Peter Raap and Shamla Moodley of the Business Studies Unit.

Special Acknowledgements

To my family, especially my wife Ragani, for the never-ending encouragement, love and support throughout the long days and nights of my academic pursuit. To my daughter Shimona, a big thank you for your support and please "take a leaf from my book for your studies".

Dedication

This study is dedicated in the memory of my late parents, Mr and Mrs Kid Nayager. May your souls rest in eternal peace. I am grateful for your inspiration in the pursuit of knowledge and my standing in life today. I still remember clearly, my dad said, "I have no money to give you, but only the education that I can afford so that you may find your rightful place in society". I thank you daily for your sacrifice.

Abstract

Unsafe incidents are a regular occurrence in the chemical industries, which have resulted, in some cases in the catastrophic destruction to the environment and loss of life. Major global organizations have shut down after experiencing fatal unsafe incidents as in the case of Union Carbide. This organization was closed after the Bhopal incident in India, in 1984, which claimed the lives of about three thousand residents (see appendix d). In this study, the safety and operational risks at a selected chemical company in Durban are researched. This study looks at the huge number of unsafe incidents in a three year period, from (2003) to year (2005), that occurred at this organization.

The objective of this study is to identify the variables that contribute to the high number of unsafe incidents within the organisation. The study will focus on the relationship between staff perceptions and management's assumptions of these contributory variables.

The sub-objectives of the study are:

- To ascertain staff perceptions of the contributors to the incidents and unsafe working conditions;
- To determine if management is accurate in their assumptions of the causes for the incidents; and
- To determine relationships between staff perceptions and actual causes of the incidents.

The contributors were themed in the study in the following manner:

- Behaviour and attitude;
- Communications;
- Plant and equipment;
- Training and development;
- Planning and workload;
- Safety aspects; and

- Other related aspects.

Implementing the recommendations made will assist in reducing the number of unsafe incidents and make the organization a safer place for all stakeholders.

Table of Contents

Title Page		i
Declaration		iii
Acknowledgements		iv
Dedication		v
Abstract		vi-vii
Table of Contents		viii-xi
List of Tables		xii
List of Figures		xiii-xv
Chapter 1	**Introduction and overview of the study**	
1.1	Introduction	1
1.2	Background	1
1.3	Problem statement	1
1.4	Research objectives and sub-objectives	2
1.5	Rationale for the study	2
1.6	Summary outline per chapter	3
1.7	Conclusion	3
Chapter 2	**Literature review**	
2.1	Introduction	4
2.2	Investigating and the management of Unsafe chemical incidents	4
2.3	Blame-free safety programmes and Management walk-a-rounds	5
2.4	Safety rules, regulations and sustainable development	6
2.5	Stakeholders safety buy-in	8
2.6	Chemical safety culture including inventory management	10
2.7	Global health and safety awareness	11

2.8	Unsafe incidents, what went wrong	13
2.9	Attitude and behaviour for safe work ethics	14
2.10	Organisational safety culture	16
2.11	Safety design considerations in new chemical plants	17
2.12	Interpersonal skills and the reduction of unsafe incidents	18
2.13	Critical aspects for reducing unsafe incidents	19
2.14	Reduction of environmental pollution	21
2.15	Handling of hazardous chemicals	25
2.16	Human error in chemical handling	27
2.17	The mixing of incompatible chemicals	28
2.18	Life cycle thinking for new safe chemical plant design	29
2.19	Empowerment of employees	31
2.20	Unsafe incidents linked to poor skills, no safety equipment and stress	32
2.21	Fire and explosions with flammable chemicals	33
2.22	Conclusion	35
Chapter 3	**Research methodology**	
3.1	Introduction	37
3.2	Respondents	37
3.3	Data collection method	37
3.4	Research instrument	38
3.5	Pilot-testing and validation	38
3.6	Questionnaire and data preparation	38
3.7	Data analysis	39
3.8	Conclusion	41
Chapter 4	**Presentation of results**	
4.1	Introduction	43
4.2	Biographical data	43
4.3	Presentation of research data	47

4.3.1	Behaviour and attitude	49
4.3.2	Communications	62
4.3.3	Plant and equipment	66
4.3.4	Training and development	69
4.3.5	Planning and workload	73
4.3.6	Safety	79
4.3.7	Other	83
4.3.8	All questions per key contributor shown together	84
4.3.8.1	Behaviour and attitude	85
4.3.8.2	Communications	86
4.3.8.3	Plant and equipment	87
4.3.8.4	Training and development	88
4.3.8.5	Planning and workload	89
4.3.8.6	Safety	90
4.3.8.7	Other	91
4.3.9	Reliability of the questionnaire	92
4.3.10	Conclusion	92
Chapter 5	**Conclusion and recommendations**	
5.1	Introduction	94
5.2	Conclusions	94
5.3	Recommendations	95
5.3.1	Plant and equipment	96
5.3.2	Other	96
5.3.3	Safety	96
5.3.4	Planning and workload	97
5.3.5	Communications	97
5.3.6	Training and development	97
5.3.7	Behaviour and attitude	98
5.4	Summary	98

Bibliography **101**

Appendices:

a) Covering letter for research questionnaire 105

b) Research questionnaire 106

c) Analysis of research data using SPSS version 13 110

d) Additional information 122

List of Tables

1.1	Incident reports	2
2.1	Revitalisation checklist	15
2.2	Examples of pollution prevention practices in chemical industries	22
2.3	Planning a pollution prevention opportunity assessment for a process	23
2.4	Chemicals which are carcinogenic to humans	26
2.5	Sustainable design criteria for new chemical plants for sustainability	30
2.6	The likely effects of an oxygen-deficient atmosphere	33
4.1	Respondents by departments	43

List of Figures

2.1: The iceberg principle 28

2.2: How employee involvement affects productivity and quality 32

2.3: Fire risk assessment plan 35

4.1: Gender of respondents 44

4.2: Race of the respondents 44

4.3: Age of respondents 45

4.4: Departments linked to respondents 45

4.5: The positions of respondents 46

4.6: Level of education of respondents 46

4.7: Years of service 47

4.8: Improvements in key variables of the study 49

4.9: Attitude of staff towards their job 49

4.10: Workers not using procedures when working 50

4.11: Employees are treated like children 50

4.12: Employees are not empowered 51

4.13: No respect shown towards employees 51

4.14: The supervisor ignores the employees 52

4.15: Employees are victimized for complaining 53

4.16: Management does not attend to faults on time 53

4.17: Operators copy unsafe methods used by the supervisors 54

4.18: Operators claim that supervisors swear them 55

4.19: My job is affected by personal problems 55

4.20: Workers show little respect for each other 56

4.21: Workers use short-cuts to finish the job quickly 57

4.22: Supervisors are absent from their work stations 57

4.23: Managers show little interest in their jobs 58

4.24: Supervisor display poor behaviour 58

4.25: Supervisor don't check the quality of work 59

List of Figures

4.26: The contractors are abused by the supervisors 59
4.27: Workers assist each other on racial lines 60
4.28: There is no unity among the supervisors 61
4.29: Supervisors blame the workers for all mistakes 61
4.30: Workers are not given recognition for outstanding work 62
4.31: Workers take instructions from many superiors 63
4.32: Radio communication is very poor 63
4.33: Supervisors write unprofessional reports 64
4.34: Incorrect work instructions are printed from the computer 64
4.35: Management takes decisions without consulting the workers 65
4.36: Staff claim that incidents are caused by incorrect work instructions 66
4.37: Staff don't have the correct tools to do the job 66
4.38: Workers have no input on plant design 67
4.39: Staff work with old equipment 68
4.40: Contractors work is of poor quality 68
4.41: The plant lighting is very poor 69
4.42: The workers have limited knowledge about chemicals 70
4.43: Staff are new and inexperienced 70
4.44: Managers are inefficient in running the company 71
4.45: Supervisors don't train the workers properly 72
4.46: Workers claim to know more than the supervisor 72
4.47: Staff don't know how to use the computer 73
4.48: Many staff that are promoted are inexperienced for the job 73
4.49: Some staff have no time for tea or lunch 74
4.50: Some supervisors claim to have no time to use the computer 75
4.51: Staff claim to have no time for training 75
4.52: Workers don't have time to do proper checks 76
4.53: Workers claim to have no time to do last minute risk assessment 76
4.54: Workers claim that there are too few staff 77
4.55: Employees claim to work very long hours 77

List of Figures

4.56: Some workers work very hard whilst others do very little 78
4.57: Workers are unhappy with members being absent regularly 79
4.58: Workers claim that there are no safety meetings 79
4.59: Staff claim that there is no provision for fire training 80
4.60: Workers don't wear PPE because it's uncomfortable 80
4.61: Some workers only use PPE during the day 81
4.62: Housekeeping in the plant is very poor 82
4.63: Workers claim that the supervisors force them to do unsafe jobs 82
4.64: Truck drivers cause most of the problems 83
4.65: Workers claim that there are not enough social activities to de-stress 84
4.66: Workers claim that they are paid lower than the industry standard 84
4.67: Behaviour and attitude 86
4.68: Communications 87
4.69: Plant and equipment 88
4.70: Training and development 89
4.71: Planning and work Load 90
4.72: Safety 91
4.73: Other 91

Chapter 1

Introduction and overview of the study

1.1 Introduction

Unsafe incidents are a regular occurrence in the chemical industries and some result in catastrophic destruction to the environment and loss of life. In this chapter, the safety and operational risks are researched at a selected chemical company. There is a brief description of the company being investigated and the objectives of the research are outlined. The unsafe incidents for three years have been tabled for examination. The factors, which management suspect that contribute to the huge number of unsafe incidents, are also listed. There is also a brief breakdown of the chapters that follow.

1.2 Background

The selected organisation is the largest chemical and oil storage, handling and logistics company in the world, with operations in 26 countries on all continents. The organisation owns and operates an international network of 75 liquid bulk storage terminals with a capacity of approximately 24 million cubic metres, approximately 220 deep-sea tankers, coastal vessels and inland tank barges, over 3000 tank containers and a number of strategically placed logistics warehouses. A number of safety and operational incidents have occurred in the recent past. These incidents have or may have, directly or indirectly, impacted on the safety of all stakeholders as well on the operational efficiency of the company.

1.3 Problem statement

There is a high number of safety incidents that occur regularly at the selected organisation. This study sets out to determine the main contributory factors that impact on the safety, environmental and operational risks for all stakeholders.

1.4 Research objective and sub-objectives

The objective of this study is to identify the variables that contribute to the high number of unsafe incidents within the organisation. The study will focus on the relationship between staff perceptions and management's assumptions of the contributing variables.

The sub-objectives of the study are:

- To ascertain staff perceptions of the contributors to the incidents and unsafe working conditions;
- To determine if management is accurate in their assumptions of the causes for the incidents; and
- To determine relationships between staff perceptions and actual causes of the incidents.

1.5 Rationale for the study

The organisation spends large sums of money in the pursuit of safety at its plants. Nevertheless, there is still an unacceptably high number of safety incidents that occur on a regular basis. Table 1 reflects details of the incidents for the period 2003 to 2005.

Table 1.1: Incident reports

INCIDENTS	2003	2004	2005
Safety	18	12	28
Environmental	18	21	55
Others	181	122	120
Total	217	155	203

Source: Taken from company being researched

Management has attributed the large number of incidents to the following factors:

- Poor equipment;
- Non-adherence to procedures; and
- Inadequate training.

This study explores ways to improve plant safety and efficiency at the selected organisation. Plant and environmental safety is vital due to the stringent regulations on the storage and handling of hazardous chemicals. This research seeks to establish the contributors to the unsafe incidents with the view of assisting in management decision-making.

1.6 Summary outline per chapter

Chapter Two: A literature review is conducted on unsafe incidents and safety rules and regulations in the chemical industry.

Chapter Three: This chapter explains the research methodology used, including the biographical data of the respondents.

Chapter Four: In this chapter, the research results are discussed and analysed. The discussion is centred around the key variables of the study.

Chapter Five: The findings of the study were established and supported by recommendations and conclusions with reference to the literature review and findings from previous chapters.

1.7 Conclusion

In this chapter, the introduction and overview are given for the study. The selected organisation for the research is described and the problem statement with the objectives are given. Further the outline for each chapter is summarised.

CHAPTER 2

Literature review

2.1 Introduction

This literature review examines the different viewpoints and contributions of the various authors on safety at chemical plants. This review includes historical reports on actual safety incidents. The rules, regulations and best practices on safety in industries, globally, are also reviewed. Additional reviews are done on management safety models that are used in many chemical organisations. These unsafe incidents affect all stakeholders and impact negatively on the environment.

2.2 Investigating and the management of unsafe chemical incidents

The American Institute of Chemical Engineers (2003:61) give details for a structured approach on how to investigate all incidents relating to safety. It is stated that most major catastrophic incidents with major consequences have evolved from lower consequence, higher frequency incidents. Organisations tend not to pay proper attention due to these minor incidents. A similar pattern is noticed at the said company with little or no proper investigations done on minor incidents that occur frequently. There are no root cause investigations done for most incidents. After the last serious case of a fire, the head office carried out a tripod investigation and published its findings. The unsafe incidents were recorded as a matter of conforming to the ISO standards but not managed properly to be effective.

Fivizzani (2004:9) believes that new approaches regarding unsafe incidents need to be examined. Most people have heard the adage "If a man is given a fish, he is fed for a day. If he is taught to fish, he is fed for a life". The lesson from that adage is that safety personnel should focus their efforts on teaching others to help themselves. Employees must be taught how to examine a work situation like a safety professional, determine the

risk, devise a strategy to minimise that risk, and follow through with safe behaviour. In other words, the employees must be made partners in the effort to make the workplace safe. Most employees still perceive safety as separate from their jobs and the responsibility of someone else. On examining safety incidents, it is found that many incidents are regularly repeated. Therefore, it is a challenge in getting co-workers to comply with safety policies and follow appropriate safety procedures.

Fullwood (2000:31) describes the use of probabilistic safety assessment (PSA) in chemical and nuclear industries to enhance safety. This assessment has been performed due to the many unsafe incidents that have occurred over the years. PSA is an analytical method of assessing safety risks before they manifest into accidents resulting in injury, death and destruction. Management and employees can use the data gained to minimise unsafe acts. Some of the aspects considered in the analysis are equipment, instrumentation, utilities, human action and external factors. These aspects are further broken down into:

- Operating procedures and practices which include the method of doing the task, recording of operations, collection of samples and safety and health requirements; and

- Employee training on the understanding of the safety and health hazards of highly hazardous chemicals. The training has to have theory and practical component taught and the trainee will finally demonstrate his/ her knowledge gained by different methods of testing. There must be periodic evaluation of training programmes to determine if the necessary skills are being learnt.

2.3 Blame-free safety programmes and management walk-a-rounds

The American Institute of Chemical Engineers (2003:65) states that the primary objective is not to assign blame after an incident investigation but to understand what happened for preventing future incidents. The Institute also states that organisations need to foster a blame-free policy and disciplinary action is not part of the investigation. Managements' systems for investigations should ensure that a blame-free procedure is in place for honest

mistakes and is clearly stated and enforced. This procedure is an important aspect as it will encourage all incidents, no matter how small and including near misses, to be reported by all. This report will give a better reflection on the state of safety at any industry. Plant personnel do not always bring to the open all incidents, including even minor ones due to fear of disciplinary action.

Cournoyer and Maestas (2004:15) describe the importance of addressing safety assessments through management walk-a-rounds. These assessments involve collecting information, evaluating it, and making changes to improve performance. Establishing and implementing an effective safety assessment programme is an integral part of every management system and is a powerful tool to improve organisational effectiveness and worker safety and security. Management will gain direct information on unsafe incidents which can be evaluated and improved to reduce unsafe incidents. Similar systems are used at this company, but problems still exist due to unknown reasons. The environmental ministry has set complex guidelines for chemical safety. The requirements from these external instruments are numerous, subject to interpretation, and are not easily applied by workers.

Mizrahi (2002:211) states that persons working in the chemical industry routinely encounter potential safety hazards, including fire, explosions, burning, poisoning, radioactivity, thermal or visual radiation, and air or water contamination. Mizrahi believes that it is the responsibility of the chemical process developers to indicate clearly and make provisions in the design specifications on how to prevent such hazards. On starting up new plants, there are several aspects that need to be taken care off to have a successful startup. Selecting the plant management team is very critical as they will make or break this plant. At this stage of plant start up, there are many incidents that take place due to the newness of the plant and its personnel.

2.4 Safety rules, regulations and sustainable development

The Occupational Health and Safety Act (1993) makes provisions to safeguard individuals

from injury or death when working with chemicals. Every person, who handles hazardous chemicals, shall firstly understand a Material Data Safety Sheet which contains critical safety information such as:

1. Product and company identification;
2. Hazards identification;
3. First-aid measure; and
4. Fire fighting measures and other information.

In a recent review of OHSA's direction for 2005 and 2006, OHSA intends to continue a balanced approach including:

- Strong, fair and effective enforcement;
- Outreach, education and compliance assistance; and
- Cooperative and voluntary programmes.

There is also an increase for improvements in data analysis and performance measurement. OHSA is also looking to better address cases that might be referred for criminal prosecution. (Occupational Health and Safety Regulations 85 of 1993)

Responsible Care Global Charter is the global chemical industry's environmental, health and safety initiative to drive continuous improvement in performance. The Charter achieves this objective by meeting and going beyond legislative and regulatory compliance, and by adopting cooperative and voluntary initiatives with government and other stakeholders. The Responsible Care Global Charter contains nine key elements:

- Adopt global responsible care core principles;
- Implement fundamental features of national responsible care programmes;
- Commit to advancing sustainable development;
- Continuously improve and report performance;
- Enhance the management of chemical products worldwide–product stewardship;
- Champion and facilitate the extension of responsible care along the chemical industry's value chain;
- Actively support national and global responsible care governance processes;

- Address stakeholder expectations about chemical industry activities and products; and
- Provide appropriate resources to effectively implement responsible care.

(Responsible_Care_Global_Charter.www.ccpa.ca/files/library/Documents/RC).

Christ (1999:5) describes the growing awareness of chemical stakeholders, especially the chemical companies in need of sustainable development for chemical production. The following are critical aspects that have to be considered:

- The demanding international and national decrees and regulations covering environmental protection;
- The allocation of costs by chemical companies to "clean up" and disposal of wastes;
- Difficulties in the disposal of waste materials due to the shortage of dumping space and the secondary costs of setting up disposal plants;
- Costs of raw material and energy;
- Increased public awareness of the importance of environmental protection; and
- The processes and production plants of chemical technology must meet high standards of workplace protection and operational safety.

2.5 Stakeholders safety buy-in

Fivizzani (2004:10) states that many techniques for obtaining employee "buy-in" have been developed and discussed. Most techniques are some variation of the "carrot and stick" approach, whereby employers either entice or threaten employees into compliance. Most people, in developed nations, expect employers to provide a safe and secure work environment. Why is it so difficult to get those same individuals to work safely? There may be competing messages that other goals, such as maximising productivity or saving money, are more important than employee safety. The normal stress of daily life may distract people from adhering to safe practices. How does one convince others that safety

should be a personal value in each of our lives? Vivid testimonials from those who have had accidents are very effective influences on employee behaviour. Such testimonials help to understand the potential adverse consequences of unsafe behaviour in the workplaces. The motivational goal should be to convert co-workers to the realisation that working safely is in their best interest and benefits their families, colleagues, and the organisations that employ them.

Geller (2005:44) postulates that a true safety culture requires continual attention to groups of three factors. The first group is environmental factors, such as equipment, tools, physical layout, temperature, chemicals and housekeeping. The second group is personal factors, such as attitudes, beliefs and personalities, and the third group is behavioural factors, such as using safe or unsafe work practices and going out of an individual's way to protect another person's safety. These environmental, personal and behavioural factors all interact with each other and lead to unsafe incidents. Statistics have shown that the greatest percentage of workplace injuries are caused by unsafe behaviours rather than unsafe conditions. These above factors need to be considered for any safety programme to be effective and successful.

Fullwood (2000:33) believes that other safety aspects have to be considered as listed below:

- Contractors must also provide personnel that are efficiently trained with certification when working on chemical sites. The contractors must work under a system of work permits and supervision for work involving any "hot work", for example, cutting, grinding and welding.
- Pre-startup safety is very important. Pre-audit checks must be done to ensure that the plant meets the design specifications and any non-compliance must be corrected before startup. The necessary procedures, including emergency procedures, must be in place.

- Mechanical integrity is equally important in the prevention of unsafe incidents. The first step will be to identify and categorize all equipment and instrumentation such as:
    - Control of documentation of manufacturers' data on mean time to failure of equipment;
    - Record-keeping of test and inspection frequencies and results for the equipment; and
    - Maintenance procedures for the maintaining of the said equipment and instrumentation.

2.6 Chemical safety culture including inventory management

Geller (2005:44) stipulates that truly successful safety programmes result when a site or facility develops and embraces a total safety culture. A total safety culture facility is one where safety awareness becomes the norm and everyone goes the extra step to insure that they and their co-workers work safely. The next question is how is such a culture developed?

In a true total safety culture, everyone feels responsible for safety and practises it on a daily basis. Workers will go beyond their normal work roles to identify unsafe conditions and the unsafe behaviours of co-workers and intervene to correct them. Safe work practices are rewarded by positive feedback from peers and managers. People actively care about their personal safety and that of their co-workers. Safety awareness and compliance also goes beyond the workplace. It becomes a part of everyday routine. Buckling of the seat belt, when driving a car, becomes automatic for all.

Cournoyer et al. (2005:16) suggest that effective chemical inventory management is key in controlling hazardous chemical incidents. International legislation requires instruments for the purpose of establishing and applying sound business management practices. These

external instruments establish management objectives and expectations, and assign responsibilities. As these instruments pertain to chemical management, a minimum set of requirements must be defined for chemical work, including the qualifications and training necessary for personnel involved in chemical work, work approval and authorisation, documentation for work, and a basic safe-work process. These requirements, which make up Chemical Management Programmes, ensure that worker health and safety are protected, prevent pollution, assist Emergency Management and Response, protect the environment, and minimise waste by controlling chemical activities.

Mizrahi (2002:211) states that, during a new plant start-up, the operating and maintenance teams will be selected at the same time as management. The project team is responsible for the introduction of the plant to the operating team and the training of all the personnel. Specialists covering all aspects of the plant, including safety give the necessary lectures, tests and feedback. The general safety training is detailed in the operating manuals. This procedure will cover all the "do's and don'ts" of new plant startup and the experiences of similar startups in other plants. Dry runs are conducted by the project and plant teams and, once successful, will be handed to the plant manager. At this stage, the plant teams make up a butt list of all problems noticed for correction by the contractors. By using the wealth of knowledge on plant startups, the operating team can keep the unsafe incidents to an absolute minimum.

2.7 Global health and safety awareness

Goehl (2005:5) postulates that the mission of *Environmental Health Perspectives* (*EHP*) is to disseminate credible chemical safety and environmental and occupational health information around the world. The overarching goal is to raise the global awareness of the connectivity of the environment with human health. The aim is to reach this goal with a broad global outreach initiative that focuses primarily on information sharing. The information is provided in multiple languages, supported by high-quality research in these regional journals. Today, technology makes it easy for chemical information to reach stakeholders in all parts of the globe so that all unsafe chemical incidents are reduced.

EHP develops and publishes a wealth of information directly related to chemical safety and global environmental and occupational health issues.

Fivizzani (2005:12) states that a Job Hazard Analysis (JHA) for a workplace determines what personal protective equipment (PPE) will be needed for the job. Workers, who understand how to evaluate risk and determine what precautions to take, are more likely to obtain and use the appropriate PPE. Experienced employees think that the proper use of PPE is obvious. They have picked up many skills through their years of experience. However, the job tasks may have changed, their physical skills may have changed, and the types of PPE have changed. Too often, managers assume that everyone knows, for example, how to select the appropriate glove for the job and this assumption can lead to unsafe conditions. A fundamental challenge facing all safety professionals is getting co-workers to comply with safety policies and follow appropriate safety procedures.

Cournoyer et al. (2005:17) suggest that these safety management programmes use the Safe Work Practices, which consists of defining the work; identifying and evaluating the hazards; developing and implementing controls; performing work safely; and providing feedback and continuous improvement. Firstly, the work components and processes must be defined in sufficient detail to enable the hazards and the situations or circumstances in which they could cause harm to be identified and evaluated by workers and supervisors. All chemicals must be properly identified, for example, Chemical Abstract Service (CAS) number; manufacturer; a bar code number; and information such as the size of container, the material in the container, the owner, and the location by building and room number. In particular, specific activities will list the chemicals used in a chemical operation. Certain chemicals (known human carcinogens, chemicals of high-acute or high-chronic toxicity, or known human reproductive toxins) shall be used in *designated areas* in which access is restricted to authorized personnel. The necessary safety controls must be put into place. The data must be stored electronically for ease of use.

Reeve (2002:2) has grave concerns that the natural processes are being disrupted by people to such extent that the quality of life, or even life itself, is being threatened. There are many indicators suggesting that the world is at a crisis point, for example, the rapid population growth which is coupled with the consequential growth in energy consumption. This crisis will bring about an early depletion of natural resources and cause inevitable environmental damage. There will be a parallel production of waste and pollution on earth. It is very ironic that the world is developing rapidly and, at the same time, the very development will destroy it.

2.8 Unsafe incidents, what went wrong

Kletz (1999:25) examines the numerous unsafe incidents and analyses what went wrong. These case studies give actual accounts of the incidents and suggestions on how to prevent similar tragedies. Many of the incidents described are similar to the incidents that occurred in the company that is been investigated and are very relevant to the thesis.

- Proper preparation for maintenance and acceptance of equipment is key in any successful completion and startup of equipment being maintained. A case in point was when three operators were killed due to the pump not being properly isolated and cleaned of all chemicals.
- All modifications, big, small, temporary or permanent, must be planned and reviewed by all the relevant experts and users to ensure that nothing is overlooked which will jeopardize the safety of the chemical processes. Many unsafe incidents have occurred due to procedures not being followed.
- Incidents caused by human error is one of the biggest contributors to accidents. These errors occur, even if the person is well-trained. Routine operations are relegated to the lower levels of the brain and are not continuously monitored by the conscious mind. It is difficult for a person to give his/ her full attention to all that is done in a day. This attention lapse gives rise to the slips that people make daily. Plant designs should consider a high level of automation with computer control for mundane and specialised tasks.
- Incorrect labelling on equipment, instruments and chemicals has caused many

incidents. For example, sampling points on tanks with no labelling caused the operator to take the incorrect sample. A lifting device, with a lifting capacity of 15 tons, had a label of 20 tons. This error resulted in more weight being lifted than its capacity. An operator was requested to control the temperature of a reactor at 60°c. The scale actually indicated 0%-100% of a temperature range of 0%-200%, so the set point was actually 120°c. This error caused a runaway reaction resulting in the operator being injured.

- Many incidents have taken place at storage tanks with over-filling being very common. This malpractice is mainly due to faulty equipment and operator error. Today, many companies fit high level alarms on tanks. However tanks are still overfilled due to untested alarms. Tanks sometimes get sucked in or blown out.
- Product spills, caused by leaks, is one of the biggest hazards in chemical plants. Many product leaks have occurred because operators have left drain valves open to drain off water bottoms and drained off product once the water had drained off. This was due to the operator not monitoring the operation. In one incident the operator drained out water off a benzene line and was busy with another task. The benzene also ran out and was ignited by a heated column. The seriously injured operator died.

2.9 Attitude and behaviour for safe work ethics

Robbins (2001:75) explains that employees are most likely to respond to change efforts made by someone who is liked, credible and convincing. People will be more apt to identify and adopt the message. Credible implies trust, expertise and objectivity. An employee is more likely to change his or her attitude if that employee sees the person as believable. Finally, successful attitude is enhanced when arguments are clearly and persuasively presented. This attitude is important in correcting poor safety behaviour.

Geller (2005:44) argues that people teach children safety with bikes and toys, water safety and fire safety. Safety is also practiced in home workshop and in yard work. It is important to take a little extra time to do something safely rather than a quick shortcut to disaster.

Safety becomes a value and not a priority that can be changed according to conditions or schedules. This ideal situation is achievable only with application of a number of safety principles. Statistics have shown that the greatest percentage of workplace injuries are caused by unsafe behaviours rather than unsafe conditions. The focus of any effective safety programme needs to be on these factors in order to be successful. Safety needs to be more than just wearing the proper PPE; it needs to be a value and an attitude change.

Holbeche (2005:75) states that to improve behaviour and attitudes and re-energize employees in a changing organisation, it needs to revitalise by performing a revitalisation checklist. Table 2.1 is self-explanatory.

Table 2.1: Revitalisation checklist

◦ Carry out and occasional emotional audit (use the grape vine). How are people feeling, what are the issues that bother them? Identify bottlenecks and deal with them.
◦ Use communications to change to revitalize people, give them a chance to make suggestions. Provide feedback on organizational progress.
◦ Paint roadmaps, which feature the direction into the future and some of the past. Praise people for their past contributions.
◦ Create and sustain pockets of good practice.
◦ Provide feedback and challenge but not blame.
◦ Give people the chance to take stock of their skills and capabilities. Make sure the individuals, own aspirations are taken to account in development planning.
◦ Bring in some new blood to assist in promoting change. It may be difficult to change people that have been long in the organization.
◦ Reward people that are innovative, flexible and deliver outstanding results.

Source: Holbeche (2005:75)

2.10 Organisational safety culture

Erickson (2006:4) enquires if companies are effectively assessing the impact of corporate culture on safety performance? Numerous studies have demonstrated the importance of organisational cultural issues such as management commitment, employee involvement, communication and treatment of employees as pivotal to the success of a safety programme and other areas of organisational functioning.

Assumptions about human nature can be either essentially positive or negative. If positive, people seem to be striving, caring and working safely. Conversely, with negative assumptions about human nature, people seem to be goofing off, not caring and purposely working unsafely. The following variables must be first considered on the assumption to cause, affect or influence the outcome. These variables must be taken into account and explained before reviewing employee behaviour as the fundamental cause of injuries and accidents. Examples of some of these variables include:

- Fatigue;
- Ineffective communication;
- Overtime;
- The environment – temperature, air quality and humidity;
- Job complexity ;
- Psychological stress – work-related, financial and marital;
- Injury and accident investigations – objective, thorough root-cause analyses;
- Adequacy of training;
- Maintenance errors;
- Production pressures;
- Mental and physical capability to perform task(s); and

- Organisational culture.

2.11 Safety design considerations in new chemical plants

Koolen (2001:9) states that new chemical plants need to be inherently safer and environmentally sound in design. The plant has to minimise all potential risks that are associated with chemicals. All hazardous materials should be minimised by JIT material control and by diluting or replacing high hazardous materials with weaker ones. The plants must be made fool-proof against operator errors by automation with the minimisation of valves and over-rides. The 21st century plant incorporates an optimal designed safe and reliable plant, operated hands-off at the most economical conditions.

Rauch (2003:191) argues that chemical plants must be planned and operated in such a way that they pose no unacceptable risk to people and the environment. A plant is only safe if the pressure and temperatures are controlled and kept within the plant. A safety plan consists of the following:

- Minimising the risk associated with the chemical reactions, pressures and temperatures;
- Suitable location;
- Suitable material and equipment;
- Safe control of the operation;
- Safety-conscious planning details, including primary protection features; and
- Secondary safety features to prevent any unforeseen mishaps.

Das (2005:194) identifies the "Twelve Principles of Green Chemistry" which are needed to curb most of the unsafe incidents that are found to be prevalent in chemical industries today. Five of the twelve principles guiding the green chemical manufacture and processing are:

- Prevent waste-it is better to prevent waste rather that cleaning the waste thereafter. In green manufacture, one must not create any waste. This waste is an additional

cost to the business;

- Use the least hazardous chemical synthesis- wherever practical, synthetic methods should be designed to generate products that possess little or no toxicity to health and the environment;
- Design safer chemicals-when chemicals are designed their structures must provide favourable environmental properties as reduction in toxicity and carcinogenicity;
- Use safer solvents and auxilliaries- safer solvents such as water, alcohols, supercritical carbon dioxide. Or biodegradable solutions must be used rather than chlorinated solvents; and
- Choose inherently safer chemistry for accident prevention- chemical combinations must be examined carefully in order to prevent major chemical accidents by the combination of unlike products. These accidents include releases, fires and explosions.

Vogel (2005:317) argues that safety is one of the key aspects that need to be considered and designed in the construction of the plant. Safe and environmentally friendly plants can operate economically. Some of the aspects that will be closely reviewed are-qualification of the employees, material properties, the process, the location, design of the plant and the requirements of the authorities and of the board of directors. The engineering phase must consider the following- location of critical equipment, emergency escape routes, the proper functioning of shut down and safety systems, explosion proof design, prevention of static charging, and fire protection for important components in the plant.

2.12 Interpersonal skills and the reduction of unsafe incidents

Woods (2006:237) advises that good interpersonal skills are a key factor in reducing or keeping unsafe incidents at bay. These skills include the following:

- Communication- this involves writing and speaking correctly by identifying multiple audiences and answering them properly. Communication must have content that will support a conclusion. Communication must be well organised, interestingly styled and grammatically correct;

- Listening- this includes focusing attention on the talker. Avoid any distracting behaviours. Show respect and acknowledge the speaker. It must be noted that untrained listeners only retain between 25 to 50% of the conversation;
- Trust- build and maintain trust. Trust glues relationships together. Don't do anything that will hurt the other person. Do keep commitments to yourself and others. Clarify expectations for yourself and others. Show personal integrity, honesty and loyalty to others. Apologise when wrong. Take time to see things from the other person's perspective;
- Pride and unwillingness to admit error-each person has pride and self-esteem and will not readily admit his/ her errors. Be human and admit. People around will accept a person better;
- High and low stress- extreme levels of stress impacts on ones judgment and performance at work or play. This will have a direct bearing on all the unsafe incidents;
- Alienation and lack of motivation- Motivation is an important factor in the work environment. Employees must have a clear idea on their expectations and rewards as incentives. People are demoralised when performing very well and don't receive deserved rewards. The work surroundings also play a big part in individual motivation; and
- "I know best" attitude- in many cases people fail to carry out orders as requested because the instructor knows best. The employee may be old and lacks discipline and motivation.

2.13 Critical aspects for reducing unsafe incidents

Fullwood (2000:34) believes that other safety aspects have to be considered. These are:

- Managing change is critical. Any modifications to equipment, procedures, raw materials, and processing conditions must have a written management of change review and approval done before the change is implemented. Temporary changes must not be tolerated;

- All incidents must be investigated properly using management systems which must include root cause analysis. This investigation is to identify underlying causes and implement steps to prevent similar incidents from occurring. Employers must have in-house capabilities to investigate incidents that occur in their facilities;
- Emergency preparedness is the capability of the plant to respond to any disaster that will have disastrous consequences on all forms of life and the environment. These could include fire and rescue teams and associated equipment, links to local and national emergency teams, links to chemical safety data bases, and emergency and disaster plans with training and preparedness to effect such emergencies; and
- The carrying out of regular compliance audits on the safety management system to ensure full compliance. The audit team must have the necessary experience and knowledge on safety compliance plant operations, systems and procedures.

Lieberman (2003:414) describes hazardous piping configuration. This configuration takes place when the product flow is restricted by having alternate ninety degree bends next to each other. This restriction creates tremendous stress and pressure in this section due to the flow changing momentum at the opposing angles. This momentum speeds up erosion within the pipe and an unsafe incident occurs. Relief valves are prone to plugging by the product, corrosion, salt or coke. This plugging becomes a dangerous situation if excessive pressures cannot be released. There could be an explosion. Regular maintenance is critical in ensuring a safe operation.

Marshall and Ruhemann (2001:273) state that organisations must have, as part of an overall safety management programme, the following aspects:

- Safety policy detailing the company's approach to health and safety;
- Organisation-there must be a transparent and rational management structure with clear lines of authority, responsibility and accountability;
- Personnel- safety depends on the attitude and the motivation of the employees of

the company. Inadequate staffing compromises safety. The staff must be competent by proper skilling so that the company can operate safely. Supervisors and managers must have enough education, training and experience to be able to:

- Understand the hazards of the operations under their control;
- Implement predetermined procedures;
- Being aware of their limitations in their knowledge and consulting others when necessary;
- Clearly instruct contract workers on the safety requirements when executing all work on site;
- Execute risk assessments thoroughly;
- Develop and maintain a culture of safety to all levels of the company; and
- Continuously monitor and improve working methods to improve safety.

2.14 Reduction of environmental pollution

Cheremisinoff (2002:53) states that there is constant air pollution from chemical plants in their normal operations from pumps, valves, flanges, storage tanks, loading, unloading and waste water treatment operations. These plants handle some of the worst chemicals known to man, for example, ethylene, propylene, butylenes, benzene, toluene, xylene, methanol, acrylonitrile, phenols, anhydride, aniline, including carcinogens such as butadiene, 1,2-dichloroethane and vinyl chloride and many toxins. Many tons of pollution takes place daily and the figures go up drastically if one includes major spills or any major chemical releases. A typical refinery may release about 2500 tons of alkenes such as propylene and ethylene in producing 500000 tons of ethylene per year. If this figure is multiplied by the number of refineries globally, one finds a number of unsafe incidents at the plant under investigation, includes many air pollution incidents. This danger is of grave concern to all stakeholders. Specific pollution prevention methods include the reduction of air emissions and pollutants (see Table 2.2). There is an urgent need to recycle and use chemicals for longer periods and ensure continuous improvement of all operating procedures. These methods must be incorporated into the new plant designs.

Table 2.2: Examples of pollution prevention practices in chemical industries:

Source Category	Pollution Prevention Practice
Reduction of air emissions	1.Minimise leakages of volatile organics, including benzene, vinyl chloride , and ethylene oxide, from valves, pumps glands, flanges and other process equipment by following good design practices and equipment maintenance procedures. 2. Use mechanical seals where appropriate. 3. Minimise losses from storages tanks, product transfer and process areas by adopting methods such as vapour recovery systems and double seals for floating roof tanks. 4. Recover catalyst and reduce particulate emissions.
Elimination or reduction of pollutants	5. Use non-chrome-based additives in cooling towers. 6. Use long-life catalysts and regeneration to extend the cycle.
Recycling and reuse	7. Recycle cooling water and treated waste water to the extent feasible.
Improved operating procedures	8. Segregate process water from storm water. 9. Optimize the frequency of tank and equipment cleaning. 10. Prevent solids and oily wastes from entering the drainage system. 11. Establish and maintain an emergency preparedness and response plan.

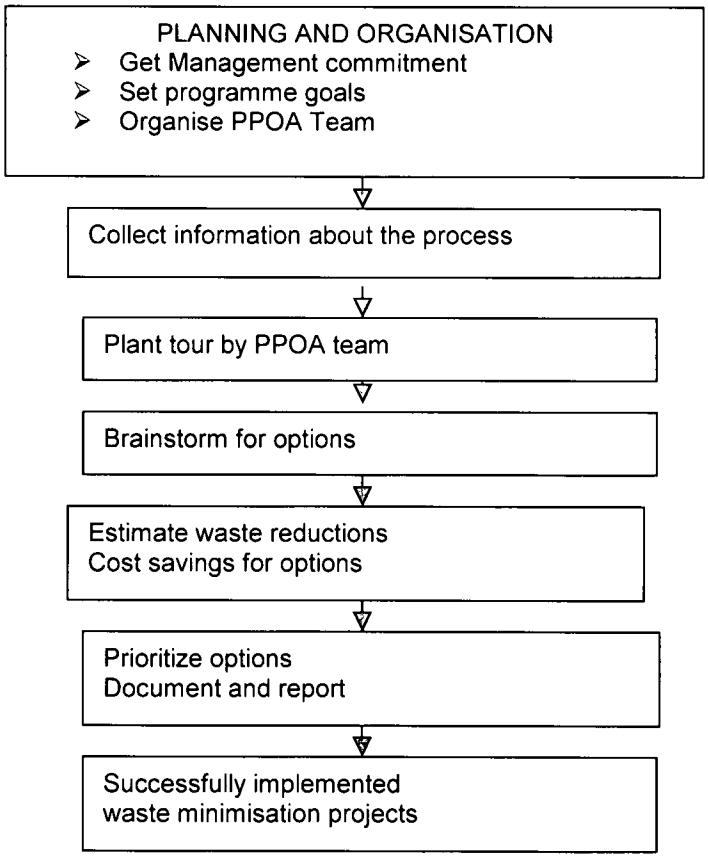
Source: Cheremisinoff (2002:53)

Ghassemi (2002:24) argues that many of the unsafe incidents relate to pollution. Pollution directly damages the environment and lives. Every company that handles hazardous materials must have an entrenched pollution prevention plan. The author refers to this plan as Pollution Prevention Opportunity Assessment (PPOA). It is a plan that will assist the employees to identify the amount of waste that is generated and find opportunities in reducing the amount of waste. The PPOA consists of the following steps:

- Understand the plant's processes and waste production;
- Identify options for reducing waste; and
- Determine if the options are technically and economically viable.

The initial process of a PPOA is to motivate all employees, including management, to get involved in this programme. Top management must issue a policy statement about total waste reduction. Table 2.3 gives a step-by-step breakdown on how to implement the pollution prevention opportunity assessment to reduce pollution.

Table 2.3: Planning a pollution prevention opportunity assessment for a process



Source: Ghassemi (2002:24)

Schmidt (2005: 526) explains the importance of companies in using chemical engineers to

solve environmental problems. Engineers design and operate the plants and have the ability in understanding the complexities of pollutants that are produced by the chemical processes. This means that plants must be designed to produce less pollutants and good methods to clean up. There must be safe methods in place. The chemical engineers must also understand biological and toxic reaction on human beings in order to control and make plants safe. The public must be educated about environmental issues. Engineers must ensure our chemical processes are safe and must make sure employees take responsibility for working safely.

Sullivan, Agardy and Traub (2001: 49) examine what environmental law means to different people. To the environmentalists, the law may mean the fundamental right to clean water. To the politicians, it may be a vehicle of public popularity or public scorn. To government agencies, it may be viewed as a powerful tool. To industry, it may be considered as vague regulations or as a necessary evil of doing business. To academicians, it may be a body of law incorporating constitutional, tort, property and administrative laws. To the realist, it may be seen as a scattered attempt at addressing developing problems with no solutions to problems. For the lawyers, it may mean that it is "in vogue". An authority on environmental law, David Sive states that "there is only one Earth" and it should be reason enough to develop a massive body of law, that is, environmental law to save the world from total destruction.

Jordening and Winter (2005:56) advise that wastewater plants have changed from being pure "end-of-pipe" units to being modules that are fully integrated into the production process. This change is referred to as production-integrated environmental protection and post-positioned wastewater purification. This design is cost effective as single flow fraction can be cleaned at higher concentrations at source rather that mixed fractions at external wastewater treatment plants. The production- specific amounts of water, wastewater, and pollutants loads should be ascertained, as well as the characteristics of the different flow fractions of the company and the places where alkalis, acids and detergents are used. The final comparison and evaluation to be considered are operational safety, economic viability,

sustainability and overall concept.

Erickson and King (1999:232) identify further environmental pollution prevention methods as follows:

- Improve on drum management by reducing leakers and spills;
- Expand chemical containment to all chemical storage areas;
- Reduce hazardous chemicals with non-hazardous ones;
- Manage and account for all chemical losses;
- Segregate all solid waste to allow for recycling; and
- Eliminate all underground storage tanks.

2.15 Handling of hazardous chemicals

Carson and Mumford (2002:67) state that many of the unsafe incidents involve hazardous chemicals. The authors believe that toxic chemicals, if not handled carefully, will pose a major risk to life. These chemicals will enter the body by inhalation, ingestion and absorption through the skin. Many of these toxic chemicals can attack living tissue and cause skin ulceration, and in severe cases, chemical burns, which lead to charring of the cells.

Some chemicals are carcinogens (cancer causing). People get cancer by being exposed and breathing these chemicals over a short or long-term. Table 2.4 lists some of the cancer causing chemicals and what organs can be damaged. Therefore people working with these chemicals must use protective equipment before handling these chemicals.

Table 2.4: Chemicals which are carcinogenic to humans:

Chemical	Effects
4-Aminobiphenyl	Bladder- carcinoma
Arsenic	Skin, lung, liver-carcinoma
Asbestos	Respiratory tract- carcinoma
Benzene	Blood -leukaemia
Benzidene	Bladder-carcinoma
Bis (chloromethyl) ether and technical grade chloromethyl ether	Lung- carcinoma
Chromium	Lung- carcinoma
Isopropanol	Respiratory tract -carcinoma
2-Naphthylamine	Bladder- carcinoma
Soots, tars and mineral oils	Skin, lung, bladder - carcinoma
Vinyl chloride	Liver- angiosarcoma Brain, lung –carcinoma Lymphatic system- lymphoma

Source: Carson and Mumford (2002:67)

McKinney (2004:414) describes the classification of hazardous chemical waste in terms of the Resource Conservation and Recovery Act (RCRA):

- Ignitability: Poses a fire hazard during routine handling;
- Corrosivity: liquid wastes having pH equal to or less than 2.0 or equal to greater than 12.5;
- Reactivity: unstable material, reacts violently with water, produces toxic gasses or is explosive; and
- Toxicity: extractable material in water that is biologically toxic.

The groups above have been further classified in the following manner:

- F-List: hazardous wastes from non-specific sources e.g. Degreasing solvents, metal plating and chlorinated organic wastes;
- K-List: hazardous wastes from processes such as wood preservation, pigment

production, chemical/ refining, iron/ steel, explosives and pesticide production;

- P-List: hazardous wastes from commercial chemical products, container residue and toxic spillages that produce more that 1 kilogram a month; and
- U-List: hazardous wastes similar to the P-List but can be accumulated to a maximum of 25 kilograms per month.

The above classification is in place so that the authorities have greater control over the hazardous wastes produced by the industries and can manage environmental pollution better.

2.16 Human error in chemical handling

Marshall and Ruhemann (2001:273) state that human error will always be present and leads to many unsafe incidents. Blame must not be attached unnecessarily to human error, if it is purely accidental. The root cause must be found and the situation rectified. It is important that clear and unambiguous instructions are given. Workers, at all levels, must be treated with respect and allowed to develop their skills to reach their full potential. The welfare of the employees must be considered when they are requested to work excessive hours which create stress and diminish their ability to work safely. It must be accepted that a healthy and well motivated workforce is a pre-condition for safety.

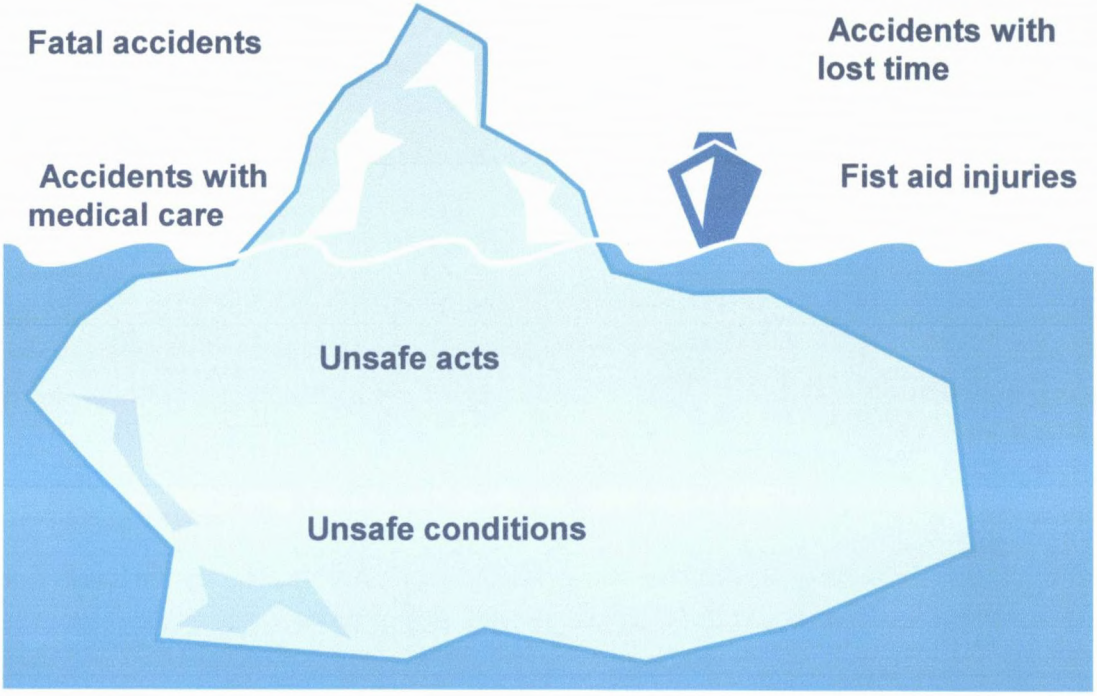
Safety systems must be reviewed and audited regularly to verify effectiveness by checking the following:

- Are the permitting systems working properly?
- Are the number of unsafe incidents decreasing or increasing?
- Are there many near misses or injuries?

These are all indicators of major unsafe incidents waiting to happen. The iceberg theory (Figure 2.1) states that what is exposed is only a third on the real situation. As long as there are many minor incidents which are not carefully investigated and resolved, the chances of some of them resulting in more serious accidents is high. Many companies

don't pay much attention on the minor incidents and only investigate the more serious ones. This is a grave mistake as the iceberg principle indicates that one must drastically reduce the number of minor ones to save the fatalities.

Figure 2.1: The Iceberg Principle



Source: Dupont safety program (2004)

2.17 The mixing of incompatible chemicals

Hackman (2002:7) states that incompatible chemicals have been mixed and resulted in major explosions and major fires. These fires occur because chemicals are not being identified properly or the markings have come off. It is critical that all chemicals have their international markings for identification so that identification can be done by anyone around the world. Recently, graphics have also been used so that illiterate persons can also identify the chemical. This is also a requirement of the OSH Act. In an accident, the

emergency response personnel will be able to render the correct assistance to stabilize the situation quickly. When storing chemicals in drums it is very important to store by compatible groups and not mix hazardous groups together. If these chemicals should leak and mix, then it will lead to disaster, for example, a bleve. A bleve is where hot flammable chemicals tanks super heat and explode sending the burning chemicals for kilometers around. This situation is also true for the labelling and identifying of all process equipment including valves, pumps, lines, tanks, heaters and associated equipment.

2.18 Life cycle thinking for new safe chemical plant design

Azapagic, Perdan and Clift (2004:207) explain that the method of designing and building chemical plants has led to many costly unsafe incidents. The authors say that the new thinking in plant designs is to consider identification of stakeholders and sustainability design criteria. This thinking is based on the life cycle concept which is the same as "cradle to grave". All stakeholders must be considered, for example, employees who will own and operate the company, investors, neighbouring communities and citizens, non-governmental organizations and governments. Each stakeholder will have an interest in the life cycle of the project. The environmental impacts are the major factors that must be considered carefully in the design as it will cause the most damage to life and the environment.

In "Life Cycle Thinking", sustainability design criteria from Table 2.5 must be considered in the overall process design in today's plants. Traditionally, chemical companies tried to fix up chemical spills and waste from their plants by using more chemicals to treat the waste. This procedure created more waste and further pollution and environmental issues. The life cycle thinking looks at proper designed plants that will reduce the creation of waste so that there is no need to create any more waste. In Table 2.5, the economic, environmental and the social criteria are considered in new chemical plant design which will be sustainable in the environment in which it will operate. This design will satisfy the requirements of all stakeholders and will result in a safer plant.

Table 2.5: Sustainable design criteria for new chemical plants for sustainability

Economic Criteria	Environmental Criteria	Social Criteria
Micro-economic : Capital costs Operating costs Profitability Decommissioning costs	Energy use Water use and discharge Solid waste Abiotic reserve depletion Acidification Summer smog	Provision of employment Employee health and safety Citizens' health and safety
Macro-economic: Value-added taxes paid-including green taxes (eg carbon tax) Investment (pollution prevention, health and safety-decommissioning and ethical investments) Potential costs of environmental liability	Global warming Ozone depletion Eutrophication Human toxicity Eco-toxicity	Customer health and safety Nuisance (odour, noise, visual impact, and transport) Public acceptability

Source: Azapagic, Perdan and Clift (2004:207)

Eccleston (2000:152) describes the Environmental Impact Study (EIS) that has to be done before a plant can be developed. The basic points that are investigated are:

- Full and fair discussion on significant environmental impacts and shall inform decision makers and the public of the reasonable alternatives;
- The draft EIS must conform to the scoping process and meet the final EIS requirements;
- The EIS must be clear to the point and in plain language so that all stakeholder can understand;
- All major environmental impacts must be disclosed and discussed in detail;
- All reasonable alternatives must be evaluated and discussed;
- There must be a range of alternative that the decision makers will consider;
- Proposed actions must be discussed that will avoid or minimize impacts to the

environment; and

- The EIS must devote substantial detail to each alternative so that it can be properly studied by the decision makers.

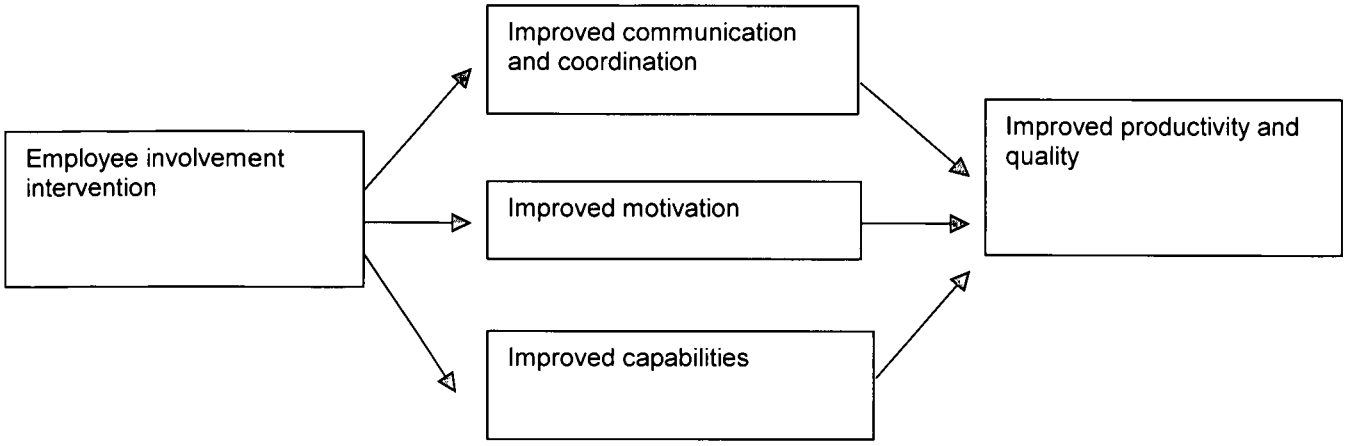
The EIS is done before plants are developed to reduce any future environmental impacts.

2.19 Empowerment of employees

Holbeche (2005:97) believes that organisation design today is placing greater emphasis on enticing people to work where the styles of management are conducive to the high performance culture. There is a growing realisation that strict controls, greater work pressure, more clearly defined jobs and tighter supervision have run their course in their ability in giving productivity gains. Individuals and groups are now the building blocks of organisations today. The key aspects are employee motivation, employees who want to do what is correct, have the knowledge and ability to do what is required. Staff must be involved in the process of design. A common complaint from employees is that nobody listens or asks them when designing. Employees who are engaged, in empowered ways, with autonomy and responsibility have a strong drive to deliver. There are many barriers to empowerment, for example, lack of trust, management delayed action and unclear goals which are not supported.

Cummings and Worsley (2005:308) state that if an employee is given more involvement in making work decisions raises their job satisfaction and makes them do the job with more care and hence make less mistakes which relates in reducing unsafe incidents. Employee involvement can improve their motivation and capabilities which translates into improved performance and quality. This improved performance in turn, results in less or no unsafe incidents (Figure 2.2).

Figure 2.2: How employee involvement affects productivity and quality



Source: Cummings and Worsley (2005:308)

2.20 Unsafe incidents linked to poor skills, no safety equipment and stress

Holbeche (2005:233) postulates that an organisation needs to build competence in all employees in order to reduce unsafe acts. When an individual has the skill to do a job, it is encouragement to do the best. If an employee is not performing, training and mentoring assists to become better. Job rotation, developmental assignments and performance management aim to improve the quality of work produced. Diffusing all kinds of competencies throughout the organisation supports the aim of being able to improvise and to engage in speedy problem-solving and decision-making. This inprovisation will help reduce unsafe incidents.

Hackman (2002:6) advises that many of the unsafe incidents have been caused by some of the operators not wearing personal protective safety equipment. The authors state that many people have many excuses on why they will not wear safety equipment. Some of the reasons are that the equipment is dirty, heavy, ill fitting, and they have worked for many years and nothing has happened to them. There are many more examples that have caused fatalities. Furthermore, operators do not wear their equipment after normal operating hours when management is not around. The basic PPE will depend on the type of chemicals handled. These are PPE for the eyes, head, face and extremities, protective

clothing, respiratory devices, protective shields and barriers. The OHS Act states that the employer must provide workers with the necessary PPE, training on how to use and care for them. Employees must wear PPE by law. The oxygen level in the atmosphere must be between 19.5% to 23.5% to sustain life. The effects of oxygen starvation to human beings is illustrated on Table 2.6.

Table 2.6: The likely effects of an oxygen-deficient atmosphere

Percentage of Oxygen in air	Effect
17%	Faster deeper breathing
15%	Dizziness, buzzing in ears, rapid breathing
13%	May lose consciousness with prolonged exposure
9%	Fainting, unconsciousness
7%	Life endangered
4-6%	Convulsions, death

Source: Hackman (2002:6)

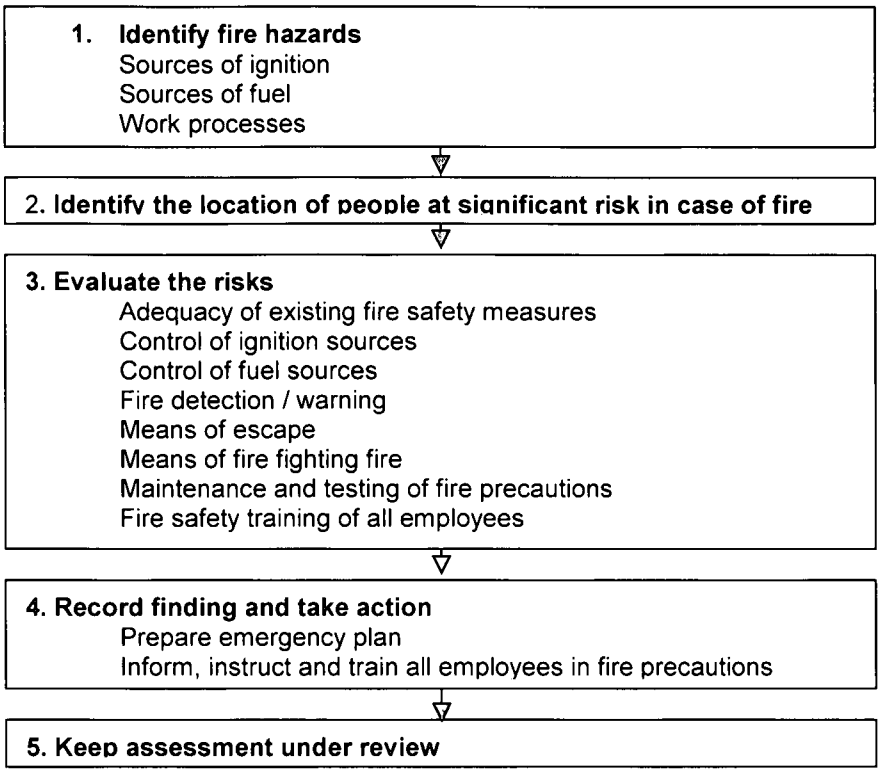
Cummings and Worsley (2005:308) state that stress plays major havoc with employees in industries. Stress has been linked to hypertension, heart attacks, diabetes, asthma, chronic pain, allergies, headaches, backaches, various skin disorders, cancer, immune system weakness, and decreased white blood cells and changes in their function. Stress can also lead to alcoholism and drug abuse. Employees under stress fail to concentrate and perform properly leading to unsafe incident and accidents. There are no stress management programs in this company that all the unsafe incidents occurred.

2.21 Fire and explosions with flammable chemicals

Carson and Mumford (2002:119) identify many chemicals, including dust, that pose a major fire risk. Petroleum vapours can be ignited by sparks produced from someone knocking steel on steel. When non-sparking tools are used, care must be taken to avoid

embedded grit particles which will cause sparks. The impact of steel on rock poses a greater hazard. A common source is sparks from petrol engines have caused many fires. Static electricity has also caused many fires with major explosions on vessels carrying flammable chemicals. Spontaneous fires are caused by two unlike chemicals coming into contact. Some chemicals are water sensitive and can generate flammable or toxic gases on contact with water. The common method to avoid the flammable products from burning is to blanket the products with inert nitrogen. The plants that handle flammable products are required to ban all possible spark and flame sources. This ban includes matches, cellular phones, non- flame proof electrical motors, petrol vehicles and motors, torches and radios. The plants are fully equipped with all fire fighting equipment and staff are trained to fight fires. An emergency plan is also available and regular drills are carried out. Permits must be issued to contractors or employees that are to carry out any hot work at the plants. Figure 2.3 provides steps to follow in carrying out a fire risk assessment at a chemical plant. The steps are easy to follow and will avert the start of fires.

Figure 2.3: Fire risk assessment plan



Source: Carson and Mumford (2002:119)

2.22 Conclusion

In summary, research has been done over a long period on health and safety at chemical companies but there are still many incidents occurring. The key is to reduce these incidents and keep all stakeholders safe. Many companies are still operating in the old paradigm and have not ventured in valuing employees by empowering them to give top performance. The human element is by far the major contributor to the unsafe incidents. Therefore, empowerment and more training must take place to reduce unsafe incidents. Plant designs are also reviewed to incorporate global best practices and the call is for more automation and less human intervention. Chemicals make up the basic ingredients in most manufacturing companies and will be here for a long time. Chemicals must blend in with all the stakeholders and not cause damage to the environment and life. There are some plants that are run very safely utilizing safety standards and have many millions of injury

free man hours of production. Many of the unsafe incidents can be avoided but to achieve maximum profits, most companies stretch all resources to the limit. The sacrifice of safety results in accidents. Today the emphasis is on sustainable development and the satisfaction of all stakeholders with the design, development and operation of chemical plants. Most of the literature reviewed explains the view that chemicals must be handled safely. The guidelines of the "Responsible Care Global Charter" should be implemented if chemical companies are serious about working safely to sustain the world for the future generations.

Chapter 3

Research methodology

3.1 Introduction

Cooper and Schindler, (2001:134) state that research design or methodology is the blueprint for the collection, measurement and analysis of data. The blueprint will include experiments, interviews, observations or simulations. This exploratory study seeks to determine the variables that contribute to the incidents that occur at the selected company. The primary data to be collected will be quantitative in nature. A questionnaire will be used to obtain the information required. The questionnaire was pre-tested for validity by using some staff members. Most of the respondents are from the departments contributing to the incidents. This quantitative study aims to identify the contributory factors influencing unsafe incidents. The data were pre-coded for analysis and the results were presented in chapter four.

3.2 Respondents

A census was conducted. All staff that work in the following service departments, Commercial / Logistics, Maintenance, Compliance and Operations, were requested to complete a questionnaire. A census is normally used when the population size is small as in this case (Cooper and Schindler, 2001:164).

3.3 Data collection method

The gathering of data may be a simple observation at one location to a major survey at sites in different parts of the world. Questionnaires, standardized tests, observational forms, laboratory notes, and instrument calibration logs were among the devices used to record data. Data are defined as the facts presented to the researcher from the study's environment. The data were collected through the use of questionnaires. Each respondent was issued with a questionnaire and the necessary basic explanations. The

questionnaires were collected immediately after completion.

3.4 Research instrument

A questionnaire was used to collect data. Questionnaires are one of the most common methods of data collection. Questionnaires are pre-formulated, written questions to which respondents record their answers, usually within closely defined alternatives (Sekaran, 2000). The research questionnaire was divided into two parts, namely, part one, which provided the respondents with a brief explanation of the study, and part two, the actual questions probing the research. The questionnaire was developed from records of all previous unsafe incidents over the years including input from stakeholders. The questionnaire accessed information on behaviour and attitude patterns, communications, plant and equipment, training and development, planning and workload, safety and any other related aspects. The questionnaire was reviewed, reformatted and approved by a focus group of four managers. The following rating scales were used to obtain the data :

- simple category scale;
- multiple choice, single and multiple response scales; and
- Likert scale.

3.5 Pre-testing and validation

A pilot test was conducted to detect weaknesses in design and instrumentation and to provide proxy data for selection of a probability sample (Cooper and Schindler, 2001:81). An important purpose of pre-testing is to discover the respondents' reactions to the questions. The questionnaire was tested for accuracy through a pilot study by a group of seven staff members. Staff members were randomly selected from the different levels of the company to complete the questionnaire. The questionnaire was further reviewed and corrected for ambiguities and other weaknesses.

3.6 Questionnaire and data preparation

A good questionnaire design should focus on three elements. The first element relates to the wording of the questions, the second element refers to planning of how the variables

will be categorized, scaled, and coded after receipt of the responses. The third element pertains to the format of the questionnaire. The preliminary analytical steps of editing, coding and tabulating the data, which are common to most studies, were used in this study. This process was applied to clean up the data set so that the capturing of errors is minimized. All the questionnaires were pre-coded. The questionnaire was divided into two sections:

Section 1: Demographic characteristics: biographical data were measured relating to the business units, gender, race, age, position, level of education and years of service.

Section 2: Quantitative Analysis : this section had 58 closed ended statements divided as follows:

- Twenty two statements related to behaviour and attitude;
- Six questions related to communications;
- Five questions related to plant and equipment;
- Seven questions related to training and development;
- Nine questions related to planning and work load;
- Six questions related to safety; and
- Three questions related to other aspects.

The Likert scale was used with the neutral point removed. The respondents had to either agree or disagree with the statements.

3.7 Data analysis

Raw data that are gathered from the research have to be summarised and coded for analysis. Data analysis usually involves reducing accumulated data to a manageable size, developing summaries, looking for patterns, and applying statistical techniques (Cooper and Schindler, 2001:82). Sekaran (2000:52) states that data analysis has the following objectives, namely, to get a good feel for the data, secondly, test the goodness of the data and lastly, test the hypotheses for the research. The data gathered for this research were

captured and coded on an Microsoft Excel spread sheet and analysed by using SPSS version 13. The statistical tests conducted were descriptive which covered frequency and percentages, measures of central tendency and measures of dispersion.

Descriptive statistics includes frequencies as well as measures of central tendency, such as the mean, mode, and median, and measures of dispersion or variability, namely, the range, variance and standard deviation and measures of relationship, namely, correlation and regression. Descriptive statistics help to condense large volumes of data into a few summary measures.

Frequencies refer to the number of times sub-categories of certain phenomena occur. From these phenomena, the percentage and cumulative percentage of the occurrence of the sub-categories can be calculated.

Measures of central tendency are useful to describe a series of observations in a data set carefully, and in a meaningful way. These measures enable individuals to get an idea of, or a feel for, the basic characteristics of the data (Sekaran, 2000:64). A central location statistic represents a typical value or middle data point of a set of observations and is useful for computing data sets. The three main measures of the central location are the mean, median and mode.

- The **mean** is the arithmetic average. It is the observed values in the distribution divided by the number of observations (Cooper and Schindler, 2001:442).
- The **mode** is the most frequently occurring value. The mode is the location measure for nominal data and a point of reference along with the median and mean for examining spread and shape (Cooper and Schindler, 2001:443). When every score has a equal number of observations, then there is no mode.
- The **median** is the midpoint of a distribution. Half the observations in the distribution fall above and the other half fall below the median (Cooper and Schindler, 2001:442). When the distribution has an even number of observations, the median is the average of the two middle scores.

Measures of dispersion or spread, alternatively referred to as dispersion or variability, are the variance, standard deviation, range, and quartile deviation. They describe how scores cluster or scatter in a distribution (Cooper and Schindler, 2001:443).

- The **range** is the difference between the largest and smallest score in the distribution. The range refers to the extreme values in a set of observations.
- The **variance** is the average of the squared deviation. The variance is calculated by subtracting the mean from each of the observations in the data set, taking the square of the difference, and dividing the total of these scores by the number of observations.

- The standard deviation summaries how far away, the data values typically are from the average. It is another measure of dispersion for interval and ratio scaled data and offers an index of spread of a distribution or the variability in the data. It is simply the square root of the variance. Like the mean, the standard deviation is affected by extreme scores (Cooper and Schindler, 2001:443).

3.8 Conclusion

In this chapter, the planning process used by the researcher is outlined. The necessary permission was obtained from the said organisation from which the initial group of respondents were selected for the pilot study. The questionnaire was divided into two parts, namely, an explanation and the actual research statements. The statements centred around the following themes:

- Behaviour and attitude;
- Communications;
- Plant and equipment;
- Training and development;
- Planning and workload;
- Safety; and
- Other

The questionnaire was corrected for errors after the pilot test. A census was conducted on the staff working in the departments that contributed most of the unsafe incidents. A Likert scale was used with the neutral point removed so that the respondents had to give an answer and not remain neutral. The main survey was carried out and the data collected, coded and processed. Finally, the results were analysed using SPSS version 13. Descriptive statistics help to condense large volumes of data into a few summary measures including the mean, mode and median.

Chapter 4

Presentation and discussions of results

4.1 Introduction

In this chapter the resultant data will be analysed and presented. The raw data were coded and analysed by using software application SPSS version 13. The results are presented and analysed below for the purpose of the study. In the first part, the biographical results will be presented and then each contributory factor in relevant themes will be presented and finally all the contributory factors under each theme will be presented. The presentation is illustrated in graphical form with detailed explanations.

4.2 Biographical data

The number of respondents by department is shown in Table 4.1 and Figure 4.1.

Table 4.1: Respondents by departments

Department	No
Commercial / Logistics	15
Maintenance	4
Compliance	3
Operations	65
Total	87

It is evident from Figure 4.1 that 82 of the respondents are male and 5 are female. This finding is a reflection of the composition of the said company which is similar to that of the sample. The related chemical industry is highly populated with males. All the respondents from the Operations, Compliance and Maintenance are males and only Commercial/ Logistics has a few females. The chemical companies are now gradually employing females in the operations departments. Biographical characteristics such as age, gender

and ability, which includes intelligence effects employee performance (Robbins, 2001:33).

Figure 4.1: Gender of respondents

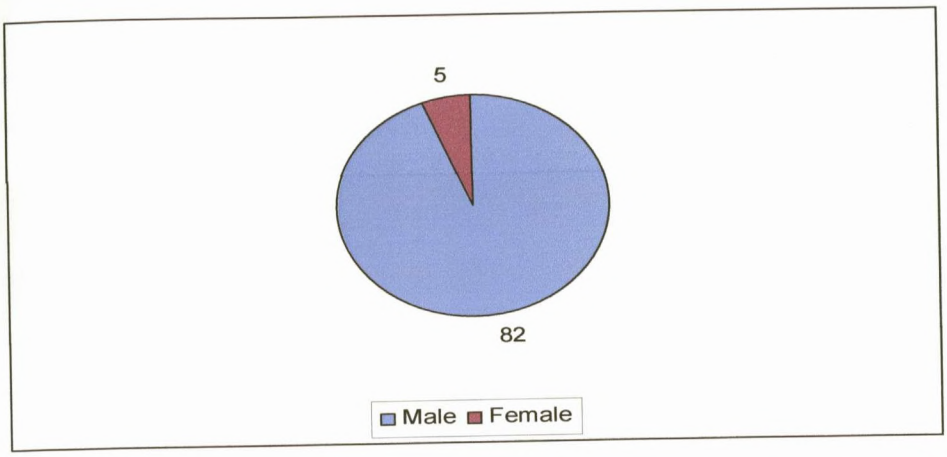
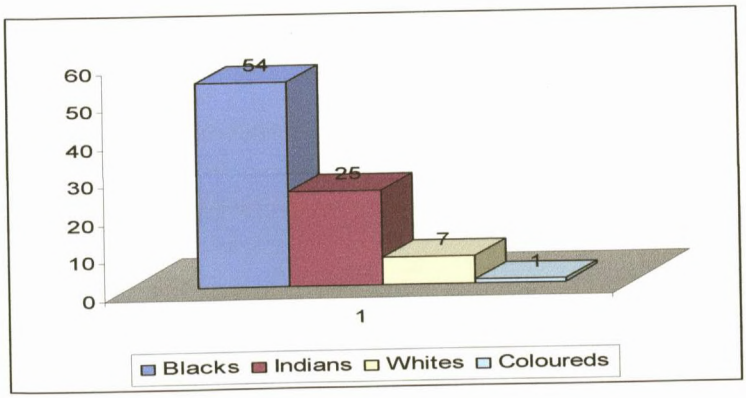


Figure 4.2 illustrates the largest number of respondents (62.1%) was made up of Blacks, followed by 28.7% Indians, 8% Whites and 1.2% Coloureds. These figures are reflective of the demographics of KwaZulu-Natal. The largest number of Blacks work in the operations department, followed by Indians, Whites and Coloureds, respectively.

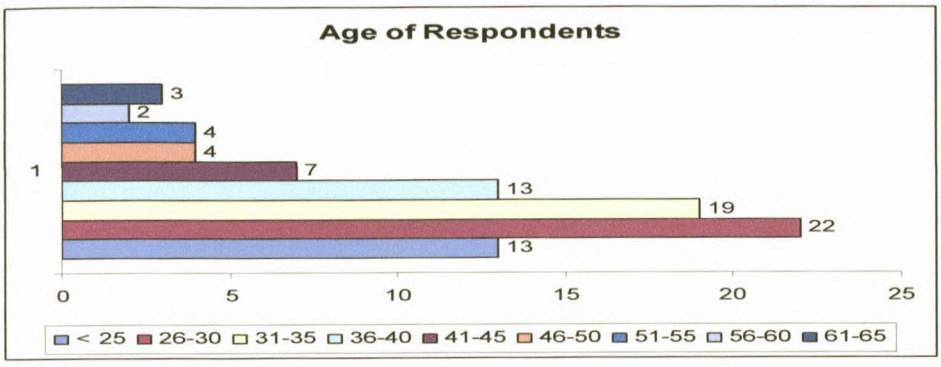
Figure 4.2: Race of the respondents



In Figure 4.3, the largest group is 25.3% and is made up of the 26-30 year olds, the 31-35 group comprises 21.8%, the under 25's and the 36-40 make up 14.9% each. The next

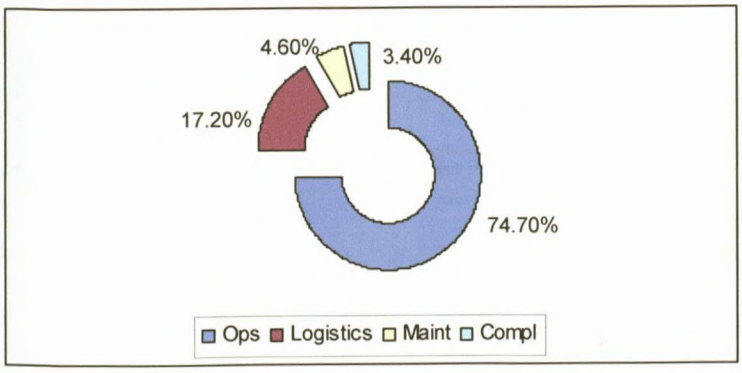
group is 8% and is made up of ages between 41-45 and the rest of the respondents are between 46 to 65. Seventy seven percent of the respondents fall below 40 and 25.3% below 30. This is a young, company with only 23% above 40 years. The older one gets the less likely that one will quit ones job, thereby accumulating experience. The problem may be that one will not produce as efficiently as a young person (Robbins, 2001:34).

Figure 4.3: Age of respondents



As indicated in Figure 4.4, 74,7% of the sample is from the Operations department, followed by Logistics with 17.2%, Maintenance with 4.6% and Compliance with 3.4%. Most of the unsafe incidents have been caused in the Operations Department, where the actual work takes place.

Figure 4.4: Departments linked to respondents



In Figure 4.5, the largest group is made up of operators at 45.9% of the sample. Supervisors make up 12.6%. Contractors and other staff make up 25.3% and Customer Services, Weighbridge Clerks and Operations Administrators make up 16.2%. these findings show that there is strong representation from the operations group, from which most of the unsafe incidents emanate.

Figure 4.5: The Positions of respondents

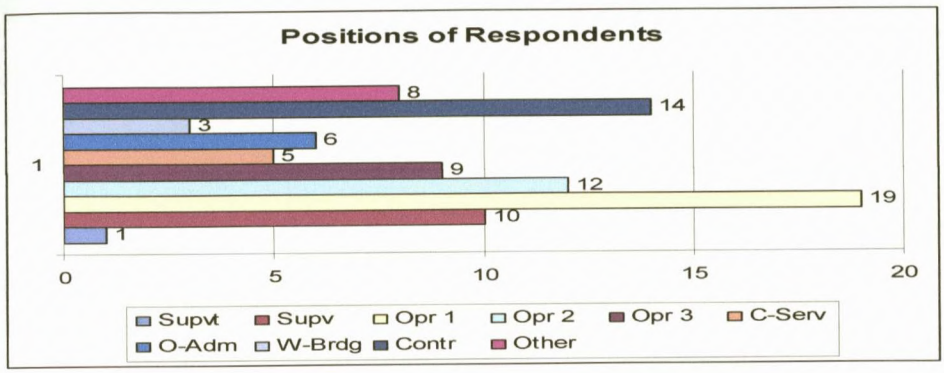
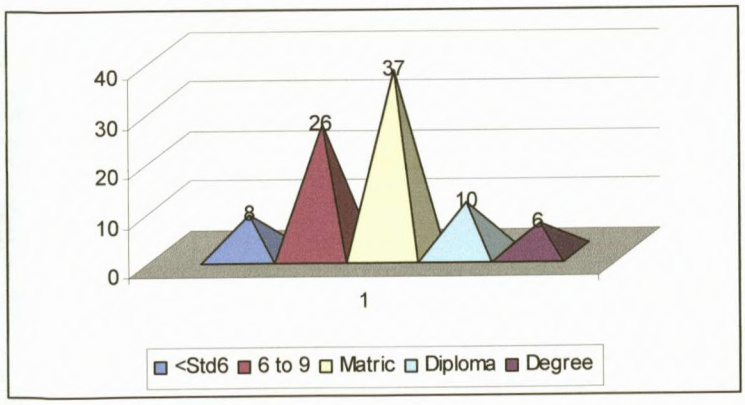


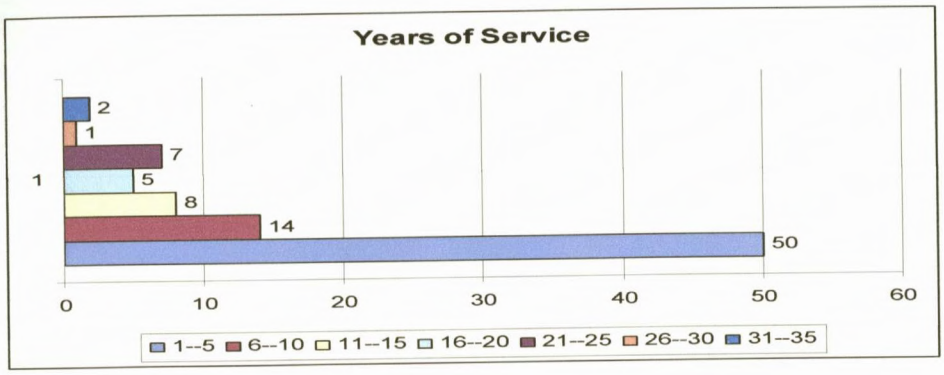
Figure 4.6 indicates, the respondents level of education with 60.9% having a matric including a diploma or degree. The next group (29.9%) has a standard six to standard nine level of education. Only 9.2% has a primary level of education. This level may have more impact in causing unsafe incidents, but this finding has to be verified.

Figure 4.6: Level of education of respondents



As illustrated in Figure 4.7, the sample has 57.5% of the employees with about five years of service. The next three groups are from eleven to twenty years and make up 31%. The next three levels, from twenty one to thirty five years, make up 11.4%, and about half the sample is young and lacks experience. There are very few experienced people.

Figure 4.7: Years of service



4.3 Presentation of research data

The following key contributors were surveyed for the study:

- Behaviour and attitude;
- Communications;
- Plant and equipment;
- Training and development;
- Planning and work load;
- Safety aspects; and
- Other related aspects.

The analysis will assist in identifying the variables that contribute to the high incident rates which impact on the safety and operational performance of the company. Descriptive statistics will be used and the report will be graphically presented with associated tables. Descriptive statistics is a method for presenting quantitative data in a manageable form. The Likert scale was use in the design of the questionnaire. The number 1 on the lower

end of the scale represented the choice of strongly disagree and 4 on the upper end was strongly agree. The neutral point was removed in order for respondents to select an answer and not be neutral. Number 2 represented the choice of disagree and 3 was agree. Respondents had to select the perceived contributors to incidents and unsafe working conditions, as listed under the various headings mentioned under the introduction.

In figure 4.8, the mean values give an indication of the level of perceptions for each factor. Values below 3 indicate that respondents disagreed with the statements. Values of 3 or more indicate that respondents agreed with the statement. The respondents are marginally satisfied with "Other" (blue box) which is expressed by a mean of 3.0498. All the other variables have means below 3, which indicate that many disagree with the statements in those categories and they perceive them to be the marginal contributors to the unsafe incidents. The categories are further examined and it is evident that the key variables need to be improved in the following manner:

- Behaviour and Attitude 65.01%
- Communication 62.45%
- Plant and Equipment 62.82%
- Training and Development 63.03%
- Planning and Workload 68.18%
- Safety 70.22%
- Other 56.43 %.

Safety is a critical requirement in a chemical environment and impacts directly on all the unsafe incidents that have occurred to date and that will still occur. The standard deviation values are low (i.e. below 1) which indicate that there is generally a small amount of deviation from the mean i.e. respondents generally "had the same opinion".

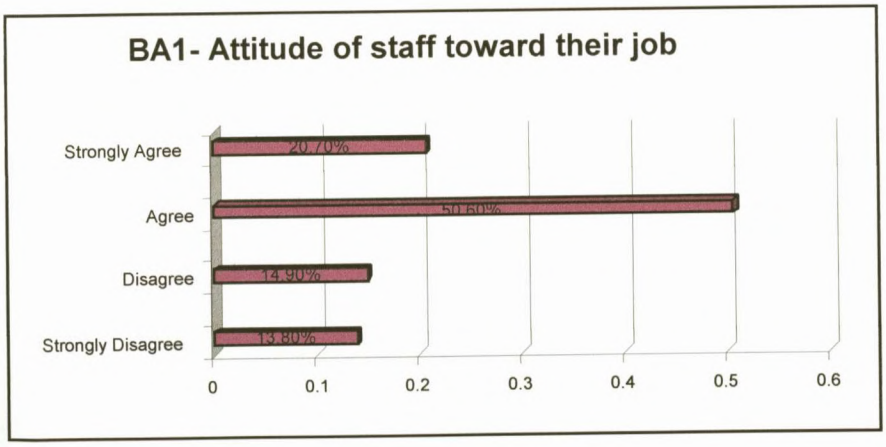
Figure 4.8: Improvement in key variables of the study

	Behaviour & Attitude	Communication	Plant & Equipment	Training & Development	Planning & Workload	Safety	Other
Mean value	2.4493	2.6284	2.6023	2.5878	2.2273	2.0843	3.0498
Mean value (%)	34.99	37.55	37.18	36.97	31.82	29.78	43.57
MV: difference for improvement	4.55	4.37	4.4	4.41	4.77	4.92	3.95
MV: %age difference for improvement	65.01	62.45	62.82	63.03	68.18	70.22	56.43

4.3.1 Behaviour and attitude

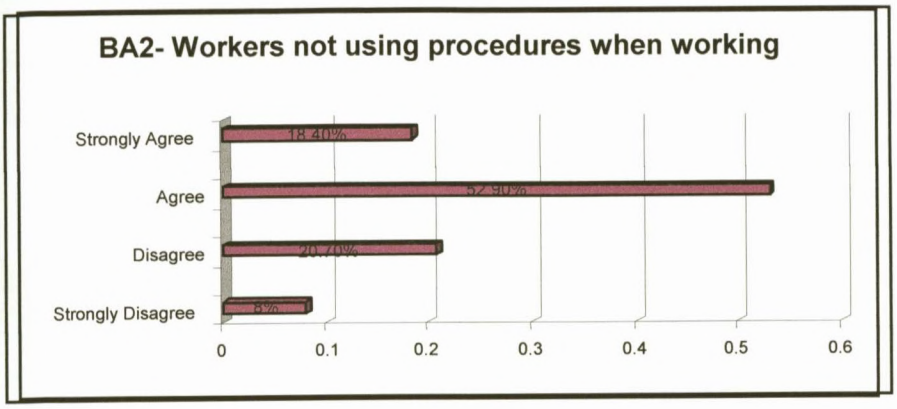
Figure 4.9 indicates that the majority of the respondents (strongly agree 20.7 + agree 50.6 =71.3%) perceived that staff have a poor attitude towards their jobs. Staff do not take responsibility for delivering quality output.

Figure 4.9: Attitude of staff towards their job



The findings in Figure 4.10 indicated that 71.3% (strongly agree + agree) of the respondents believed that employees don't follow procedures and this non-compliance contributes directly to the unsafe incidents. Employees must be taught how to examine a work situation like a safety professional, determine the risk, devise a strategy to minimize that risk, and follow through with safe behaviour (Fivizzani, 2004:9).

Figure 4.10: Workers not using procedures when working



In Figure 4.11, 50% (strongly agree + agree) of the staff indicated that they were treated like children by their supervisors/ managers. Holbeche (2005:75) recommends the following:

- Carry out occasional emotional audits (use the grape vine);
- Check how people are feeling, what are the issues that bother them; and
- Identify bottlenecks and deal with them.

Figure 4.11: Employees are treated like children

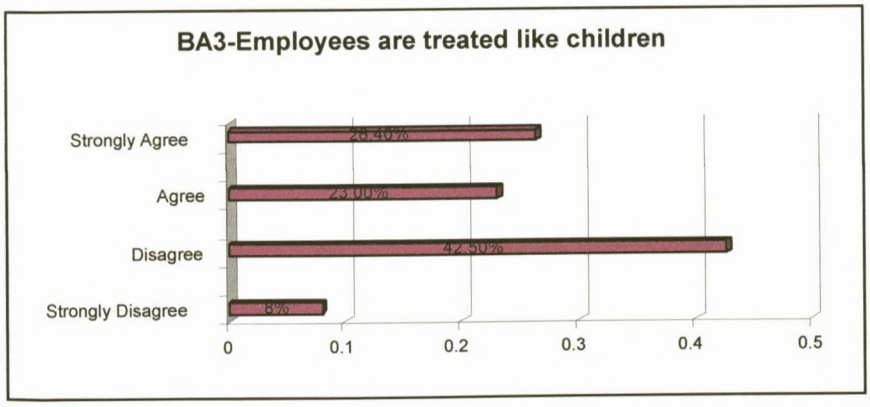
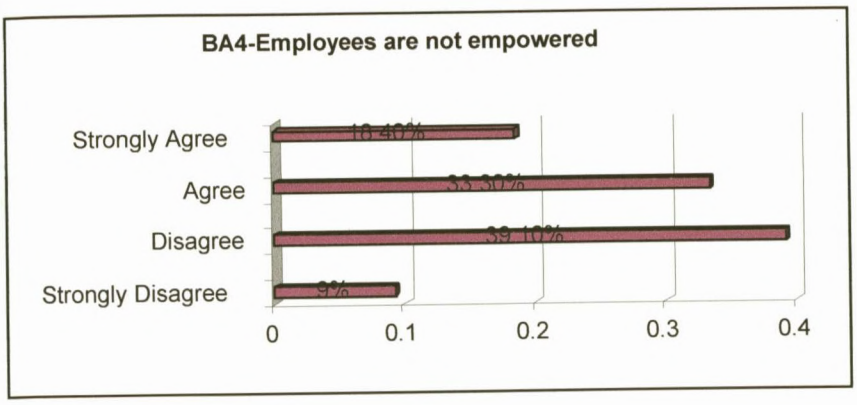


Figure 4.12 shows that 52% (strongly agree + agree) of the respondents indicated that supervisors / management do not empower them to manage their own jobs. When the people who actually do the work are allowed to make their own job-related decisions, both

the speed and quality of those decisions often improve (Robbins, 2001:375).

Figure 4.12: Employees are not empowered



In Figure 4.13, 47% (strongly agree + agree) of the respondents perceived that they are not respected by supervisors / managers. Woods (2006:237) recommends the following measures:

- Listening- this includes focusing attention on the talker;
- Avoid any distracting behaviours;
- Show respect and acknowledge the speaker; and
- It must be noted that untrained listeners only retain between 25 to 50% of the conversation.

Figure 4.13: No respect shown towards employees

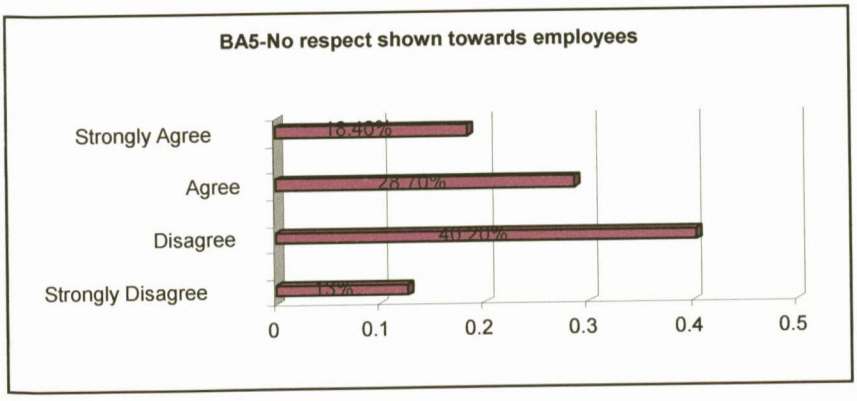
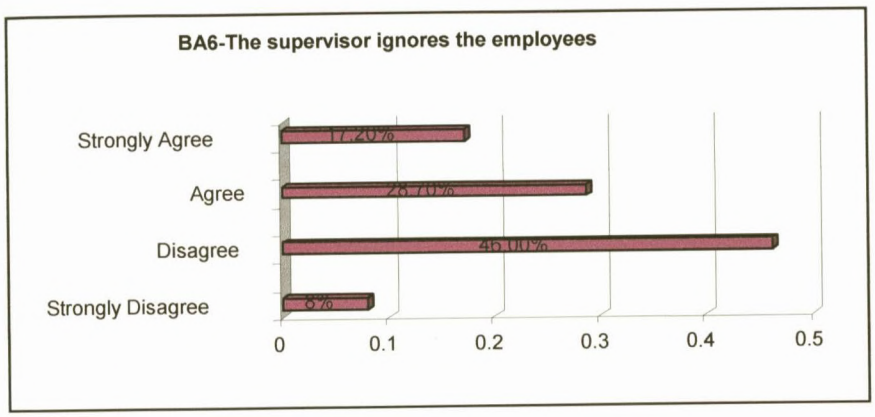


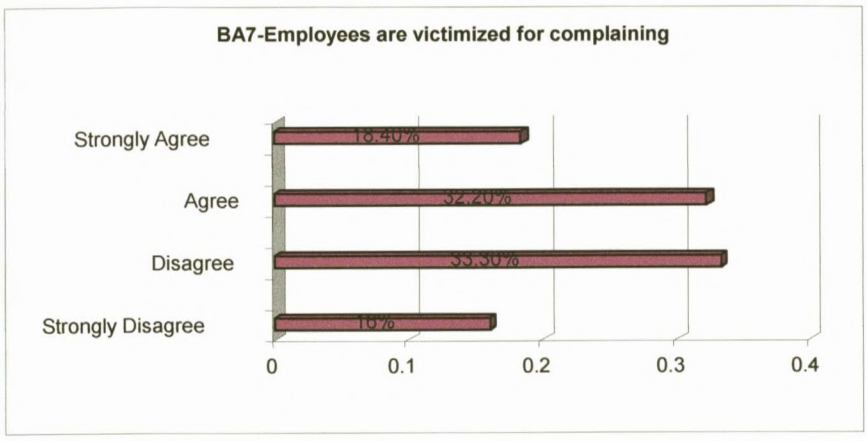
Figure 4.14 indicates that 46% (strongly agree + agree) of the respondents revealed that the supervisors do not listen to them. Listening is a key function in understanding and communications. The difference between hearing and listening is wide. Hearing is merely picking up sound vibrations. Listening is making sense out of what one hears. That is, listening requires paying attention, interpreting, and remembering sound stimuli (Robbins, 2001:303).

Figure 4.14: The supervisor ignores the employees



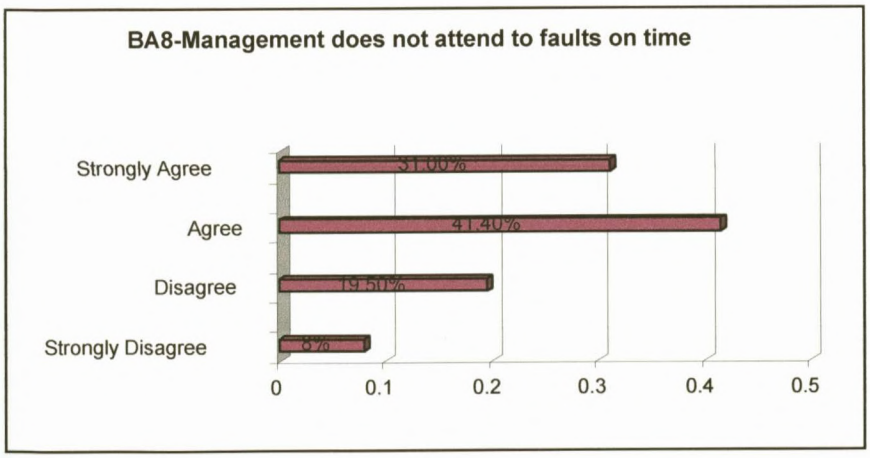
In Figure 4.15, 50% (strongly agree + agree) of the respondents believed that they get victimized when they complain. This finding shows that the grievance system does not work. When people feel that they're being threatened, they tend to react in ways that reduce their ability to achieve mutual understanding. They become defensive and will victimize the complainant (Robbins, 2001:287).

Figure 4.15: Employees are victimized for complaining



As illustrated in Figure 4.16, 72% (strongly agree + agree) of the respondents indicated that faults are reported and no maintenance is done to equipment. Numerous studies have demonstrated the importance of organizational cultural issues such as management commitment, employee involvement, communication and treatment of employees as pivotal to the success of a safety programme and other areas of organizational functioning (Erickson, 2006:5).

Figure 4.16: Management does not attend to faults on time



In Figure 4.17, 38% (strongly agree + agree) of the respondents agreed that the operators

copy the unsafe methods from their supervisors. Specialists covering all aspects of the plant, including safety, must give the necessary lectures, tests and feedback. The general safety training must be detailed in the operating manuals. This detail must cover all the "do's and don'ts" of plant startup and the experiences of similar startups in other plants (Mizrahi, 2002:211).

Figure 4.17: Operators copy unsafe methods used by the supervisors

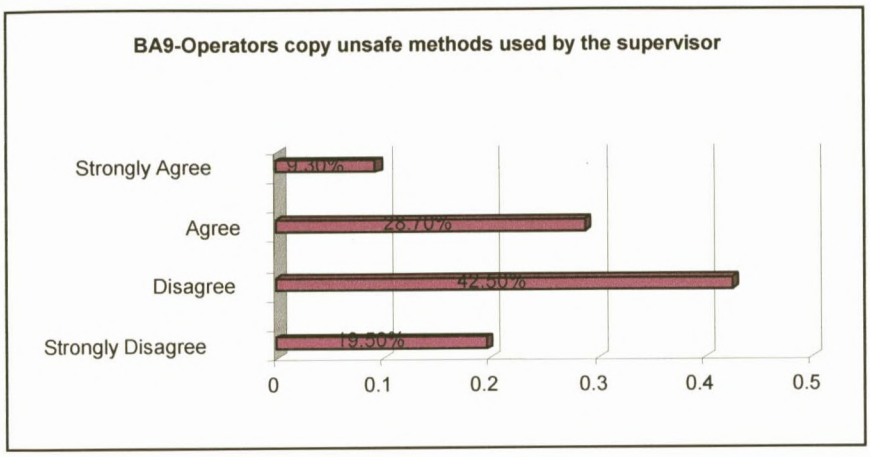


Figure 4.18 illustrates that 22% (strongly agree + agree) of the respondents indicated that the supervisors use foul language on them. A conflict is where a process begins when one party perceives that another party has negatively affected, or is about to negatively affect, something that the first party cares about (Robbins, 2001:384).

Figure 4.18: Operators claim that supervisors swear them

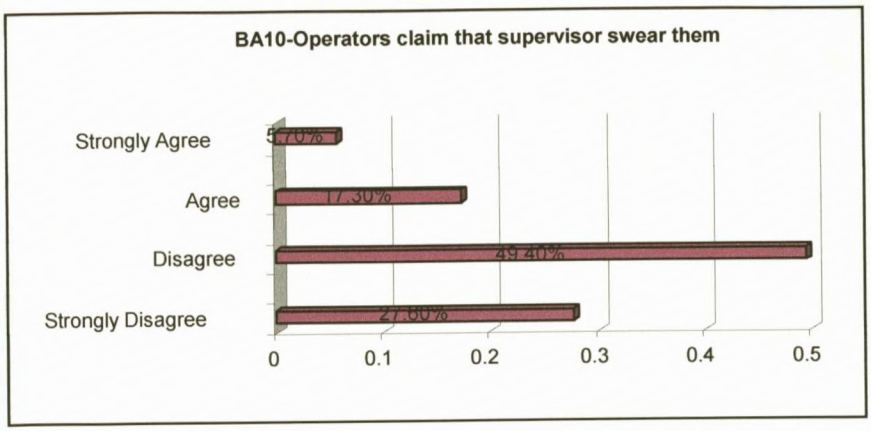


Figure 4.19 indicates that 24% (strongly agree + agree) of the respondents perceived that their personal problems affect their focus on their jobs. Psychological stress – work-related, financial and marital, also contribute to unsafe incidents (Erickson, 2006:4).

Figure 4.19: My job is affected by personal problems

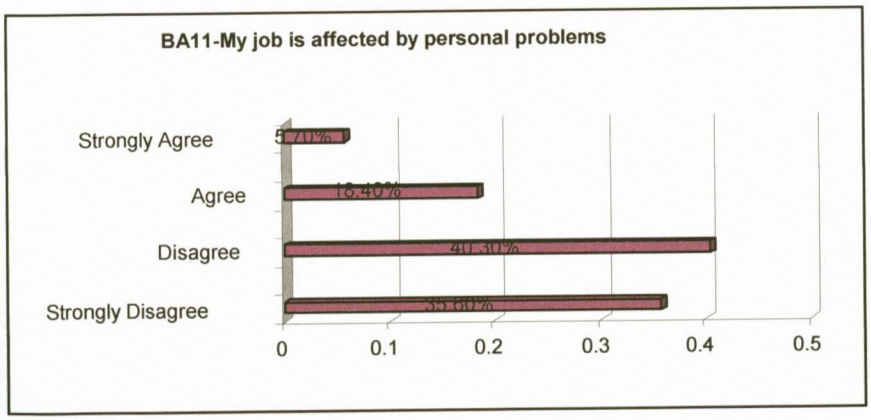


Figure 4.20 illustrates that 24% (strongly agree + agree) of the respondents indicated that they are not treated with respect by their fellow workers. Woods (2006:237) recommends the following:

- Build and maintain trust. Trust glues relationships together;
- Don't do anything that will hurt the other person;

- Commitments must be kept to yourself and others;
- Clarify expectations for yourself and others;
- Show personal integrity, honesty and loyalty to others;
- Apologize when in the wrong; and
- Take time to see things from the other person perspective.

Figure 4.20: Workers show little respect for each other

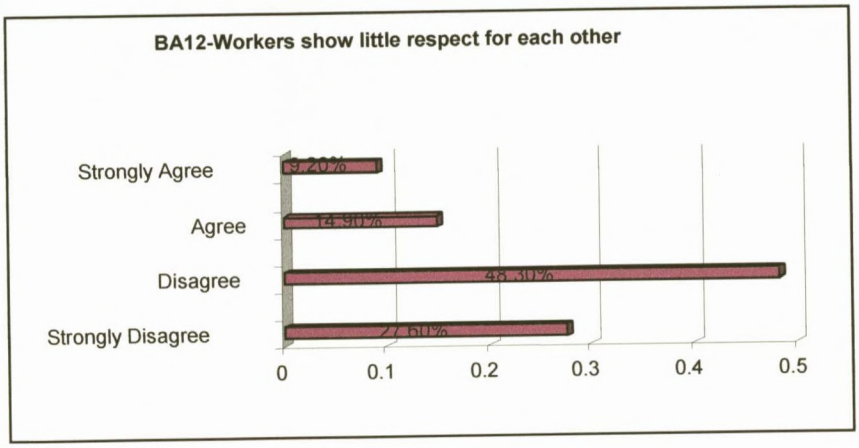


Figure 4.21 indicates that 37% (strongly agree + agree) of the respondents agreed that employees use short cuts in order to complete the job quickly. There must be regular evaluation of training programmes to determine if the necessary skills are being learnt (Fullwood, 2000:31).

Figure 4.21: workers use short-cuts to finish the job quickly

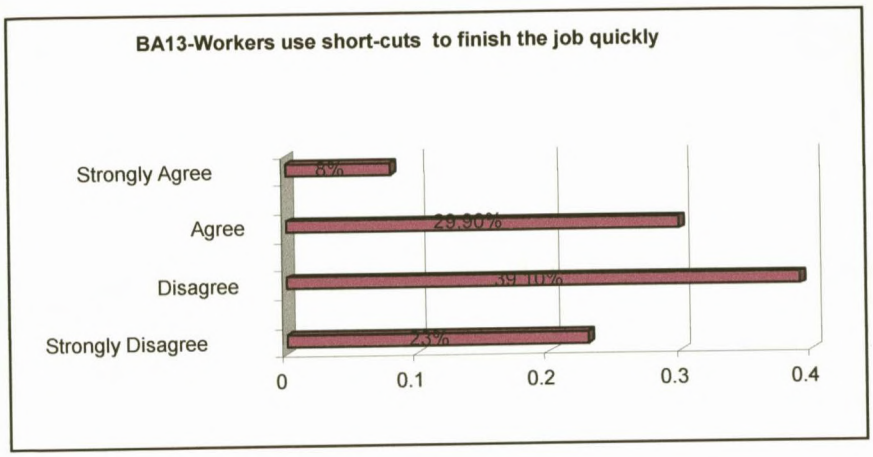


Figure 4.22 indicates that 34% (strongly agree + agree) of the workers agreed that the supervisor is not around when they need him. In an organization, there must be a transparent and rational management structure with clear lines of authority, responsibility and accountability (Marshall and Ruhemann, 2001:237).

Figure 4.22: Supervisor are absent from their workstations

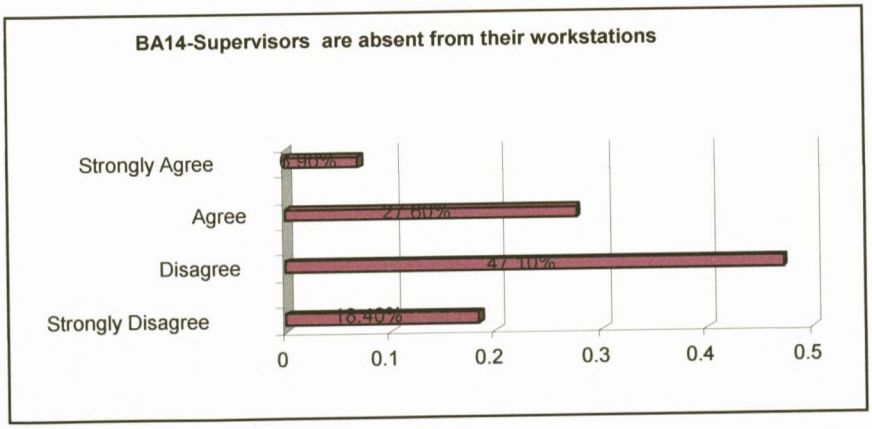
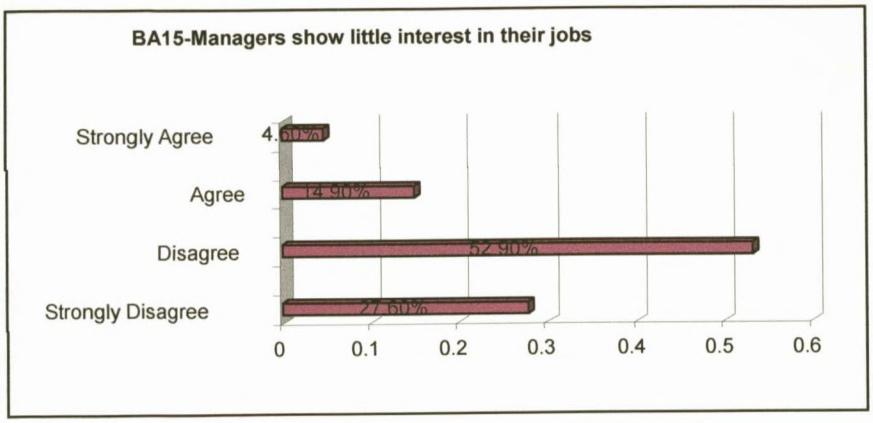


Figure 4.23 shows that 19% (strongly agree + agree) of the respondents perceived that they copy the attitude of their supervisors/ managers. Personal factors, such as attitudes, beliefs and personalities, and behavioural factors, such as using safe or unsafe work practices and going out of an individuals way to protect another person's safety, are important to develop a true safety culture (Geller, 2005:44).

Figure 4.23: Managers show little interest in their jobs



In Figure 4.24, 28% (strongly agree + agree) of the respondents indicated that the supervisors are not approachable. Communication is key in any operational environment. When an individual is confronted by divergent role expectations, the result is role conflict. Conflict exists when an individual finds that compliance with one role requirement may make more difficult the compliance with another. At an extreme level conflict would include situations in which two or more role expectations are mutually contradictory (Robbins, 2001:228)

Figure 4.24: Supervisors display poor behaviour

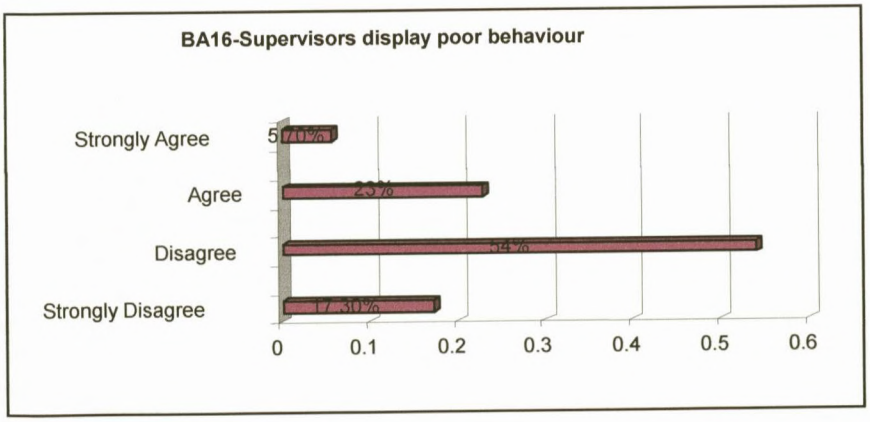


Figure 4.25 reveals that 37% (strongly agree + agree) of the respondents agreed that the supervisor does not check their jobs. By utilizing Management Walk-a-Rounds, supervisors

will be able to check first hand and gain direct information on unsafe incidents which can be evaluated and improved. This procedure is a sure way in reducing unsafe incidents (Cournoyer and Maestas, 2004:15).

Figure 4.25: Supervisors don't check the quality of work

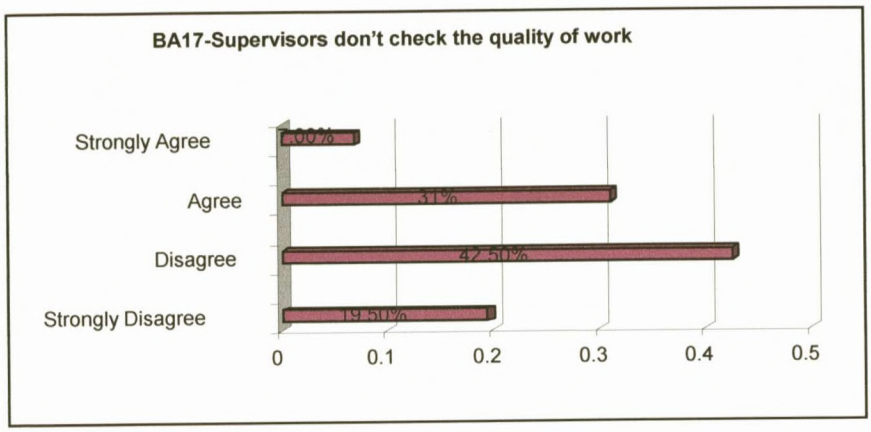
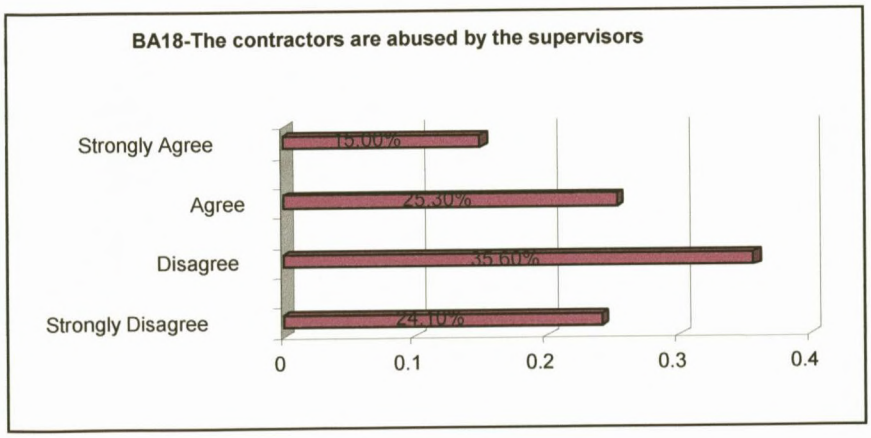


Figure 4.26 indicates that 40% (strongly agree + agree) of the respondents perceived that supervisors abuse contract workers. Workers at all levels must be treated with respect and allowed to develop their skills to reach their full potential. The welfare of the employees must be considered (Marshall and Ruhemann, 2001:273).

Figure 4.26: The contractors are abused by the supervisors



In Figure 4.27, 62% (strongly agree + agree) believed that each race group works well with

his/ her own kind. Generally different racial groups have more difficulty in learning to work with each other and in solving problems, but, with time, they seem to dissipate (Robbins, 2001:236).

Figure 4.27: Workers assist each other on racial lines

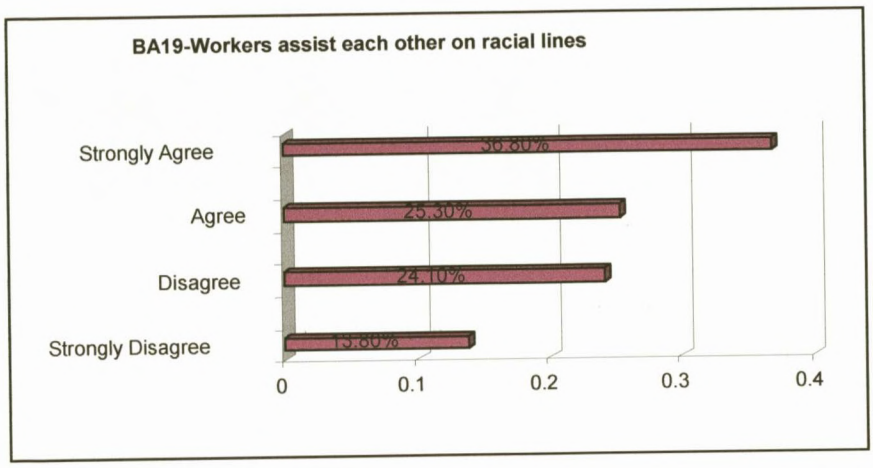


Figure 4.28 shows that 49% (strongly agree + agree) of the respondents agreed that there is no unity among the supervisors. Woods (2006:237) recommends due consideration on the following:

- People are unwilling to admit errors;
- Each person has pride and self esteem;
- One needs to show that one is only human and admit; and
- People around you will accept you better.

Figure 4.28: There is no unity among the supervisors

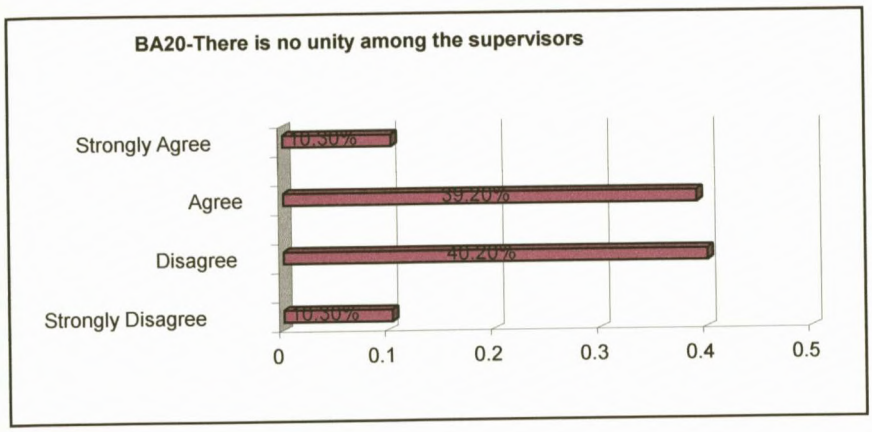


Figure 4.29 illustrates that 60% (strongly agree + agree) of the respondents indicated that supervisors blame them all the time for mistakes. Management systems for investigations should ensure that a blame-free procedure is in place for honest mistakes and is clearly stated and enforced. This procedure is an important aspect and ensures that all incidents, no matter how small and including near misses, are to be reported by all. This report will give a true reflection on the state of safety at any industry (The American Institute of Chemical Engineers, 2003).

Figure 4.29: Supervisors blame the workers for all the mistakes

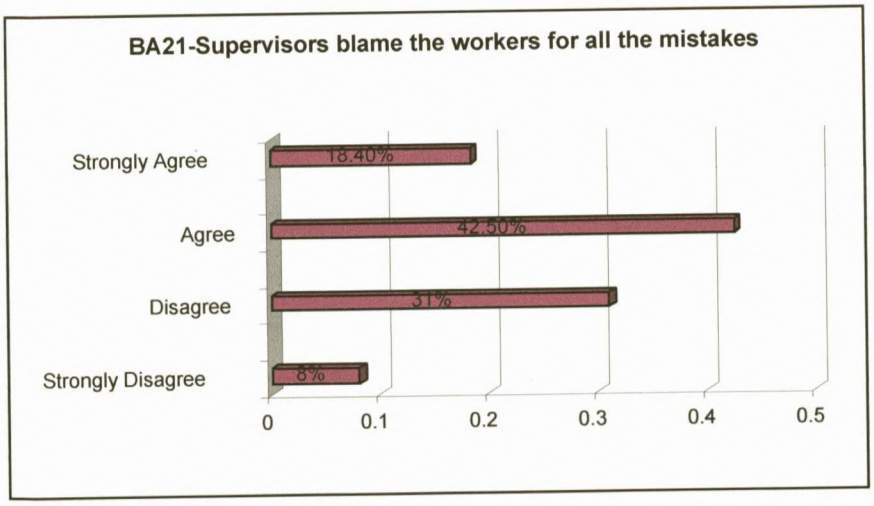
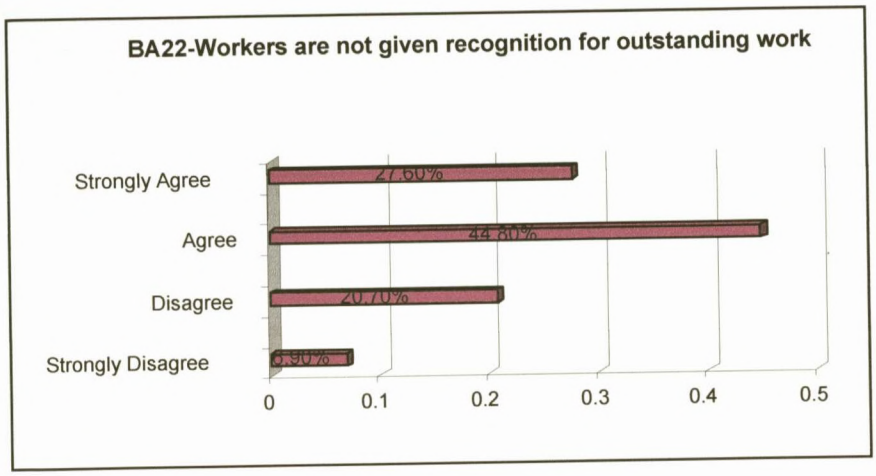


Figure 4.30 indicates that 72% (strongly agree + agree) of the respondents believed that

supervisors don't praise them for good contributions from them. Robbins (2001:334) believes that team leaders are trouble shooters, conflict managers and coaches. They clarify expectations and roles, teach, offer, support, cheerlead, and whatever else is necessary to help team members improve their work performance.

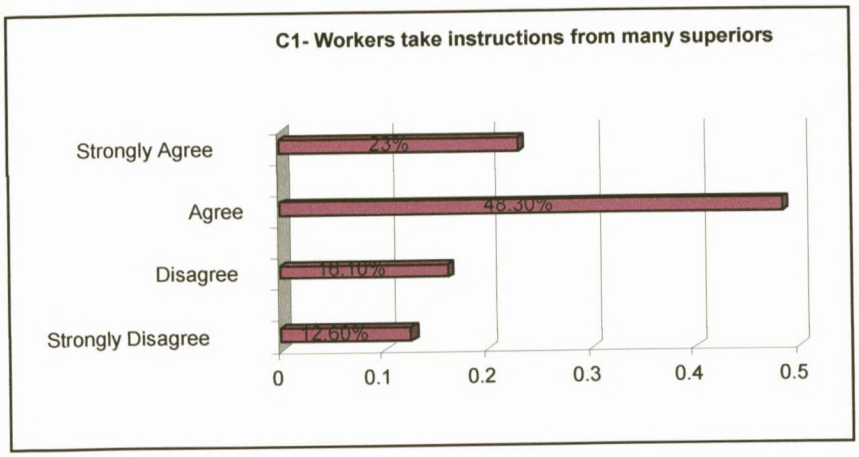
Figure 4.30: Workers are not given recognition for outstanding work



4.3.2 Communications

Figure 4.31 reveals that 71% (strongly agree + agree) of the respondents agreed that there are too many people giving them instructions. Power equalization-effective organizations deemphasize hierarchical authority and control (Robbins, 2001:553).

Figure 4.31: Workers take instructions from many superiors



In Figure 4.32, 47% (strongly agree + agree) of the respondents perceived that staff do not answer their communication radios. It is imperative to follow operating procedures and practices which include the method of doing the task, recording of operations, collection of samples and safety and health requirements (Fullwood, 2000:31).

Figure 4.32: Radio communication is very poor

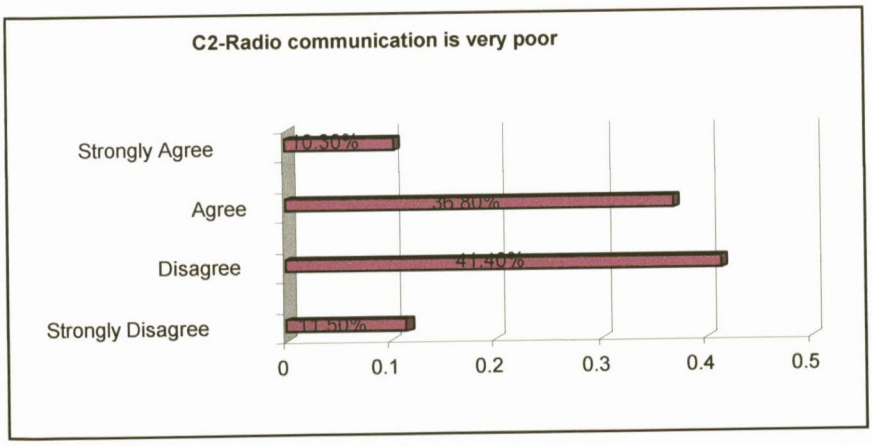


Figure 4.33 indicates that 43% (strongly agree + agree)of the respondents felt that senior staff cannot write proper reports. Communication involves writing and speaking correctly. The content must support a conclusion. The report should be well organized, and use an interesting style and is grammatically correct (Woods, 2006:237).

Figure 4.33: Supervisors write unprofessional reports

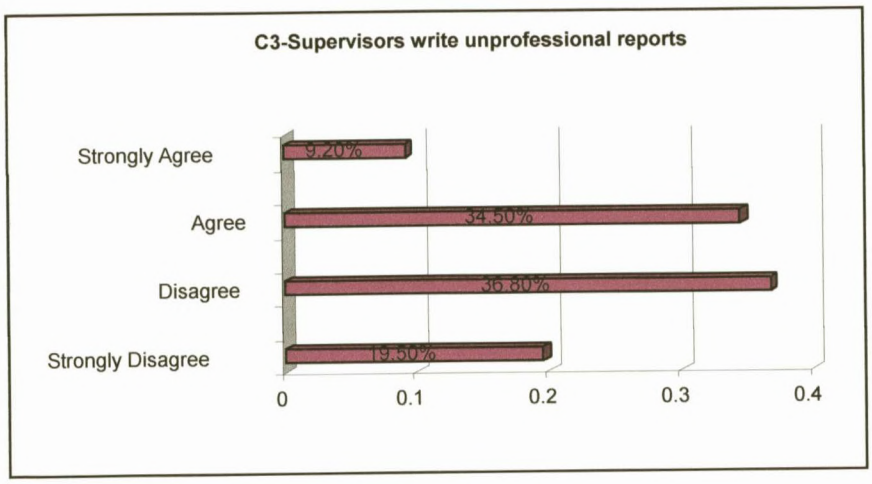
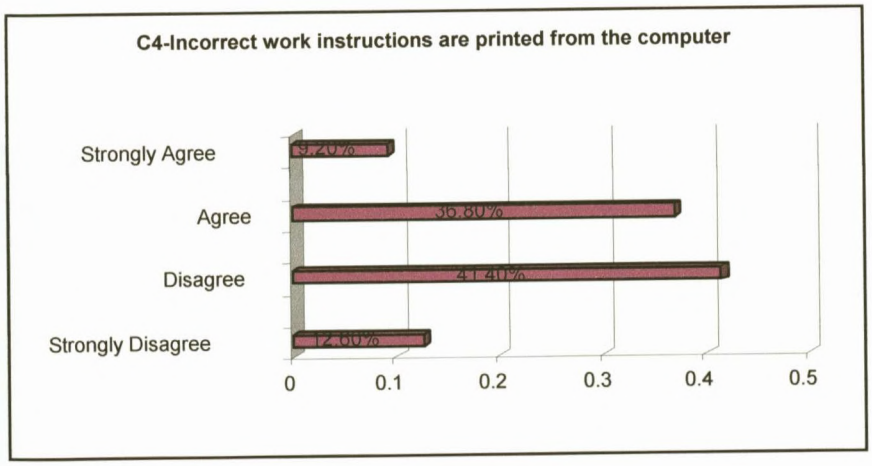


Figure 4.34 shows that 46% (strongly agree + agree) of the respondents believed that computer programmes are problematic and cause many unsafe incidents. Pre-startup safety is very important. Pre-audit checks must be done to ensure that the plant meets the design specifications and any non-compliance must be corrected before startup. The necessary procedures including emergency procedures, must be in place. (Fullwood, 2000:33).

Figure 4.34: Incorrect work instructions are printed from the computer

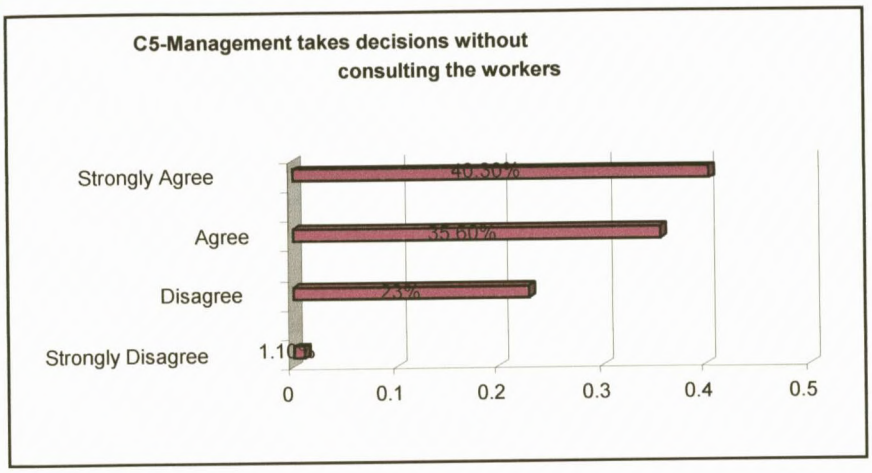


According to Figure 4.35, 75% (strongly agree + agree) of the respondents agreed that

management takes decisions without consulting them. Holbeche (2005:75) recommends the following:

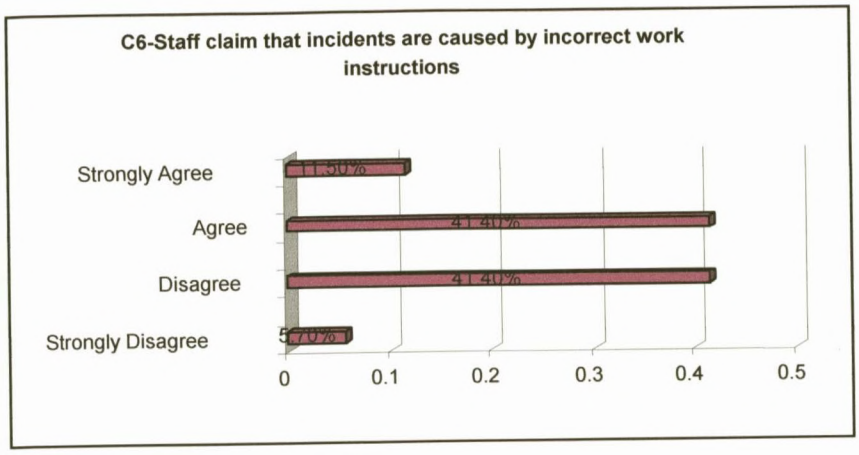
- Use communications to change and revitalize people:
- Give them a chance to make suggestions; and
- Provide feedback on organizational progress.

Figure 4.35: Management takes decisions without consulting the workers



In Figure 4.36, 52% (strongly agree + agree) of the respondents indicated that incidents are caused by the creation of incorrect work instructions. Managing change is critical. Any modifications to equipment, procedures, raw materials, and processing conditions must have a written management of change review and approval done before the change is implemented. Temporary changes must not be tolerated (Fullwood, 2000:34).

Figure 4.36: Staff claim that incidents are caused by incorrect work instructions



4.3.3 Plant and equipment

The respondents, in Figure 4.37, 42% (strongly agree + agree) believed that they don't have the correct tools to do their job properly. The engineering phase must consider the following- location of critical equipment, emergency escape routes, the proper functioning of shut down and safety systems, explosion proof design, prevention of static charging, and fire protection for important components in the plant (Vogel, 2005:317).

Figure 4.37: Staff don't have the correct tools for the job

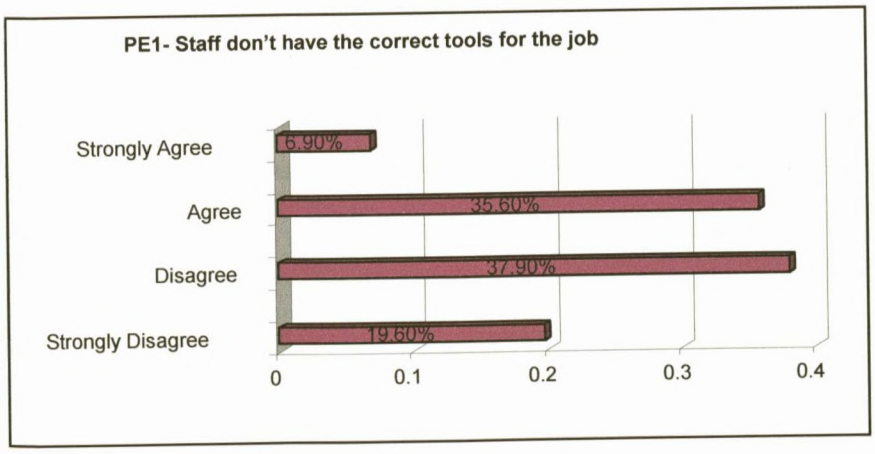
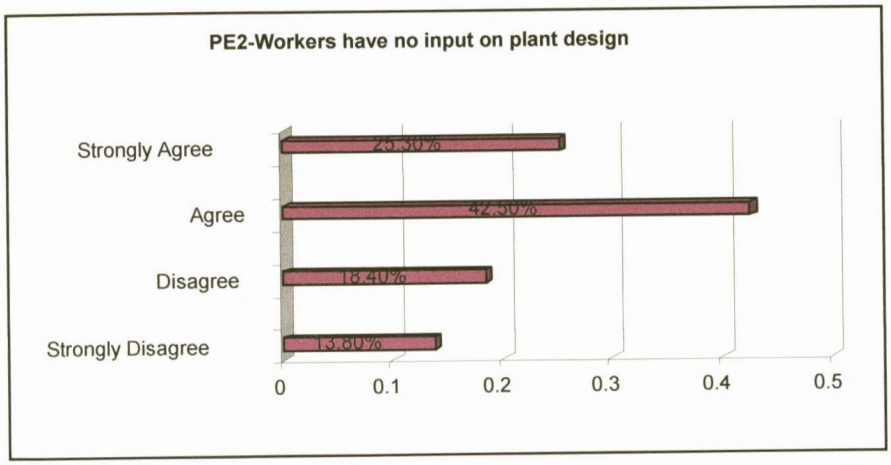


Figure 4.38 indicates that 67% (strongly agree + agree) of the respondents perceived that

they have no input in plant design. Incidents caused by human error is one of the biggest contributors to accidents. These errors occur, even if the person is well trained. Routine operations are relegated to the lower levels of the brain and are not continuously monitored by the conscious mind. It is difficult for a person to give his/ her full attention to all that is done in a day. This lapse in communications gives rise to the slips that people make daily. Plant designs should consider a high level of automation with computer control for mundane and specialized tasks (Kleitz, 1999:25).

Figure 4.38: Workers have no input on plant design



In Figure 4.39, 50 % (strongly agree + agree) of the respondents believed that the company uses outdated equipment. The plants must be made fool-proof against operator errors by automation with the minimization of valves and over-rides. The 21st century plant incorporates an optimal designed safe and reliable plant, operated hands-off at the most economical conditions (Koolen, 2001:9).

Figure 4.39: Staff work with old equipment

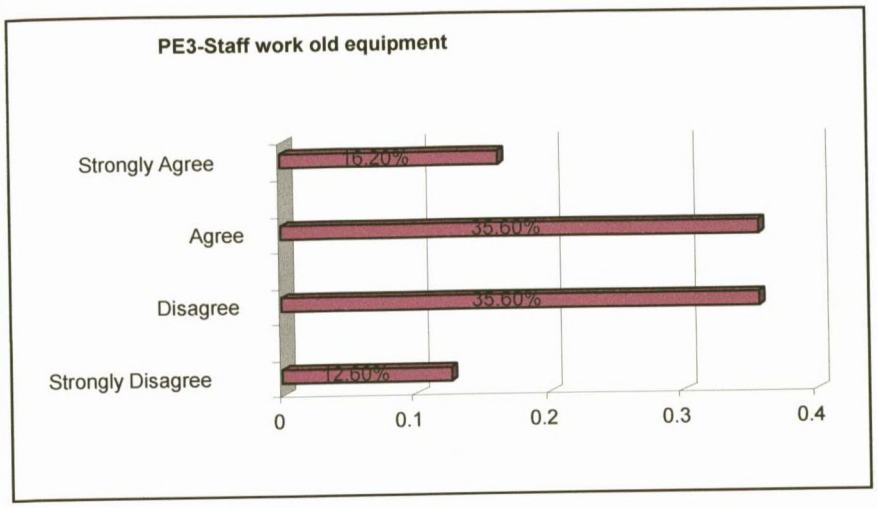


Figure 4.40 indicates that 63% (strongly agree + agree) of the respondents agreed that contractors hand back poorly maintained equipment that breaks down or is not fit for the job. Proper preparation for maintenance and acceptance of equipment is key in any successful completion and startup of equipment being maintained. A case in point was when three operators were killed due to the pump not being properly isolated and cleaned of all chemicals (Kleitz,1999:25).

Figure 4.40: Contractors work is of poor quality

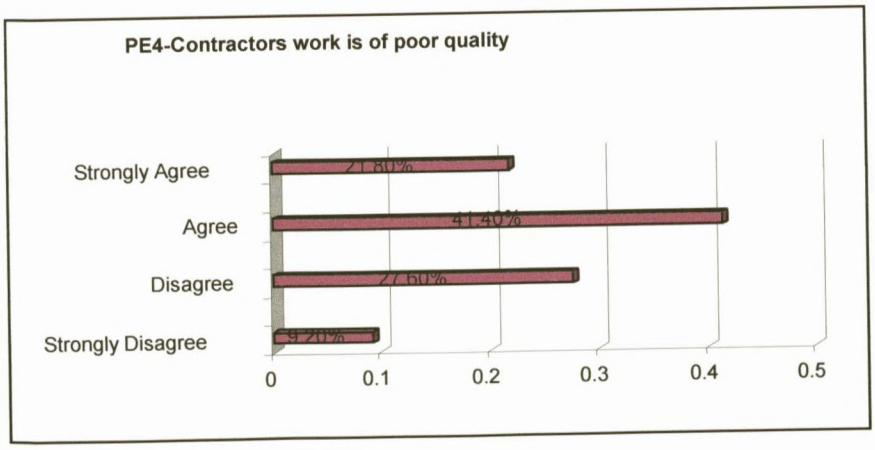
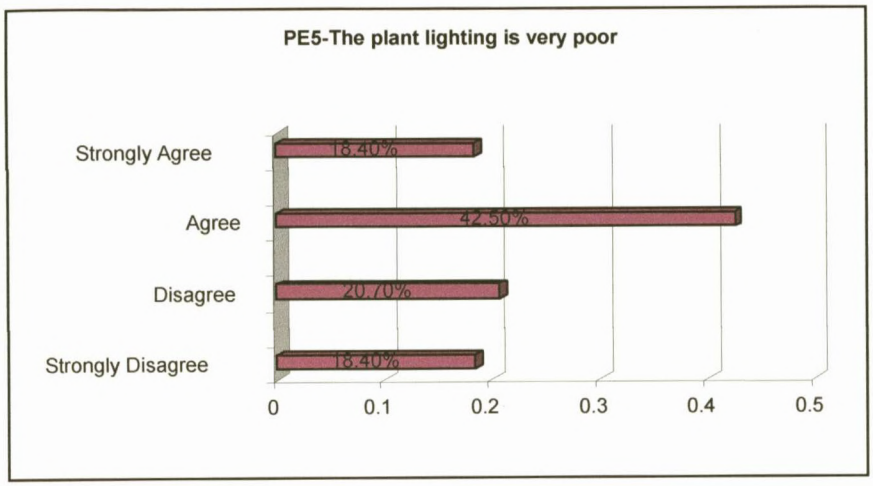


Figure 4.41 indicates that 60% (strongly agree + agree) of the respondents believed that poor lighting causes many unsafe incidents. Mechanical integrity is equally important in the

prevention of unsafe incidents (Fullwood,2000:33).

Figure 4.41: The plant lighting is very poor



4.3.4 Training and development

In Figure 4.42, 67% (strongly agree + agree) of the respondents indicated that they don't know everything about chemicals. According to the Occupational Health and Safety Act (1993), every person who handles hazardous chemicals, shall firstly understand a Material Data Safety Sheet which contains critical safety information such as:

1. Product and company identification;
2. Hazards identification;
3. First- aid measures; and
4. Fire fighting measures and other information.

Figure 4.42: The workers have limited knowledge about chemicals

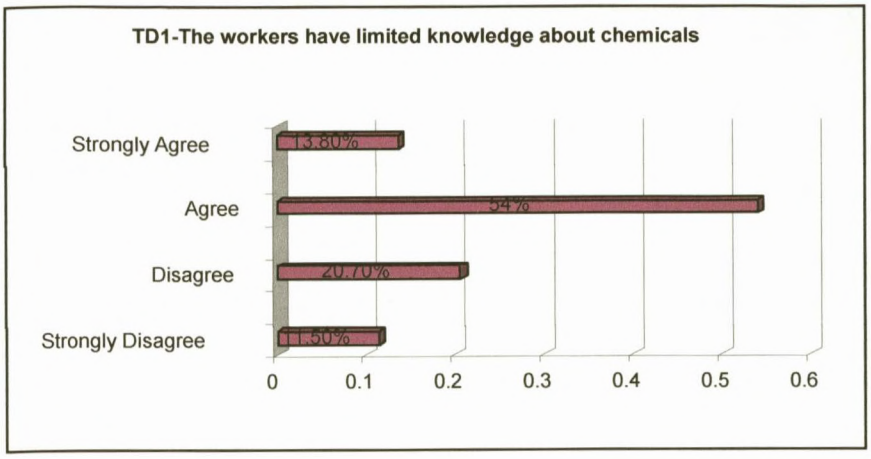
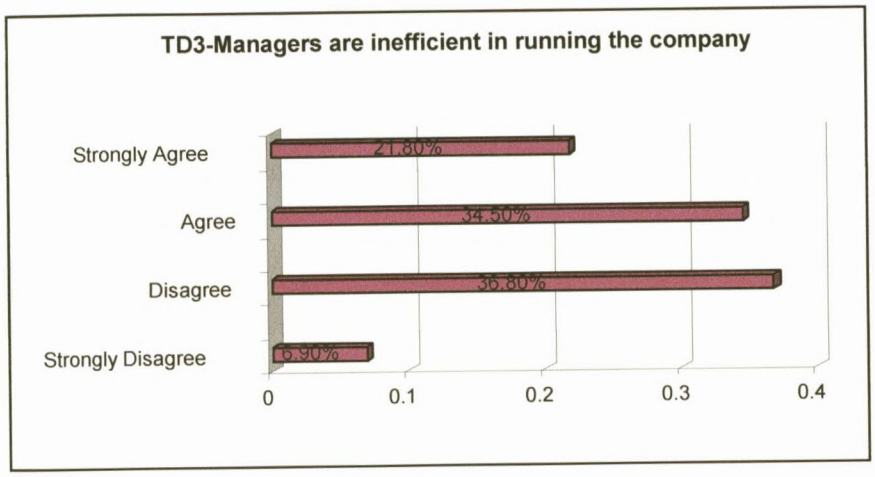


Figure 4.43 shows that 64% (strongly agree + agree) of the respondents perceived that too many inexperienced staff caused many unsafe incidents. Employee training must focus on the understanding of the safety and health hazard of highly hazardous chemicals. The training has to have theory and practical components taught and the trainee will finally demonstrate his/ her knowledge gained by different methods of testing. There must be periodic evaluation of training programmes to determine if the necessary skills are being learnt (Fullwood, 2000:34).

Figure 4.43: Staff are new and inexperienced

Figure 4.44 reveals that 56% (strongly agree + agree) of the respondents believed that the managers are running the company very poorly. Schmidt (2005:526) explains the importance of companies in using chemical engineers to solve environmental problems. They design and operate the plants and have the ability in understanding the complexities of pollutants that are produced by the chemical processes.

Figure 4.44: Managers are inefficient in running the company



In Figure 4.45, 47% (strongly agree + agree) of the respondents agreed that the supervisors don't train them properly. Competent employees don't remain competent forever. Skills deteriorate and can become obsolete. That is why organizations spend billions each year on formal training (Robbins, 2001:480).

Figure 4.45: Supervisors don't train the workers properly

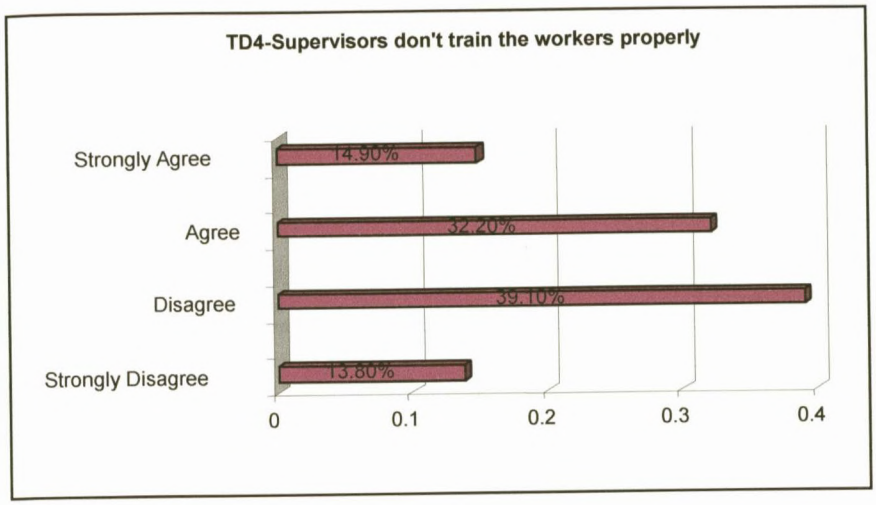


Figure 4.46 illustrates that 34% (strongly agree + agree) of the respondents indicated that they know more than their supervisors. "I know best" attitude- in many cases, people fail to carry out orders as requested because they know best. The employee may be old and lacks discipline and motivation (Woods, 2006:237).

Figure 4.46: Workers claim to know more than the supervisor

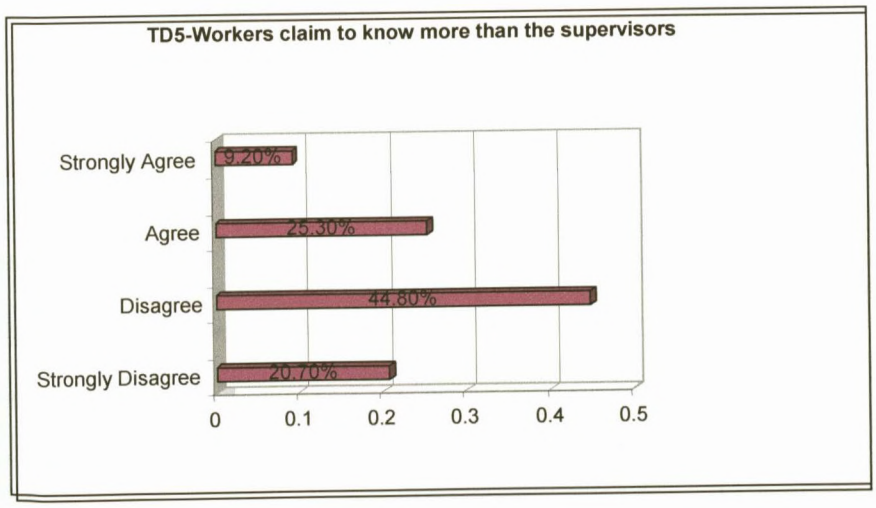
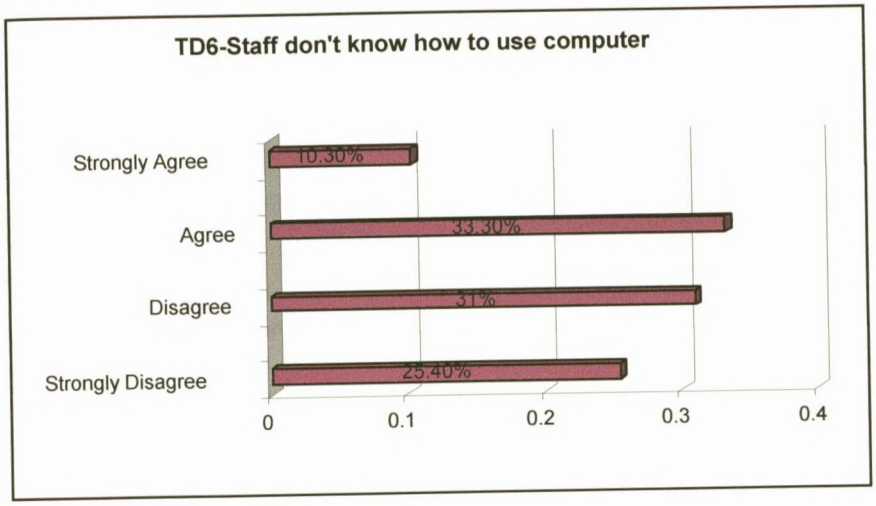


Figure 4.47 indicates that 43% (strongly agree + agree) of the respondents agreed that they don't know how to use the computer. Today, technology makes it easy for chemical information to reach stakeholders in all parts of the globe so that all unsafe chemical

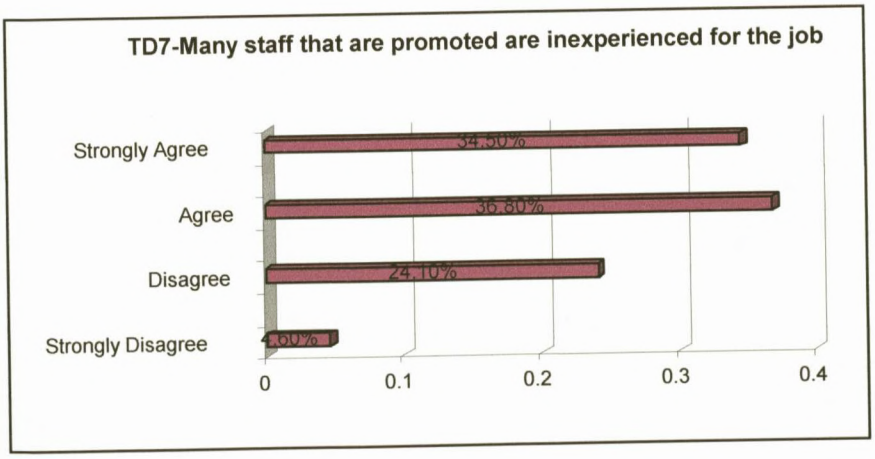
incidents are reduced (Goehl, 2005:5).

Figure 4.47: Staff don't know how to use the computer



In Figure 4.48, 71% (strongly agree + agree) of the respondents agreed that staff are promoted with little or no experience. Employee involvement can improve their motivation and capabilities which translate into improved performance and quality (Cummings and Worsley, 2005:308)

Figure 4.48: Many staff that are promoted are inexperienced for the job



4.3.5 Planning and work load

Figure 4.49 indicates that 40% (strongly agree + agree) of the respondents revealed that they have no time for tea or lunch and work through these breaks. The basic conditions of employment dictate that staff must appropriate breaks. There is a growing realisation that strict controls, greater work pressure, more clearly defined jobs and tighter supervision have run their course in their ability in giving productivity gains (Holbeche, 2005:97).

Figure 4.49: Some staff have no time for tea or lunch

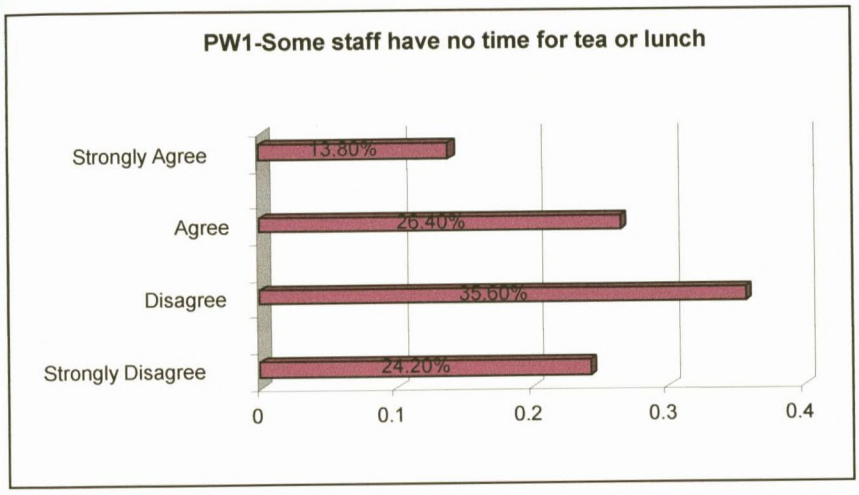
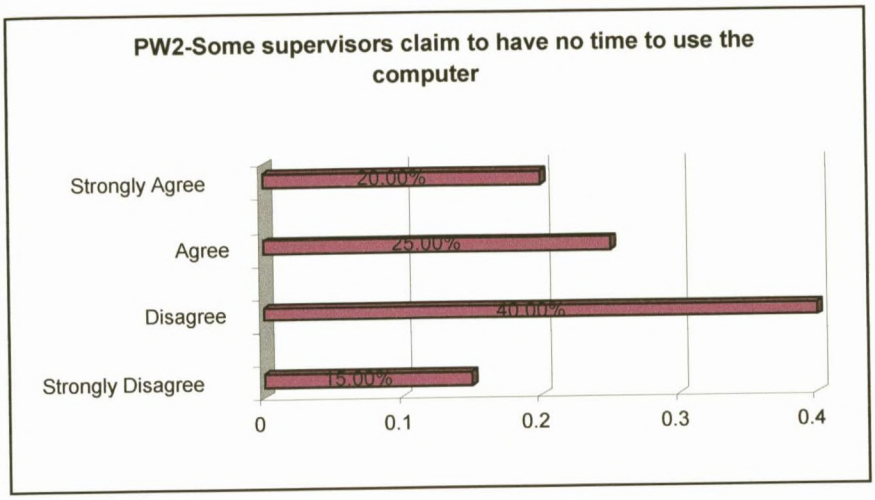


Figure 4.50 shows that 45% (strongly agree + agree) of the respondents perceived that they (supervisors) have no time to use their computers. When an individual has the skill to do a job, he or she is encouraged to do their best (Holbeche, 2005:233).

Figure 4.50: Some supervisors claim to have no time to use the computer



In Figure 4.51, 37% (strongly agree + agree) of the respondents agreed that they have no time for training. An organization needs to build competence of all employees in order to reduce unsafe acts (Holbeche, 2005:233).

Figure 4.51: Staff claim to have no time for training

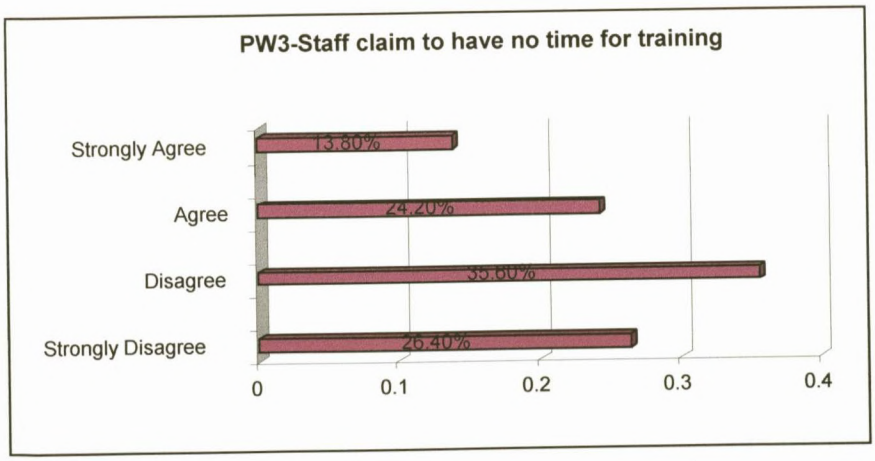
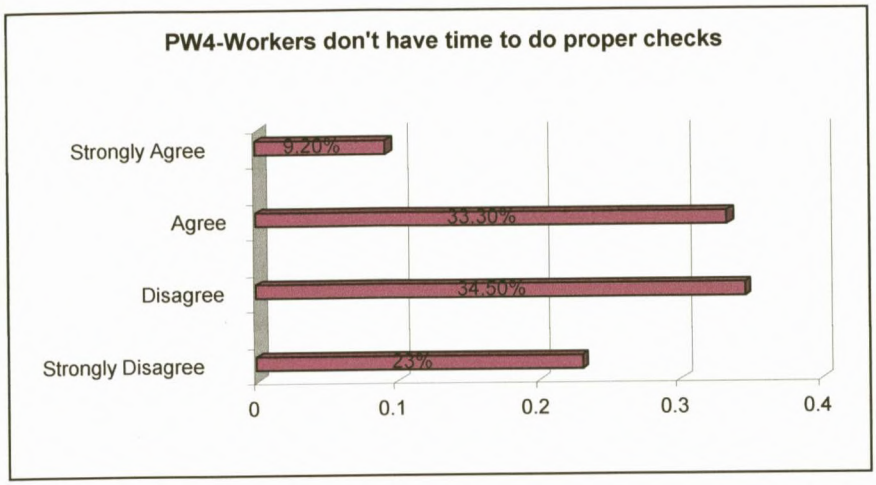


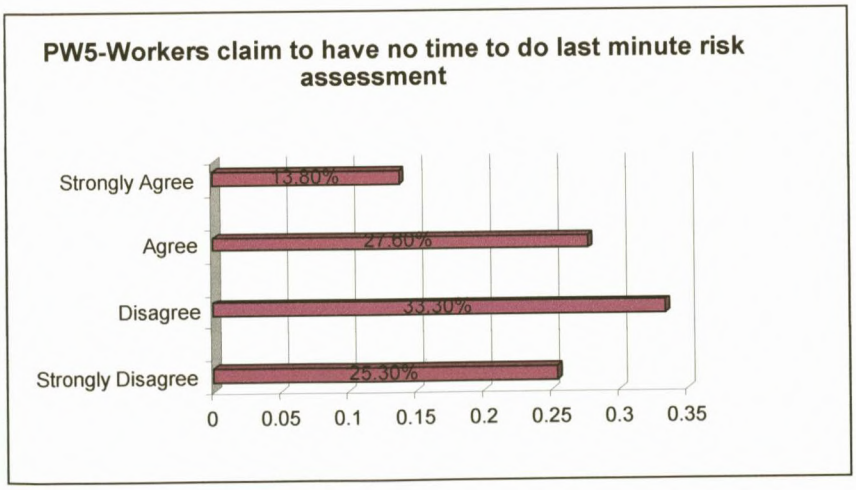
Figure 4.52 reveals that 42% (strongly agree + agree) of the respondents indicated that they have no time to do proper checks on their jobs. The normal stress of daily life may distract people from adhering to safe work practices (Fivizzani, 2004:10)

Figure 4.52: Workers don't have time to do proper checks



In Figure 4.53, 41% (strongly agree + agree) of the respondents perceived that they have no time to do the last minute risk assessment. If an employee is not performing his or her best , then he/ she must be retrained, tested and mentored to become better in his/ her job (Holbeche, 2005:233).

Figure 4.53: Workers claim to have no time to do last minute risk assessment



In Figure 4.54, 57% (strongly agree + agree) of the respondents agreed that there are too few staff to do the job properly. Inadequate staffing compromises safety (Marshall and Ruhemann, 2001:273).

Figure 4.54: Workers claim that there are too few staff

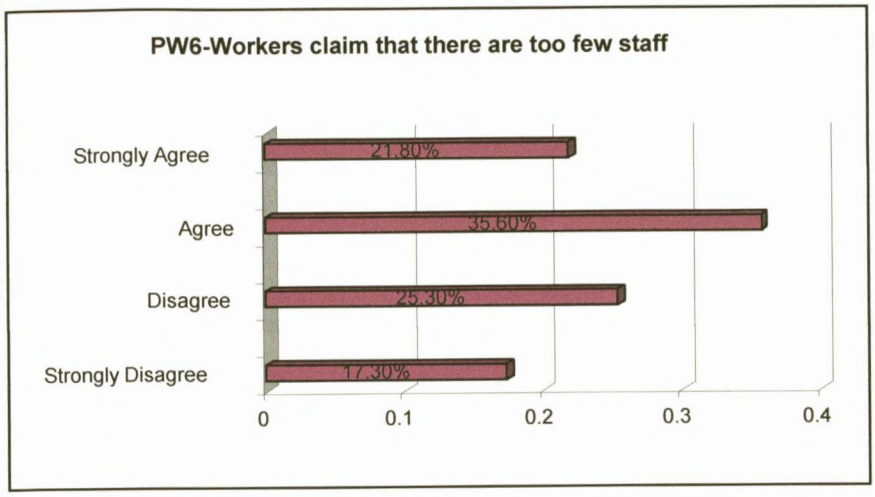
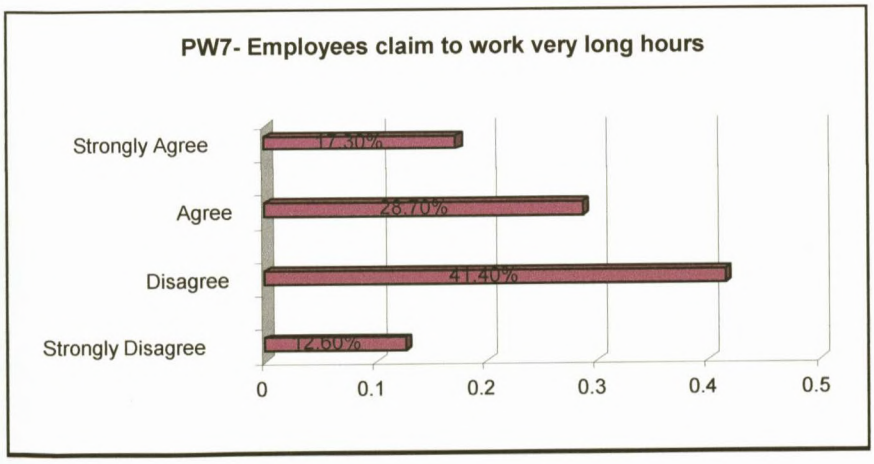


Figure 4.55 indicates that 45% (strongly agree + agree) of the respondents believed that they work very long hours which contribute to unsafe incidents. The welfare of the employees must be considered when they are requested to work excessive hours which creates stress and diminish their ability to work safely. It must be accepted that a healthy and well motivated staff works safely (Marshall and Ruhemann, 2001:273)

Figure 4.55: Employees claim to work very long hours



In Figure 5.56, 58% (strongly agree + agree) of the respondents indicated that there are many staff members who do very little work. Alienation and lack of motivation is an important factor in the work environment. Employees must have a clear idea on their

expectations and rewards as incentives. People are demoralized if they perform very well and don't receive deserved rewards. The work surroundings also play a big part in individual motivation (Woods, 2006:237).

Figure 4.56: Some workers work very hard whilst others do very little

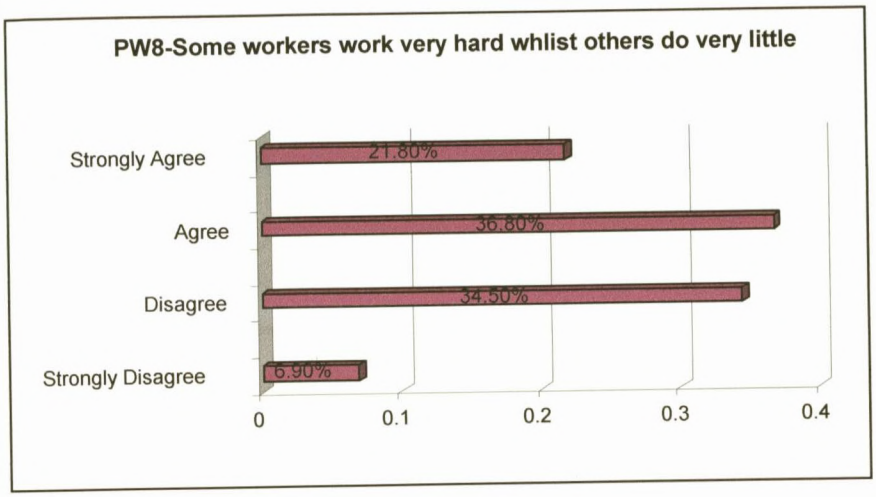
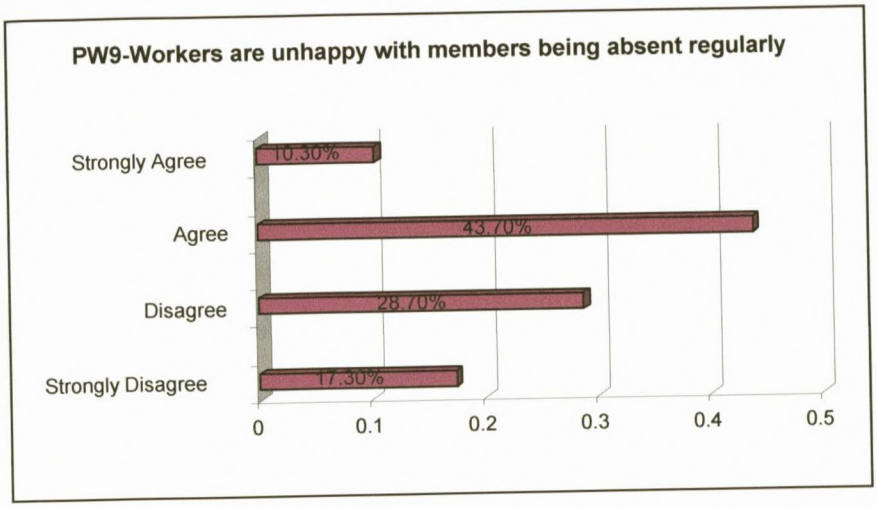


Figure 5.57 demonstrates that 54% (strongly agree + agree) of the staff agreed that many employees are absent regularly. At the job level, a one day absence can cost up to 100 million dollars and reduced efficiency and increased supervisory workload in the US. These figures indicate the importance to an organisation of keeping absenteeism low (Robbins, 201:20).

Figure 4.57: Workers are unhappy with members being absent regularly



4.3.6 Safety

In Figure 4.58, 36% (strongly agree + agree) of the respondents indicated that there are no safety meetings in place. Top management must emphasize and share safety results when they have discussions with staff (Geller, 2005:44).

Figure 4.58: Workers claim that there are no safety meetings

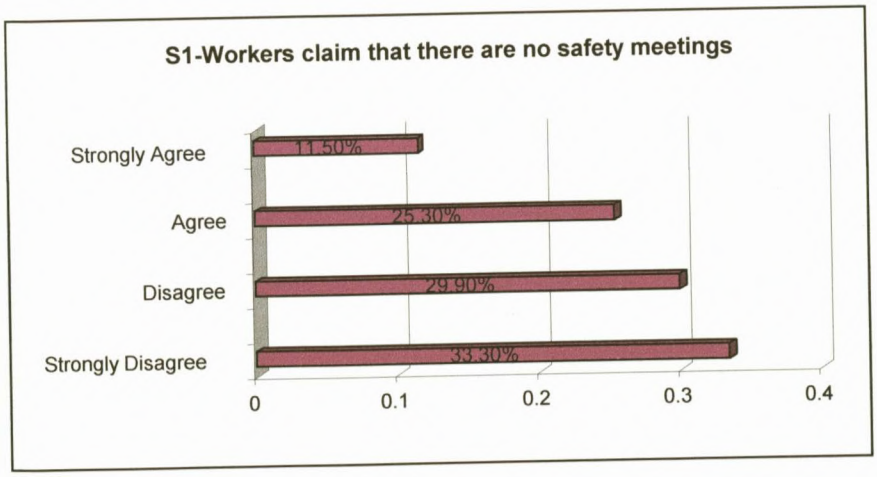
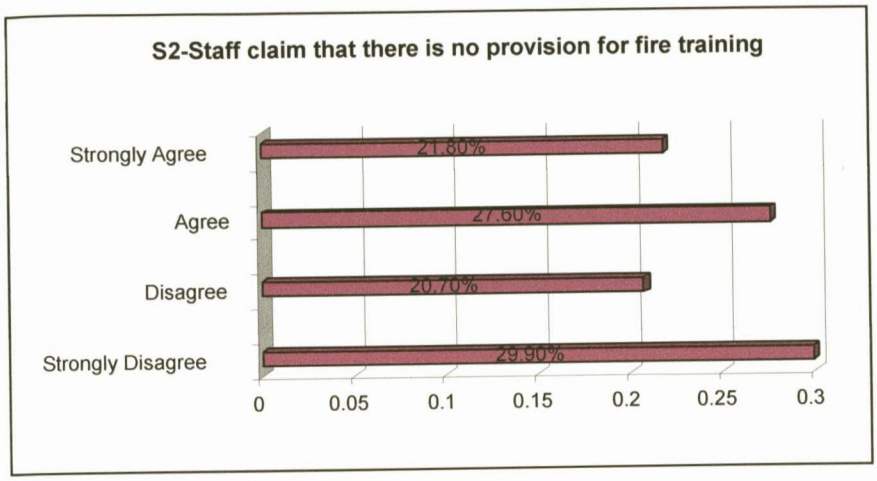


Figure 4.59 illustrates that 49% (strongly agree + agree) of the respondents believed that there is no provision for fire training in emergency cases. All employees should be

informed, and trained in fire precautions (Carson and Mumford, 2002:119).

Figure 4.59: Staff claim that there is no provision for fire training



According to Figure 4.60, 42% (strongly agree + agree) of the respondents indicated that they don't wear personal protective equipment because it is uncomfortable. Safety needs to be more than just wearing the proper PPE. There needs to be a value and an attitude change (Geller, 2005:44).

Figure 4.60: Workers don't wear PPE because it's uncomfortable

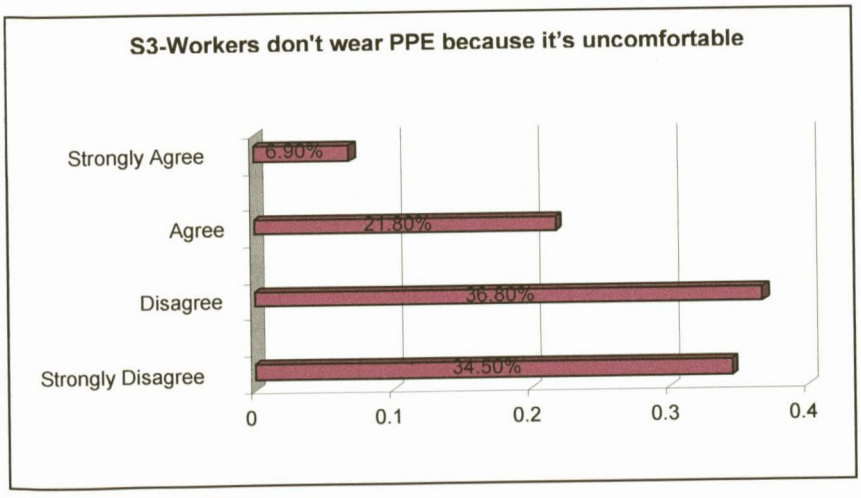
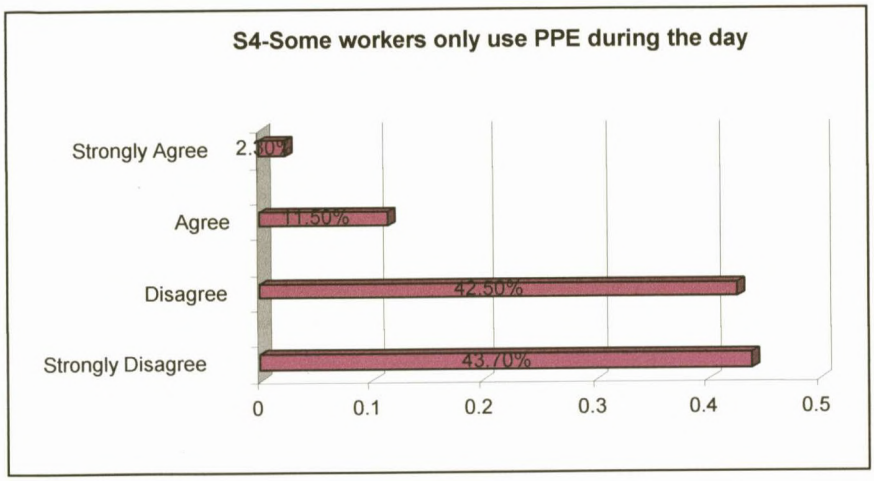


Figure 4.61 indicates that 13% (strongly agree + agree) of the respondents agreed that

they only use PPE during the day. Workers who understand how to evaluate risk and determine what precautions to take are more likely to obtain and use the appropriate PPE. Experienced employees think that the proper use of PPE is obvious. They have picked up many skills through their years of experience. However the job tasks may have changed, their physical skills may have changed, and the types of PPE have changed (Fivizzani, 2005:12).

Figure 4.61: Some workers only use PPE during the day



In Figure 4.62, 32% (strongly agree + agree) of the respondents indicated that housekeeping is very poor. It is better to prevent waste rather that cleaning the waste thereafter. In green manufacture, one must not create any waste. This waste is an additional cost to the business (Das, 2005:191).

Figure 4.62: Housekeeping in the plant is very poor

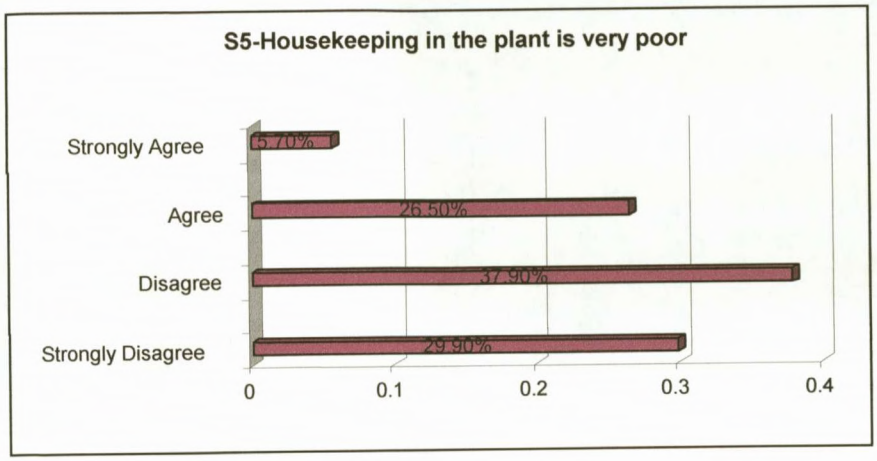
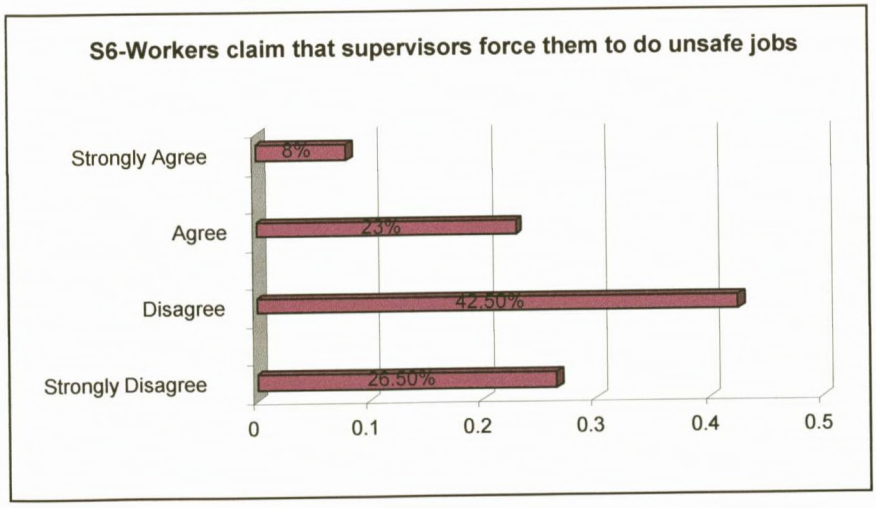


Figure 4.63 shows that 30% (strongly agree + agree) of the respondents believed that the supervisor forces them to commit unsafe acts by doing unsafe jobs. Employee motivation is the key aspect in getting the employees to do the correct job. Employees are knowledgeable and will do what is required and have the ability of understanding what is right or wrong (Holbeche, 2005:97).

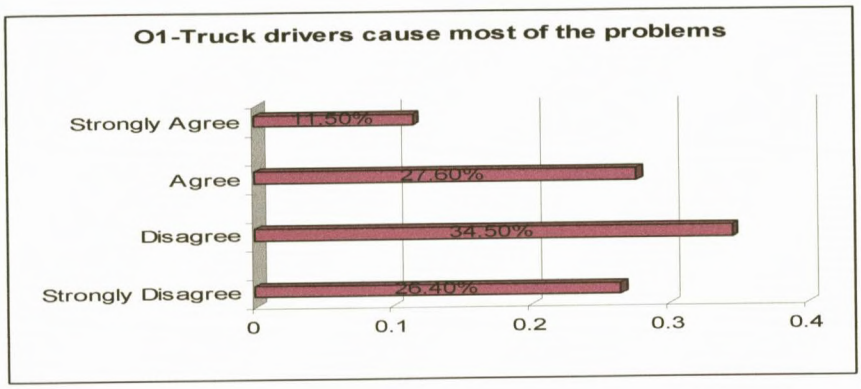
Figure 4.63: Workers claim that supervisors force them to do unsafe jobs



4.3.7 Other

Figure 4.64 illustrates that 39% (strongly agree + agree) of the respondetns perceived that truck drivers cause most of the unsafe incidents. Contractors must also provide personnel that are efficiently trained with certification when working on chemical sites (Fullwood, 2000:33).

Figure 4.64: Truck drivers cause most of the problems



In Figure 4.65, 82% (strongly agree + agree) of the respondents agreed that there are not enough social events for staff to de-stress. Stress causes staff not to focus on their jobs. Stress plays major havoc with employees in industries. Stress has been linked to hypertension, heart attacks, diabetes, asthma, chronic pain, allergies, headaches, backaches, various skin disorders, cancer, immune system weakness, and decreased white blood cells and changes in their function (Cummings and Worsley, 2005:308). Other types of non-competitive physical exercise such as aerobics, walking, jogging, swimming, and riding a bicycle can assist in reducing stress (Robbins, 2001: 570).

Figure 4.65: Workers claim that there are not enough social activities to de-stress

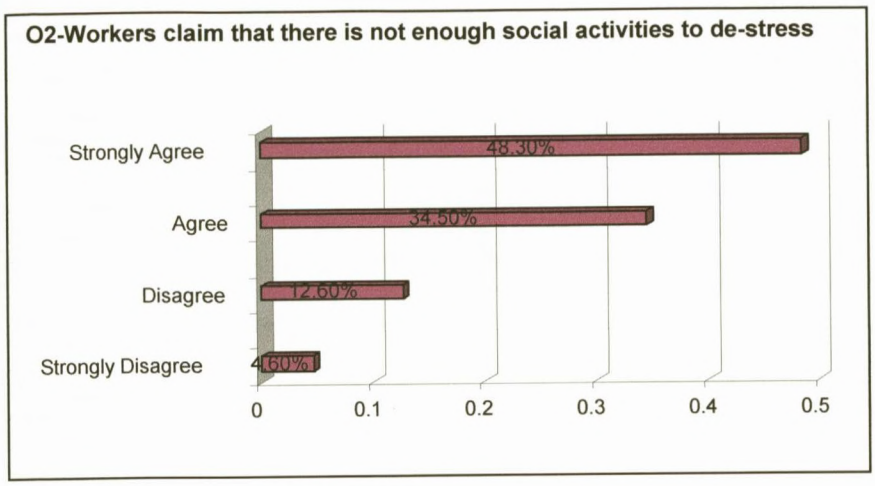
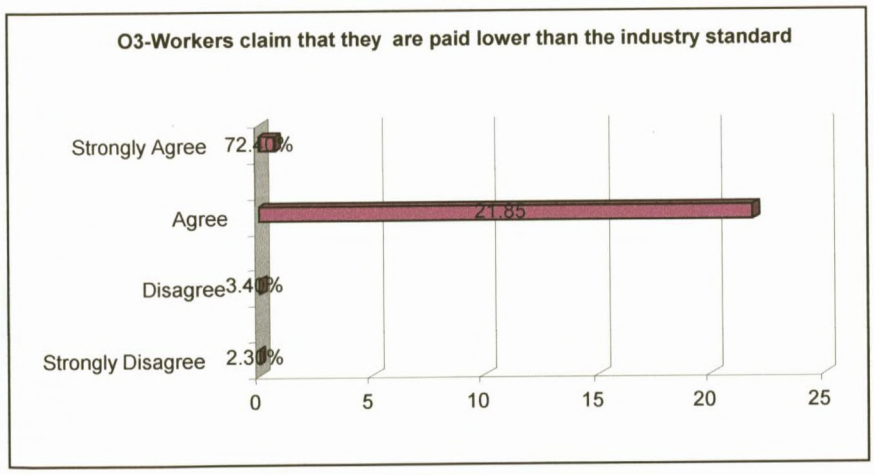


Figure 4.68 reveals that 94% (strongly agree + agree) of the respondents perceived that they are paid salaries way below the industry standard. Rewards should be awarded to people that are innovative, flexible and deliver outstanding results (Holbeche, 2005:75).

Figure 4.66: Workers claim that they are paid lower than the industry standard



4.3.8 All questions per key contributor shown together

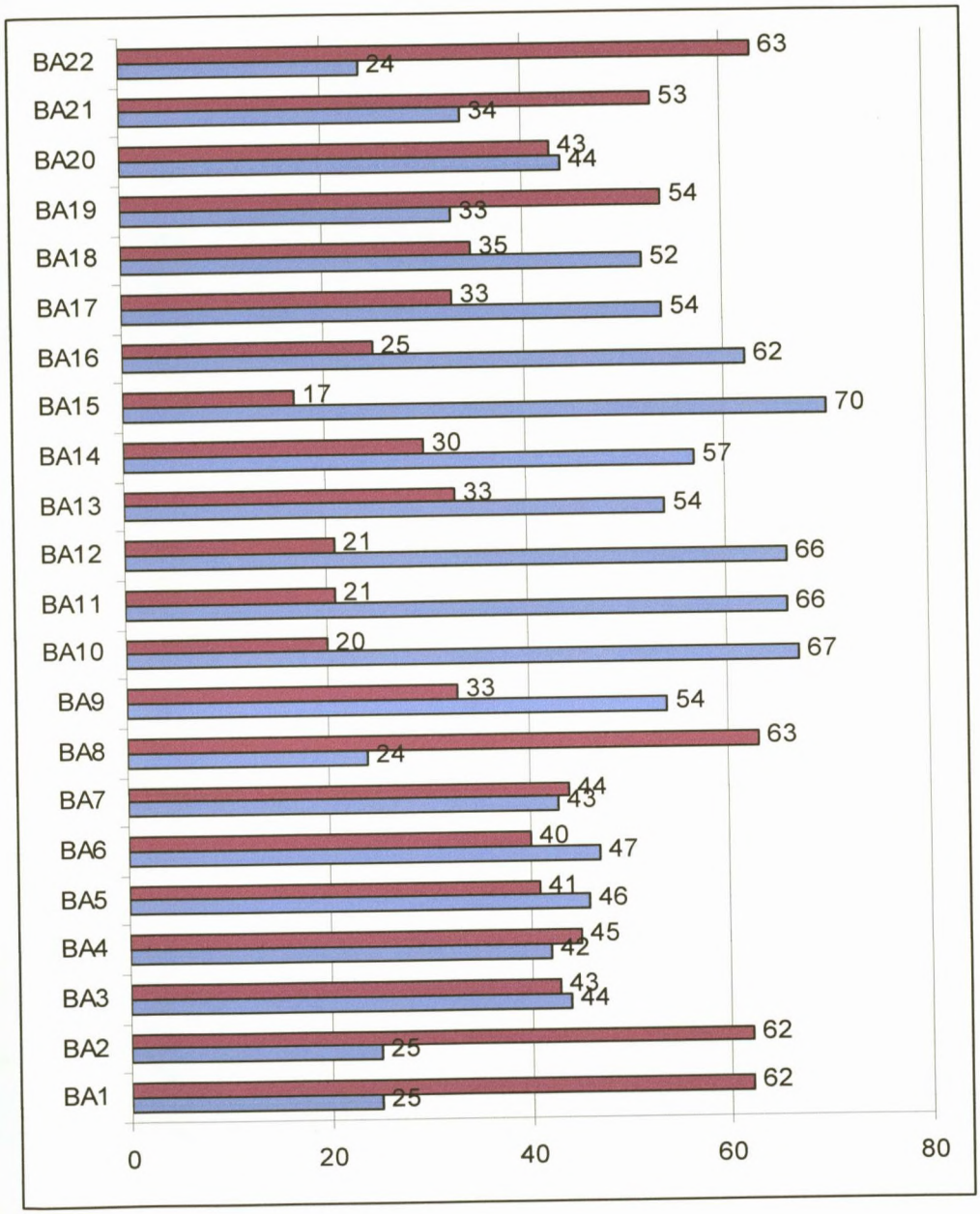
4.3.8.1 Behaviour and attitude

In Figure 4.67, there are twenty two statements that probed the impact that behaviour and attitude had on unsafe incidents. The number of respondents that disagreed are indicated by (in purple) and the number (in maroon) agreed that the behaviour and attitude of the employees directly contributed to the unsafe incidents. There were a minimum of at least twenty respondents and a maximum of sixty three respondents in each of the twenty two questions that agreed that behaviour and attitude directly contributed to unsafe incidents. The following aspects had the highest percentages:

- Attitude of staff towards their job 71.3%
- Not using procedures when working 71.3%
- Employees are treated like children 50%
- Employees not empowered 52%
- No respect shown towards employees 47%
- The supervisors ignore the employees 46%
- Employees are victimized for complaining 50%
- Management does not attend to faults on time 72%
- Operators copy unsafe methods used by the supervisors 38%
- Short-cuts are used to finish the job quickly 37%
- The supervisor does not check the quality of work 37%
- Workers assist each other on racial lines 62%
- There is no unity among the supervisors 49%
- Supervisors blame the workers for all the mistakes 60%
- Workers are not given recognition for outstanding work 72%

The above aspects are critical in improving work performance and unsafe incidents.

Figure 4.67: Behaviour and attitude



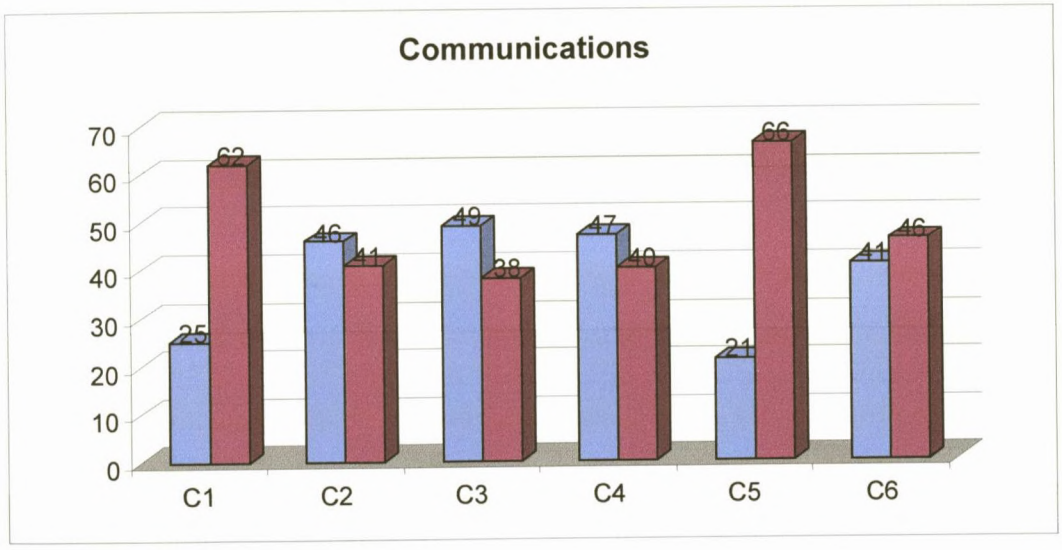
4.3.8.2 Communications

Figure 4.68 indicates the number of respondents that agreed (in maroon) and the number that disagreed (in purple) to communications contributing directly to unsafe incidents. the

majority of the respondents agreed that communications contribute significantly to unsafe incidents. The following is a list of the statements posed and the related responses by percentage:

- Workers take instructions from many superiors 71%
- Radio communication is very poor 47%
- Supervisors write unprofessional reports 43%
- Incorrect work instructions are printed from the computer 46%
- Management takes decisions without consulting the workers 75%
- Staff claim that incidents are caused by incorrect work instructions 52%

Figure 4.68: Communications



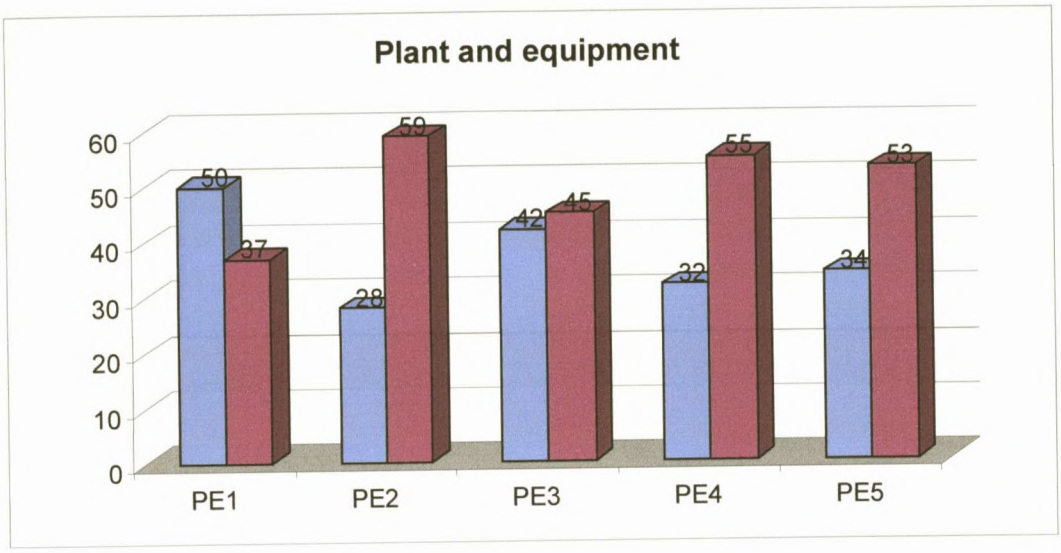
4.3.8.3 Plant and equipment

Figure 4.69 shows the number of respondents that agreed (in maroon) and those that disagreed (in purple) to plant and equipment contributing directly to unsafe incidents. Generally respondents agreed that plant and equipment does contribute to unsafe incidents. The results are listed by percentages in terms of the statements posed in the survey:

- Staff use incorrect tools for the job 42%
- Workers have no input in plant design 67%

- Staff work with old equipment 50%
- Contractors work is of poor quality 63%
- The plant lighting is very poor 60%

Figure 4.69: Plant and equipment

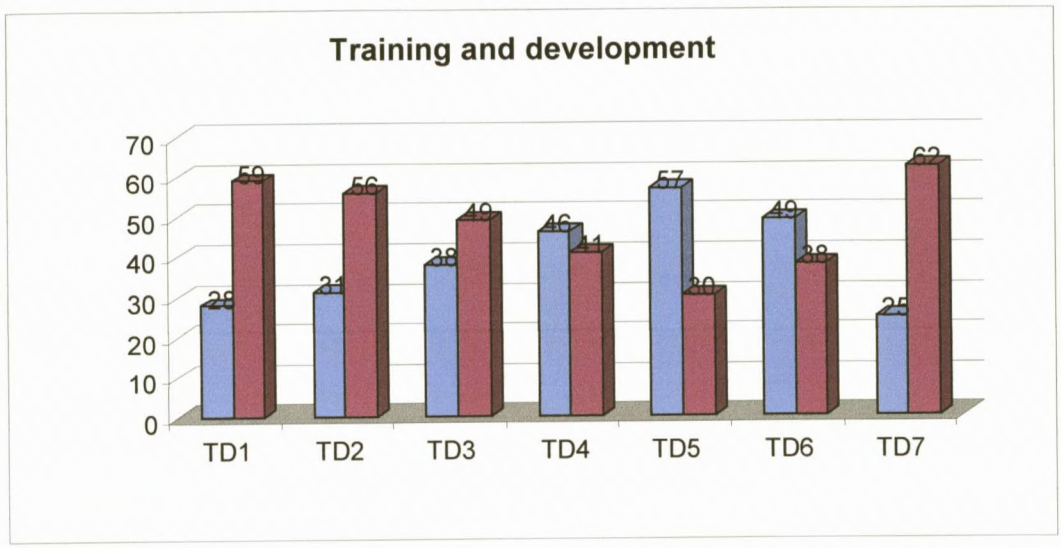


4.3.8.4 Training and development

Figure 4.70 shows the number of respondents that agreed (in maroon) and those that disagreed (in purple) to training and development contributing directly to unsafe incidents. The majority agreed that the lack of training and development contributed to the unsafe incidents. The statements used in the research together with the associated results are listed:

- The workers have limited knowledge about chemicals 67%
- Staff are new and inexperienced 64%
- Managers are inefficient in running the company 56%
- Supervisors don't train the workers properly 47%
- Staff don't know how to use the computer 43%
- Many staff that are promoted are inexperienced for the job 71%

Figure 4.70: Training and development

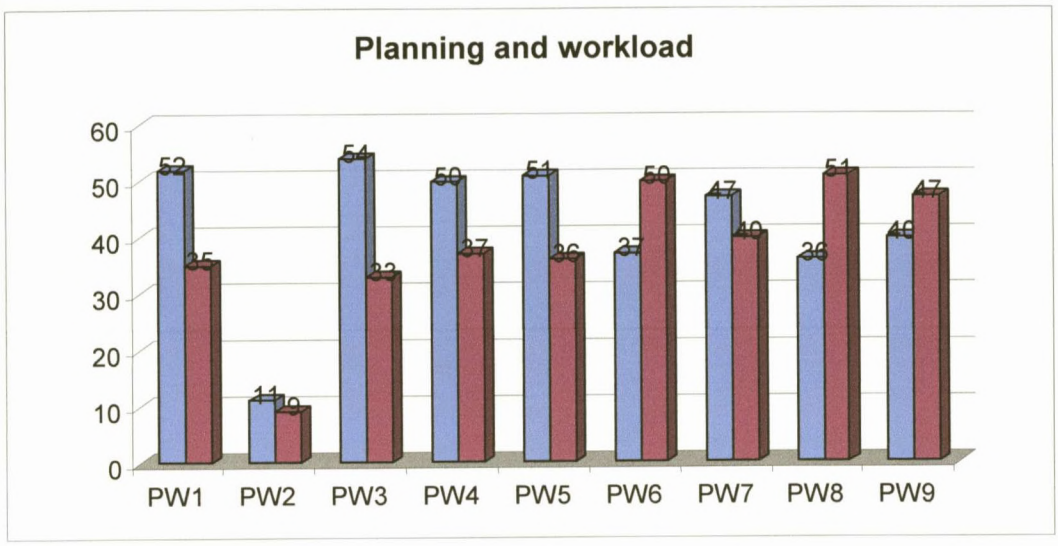


4.3.8.5 Planning and work Load

Figure 4.71 shows the number of respondents that agreed (in maroon) and that disagreed (in purple) to planning and workload contributing directly to unsafe incidents. Listed below is the statements posed in the survey and the resultant major contributors by percentage to unsafe incidents:

- Some staff have no time for tea or lunch 40%
- Some supervisors claim to have no time to use the computers 45%
- Staff claim to have no time for training 37%
- Workers have no time to do proper checks 42%
- Workers claim to have no time to do last minute risk assessments 41%
- Workers claim that there are too few staff 57%
- Employees claim to work long hours 45%
- Some workers work very hard whilst others do very little 85%
- Workers are unhappy with their members being absent regularly 54%

Figure 4.71: Planning and workload

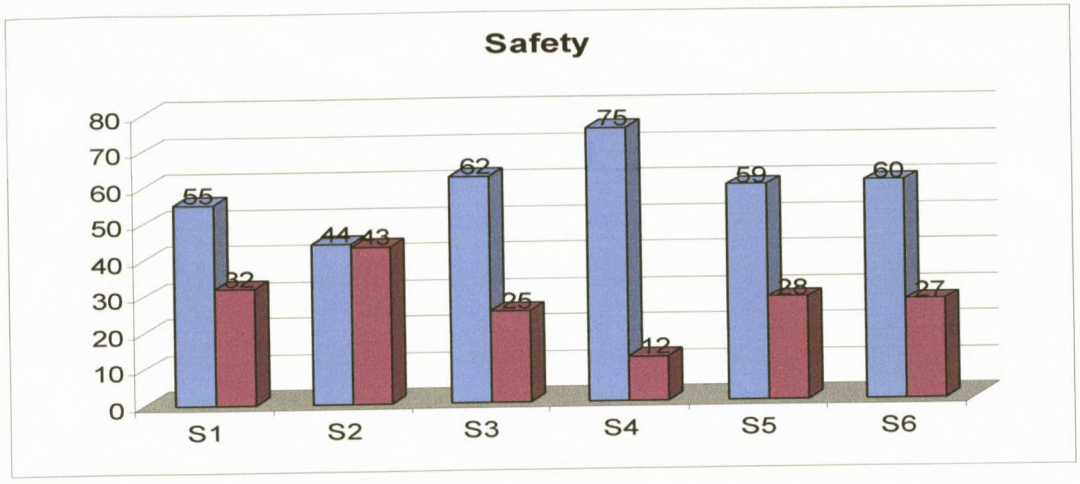


4.3.8.6 Safety

Figure 4.72 shows the number of respondents that agreed (in maroon) and the number that disagreed (in purple) to the statements posed on safety. Listed below are the statements posed in the survey and the associated results by critical percentage perstatement:

- Workers claim that there are no safety meetings 36%
- Staff claim that there is no provision for fire training 49%
- Workers don't wear PPE because its uncomfortable 42%
- Housekeeping in the plant is very poor 32%
- The workers claim that supervisors force them to do unsafe jobs 30%

Figure 4.72: Safety

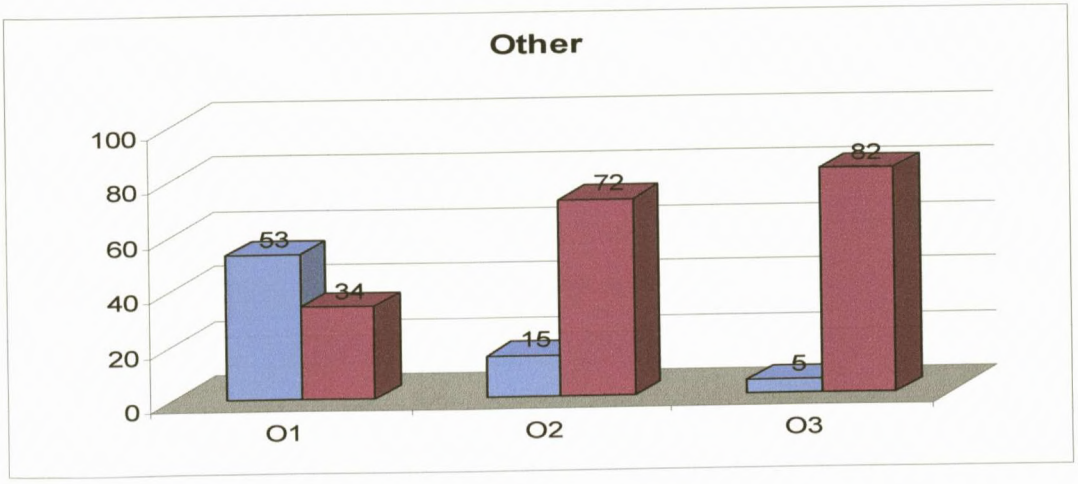


4.3.8.7 Other

Figure 4.73 shows the number of respondents that agreed (in maroon) and the number that disagreed (in purple) to other aspects contributing directly to unsafe incidents. Listed below are the statements posed in the survey and resultant degree of agreement by the respondents in percentages:

- Truck drivers cause most of the problems 39%
- Workers claim that there are not enough social activities to de-stress 82%
- Workers claim that they are paid lower than the industry standard 94%

Figure 4.73: Other



4.3.9 Reliability of the Questionnaire

The Coefficient Alpha for this questionnaire is .885 which indicates that there is a very high degree of internal consistency and stability with the responses. The closer the coefficient alpha is to 1, the greater the internal consistency of the items and the greater the reliability of the questionnaire. Cronbach's Alpha is used to test the internal consistency or homogeneity among the items present (Cooper & Schindler, 2001:217).

4.3.10 Conclusion

The biographical data reflect a total of 87 respondents, made up of 82 males and 5 females. The respondents comprise 54 Blacks, 25 Indians, 7 Whites and 1 Coloured. The average age is 35 years and level of education ranges from primary to tertiary. The average service is about eight years. This finding shows the respondents are mainly Blacks followed by Indians.

On the analysis of the research data, Plant and Equipment had the highest impact on unsafe incidents followed by Other, Safety, Planning and Workload, Communications, Training & Development and lastly Behaviour and Attitude. In the presentation, the responses to the survey statements for each of the contributors are represented in graphical format with detailed explanations on each contributor. The number of questions asked for each contributor is as follows:

- Other 3
- Plant and equipment 5
- Communications 6
- Training and development 7
- Behaviour and attitude 22
- Planning and workload 9
- Safety 6

The majority of the respondents in the survey agreed that the contributors played a major

part in the occurrence of unsafe incidents. The analysis also indicated that the Coefficient Alpha for this questionnaire was .885 which indicates that there is a very high degree of internal consistency and stability with the responses. The closer the coefficient alpha is to 1, the greater the internal consistency of the items and the greater the reliability of the questionnaire. The overall findings are that all the key contributors contributed, in some measure, to the unsafe incidents at the company in question.

Chapter 5

Conclusion and recommendations

5.1 Introduction

In this chapter, the conclusions are drawn by briefly describing the aim of the study, the literature review done, the methodology used in the study and the overall findings. Recommendations are made under each theme per contributor and, finally, a summary is presented.

5.2 Conclusions

The aim of this research was to determine the main contributory factors that impacted on the safety, environmental and operational risks for all stakeholders at the selected organization. Discussions were held with management and data on unsafe incidents were examined and tabulated. Management has attributed the large number of incidents to the following factors:

- Poor equipment;
- Non-adherence to procedures; and
- Inadequate training.

There was an average of 190 unsafe incidents recorded per year. The respective departments, where most of the incidents originated, were requested to complete questionnaires. The questionnaires included biographical demographics, and closed ended statements covering seven key areas. The respondents had to give their perceptions on the main contributors to the said incidents. A literature review was also done in order to set up a benchmark for this study. The conclusions were drawn using the findings of this study together with the literature review. The review outlined the actual unsafe incidents that occurred in many chemical companies, new safety culture, new sustainable plant designs, human attitude and behaviour, creating blame free programmes, following safety rules and

checklists, waste prevention and pollution, human error, life cycle thinking and employee empowerment.

In summary, research has been done over a long period on health and safety at chemical companies but there are still many incidents occurring. The key is to reduce these incidents and keep all stakeholders safe. The human element is by far the major contributor to the unsafe incidents. Therefore, empowerment and more training must take place to reduce unsafe incidents. Plant designs are also reviewed to incorporate global best practices and the call is for more automation and less human intervention. The bottom line is that chemical plants are here to stay but they must blend in with all the stakeholders and not cause damage to the environment and life.

The planning process used for the research was outlined. The necessary permission was obtained from the said organization and the initial group of respondents selected for the pilot study. The questionnaire was corrected for errors after the pilot test. The main survey was carried out and the data collected, coded and processed. Finally, the results were analysed using SPSS version 13. Biographical data reflect a total of 87 respondents, made up of 82 males and 5 females. On the analysis of the research data, the beta values showed that Plant and Equipment had the highest impact on unsafe incidents followed by Other, Safety, Planning and Workload, Communications, Training and Development and lastly Behaviour and Attitude. The analysis also indicated that there was a very high degree of internal consistency and stability with the responses from respondents. The overall findings are that all the key contributors directly impacted the company in question by creating many unsafe incidents.

5.3 Recommendations

The recommendations are made to key contributors ranked in order of significance. The company should do the following to improve on unsafe incidents per contributor:

5.3.1 Plant and Equipment

Management need to take an inventory of all plant tools, replace and set up controls to safeguard them. Plant engineers must get operators to buy-in by allowing operators to have a say in plant design. The engineers need to do an audit on the state of the plant and upgrade to the latest global safe plant designs. Management need to take disciplinary steps against those that are signing off work with out the proper verification and quality checks being done. The plant maintenance team needs to carry out a complete lighting check and replace the faulty lights and add new lights in poorly lit areas.

5.3.2 Other

Management must ensure that contractors provide personnel that are efficiently trained with certification when working on chemical sites. The company needs to provide employees more leisure activities and also train them on how to handle stress. A review needs to be carried out on the industry related salaries and adjust employee salaries if far below or if on par, relate findings to staff.

5.3.3 Safety

The company has had many unsafe incidents and should ensure that the safety program is re implemented as a matter of urgency to improve safety. The fire teams need to have fire training and must be in readiness for fire fighting. Ensure that the proper fitting PPE is obtained and all workers use PPE at all times in comfort. Take disciplinary action against those who do not use PPE at night. Instill in all workers that housekeeping is part of the daily work pattern and done at the completion of a task. Management must discipline supervisors who force workers to do unsafe jobs.

5.3.4 Planning and Workload

Ensure that all staff have tea and lunch breaks accordingly as per the basic conditions of employment act. To work smartly, senior staff must use computers as part of the job. Ensure training is part of the staff job requirements and must be done diligently by all. Ensure that staff do proper checks including risk assessments on their jobs. Management

must ensure that the staffing levels are adequate for the job. Take disciplinary action against staff that allow workers to work very long hours. Ensure the work is evenly distributed to all. Discipline staff who are regularly absent and keep absenteeism low.

5.3.5 Communications

Management must ensure that the channels of communications are clear to all. Ensure radio operating procedures and practices are followed by all. Train staff on proper report writing skills. Regularly have computer programs checked for fault free functioning. Consult where appropriate with staff before making decisions. Test work instructions for accuracy before issuing to workers.

5.3.6 Training and Development

Management must train all staff on the hazards of chemicals that are handled. Train all new staff sufficiently for them to work safely. Improve management skills so that managers can run the company efficiently. Ensure supervisors do on the job training with the workers. Supervisors must be sufficiently trained so that they know more than the workers. Additional training must be given to staff on the use of computers. Promote staff on merit with sufficient experience.

5.3.7 Behaviour and Attitude

Management must motivate staff in changing their attitudes towards their job. Discipline staff for not following procedures. Ensure that all workers are treated with respect and dignity. Ensure all employees are empowered to do the job. Improve two way communications by ensuring supervisor listen to the workers and feedback to them. Discipline supervisors that victimize workers that complain. Maintenance staff must repair faults that are reported immediately. Discipline operators and supervisors that use short cuts or unsafe operating methods. Ensure supervisors are disciplined if they swears operators. Managers must check the stress levels and other personal problems and assist to rectify. Ensure supervisors notify workers when they have to leave their work stations.

Ensure managers improve their attitudes and take care of the job. Skill supervisors on how to be approachable to the workers. Ensure supervisors check the job of the worker for quality and output. Discipline supervisors that abuse contract workers. Train the work force to work with all employees and not assist only their own race groups. Train supervisors on how to work with their counterparts. Ensure that there a "blame-free" work environment. Skill supervisors on how to motivate workers by praising then for outstanding input.

5.4 Summary

The objective of this study was to identify the variables that contribute to the high number of unsafe incidents within the organisation.

The sub-objectives of the study are:

- To ascertain staff perceptions of the contributors to the incidents and unsafe working conditions;
- To determine if management is accurate in their assumptions of the causes for the incidents; and
- To determine relationships between staff perceptions and actual causes of the incidents.

The aim of the study was achieved in identifying the following contributing factors, in order of significance:

- Plant & equipment;
- Other;
- Safety;
- Planning & workload;
- Communications;
- Training & development; and
- Behaviour & attitude.

The first sub-objective was to ascertain staff perceptions on the contributors of unsafe

incidents and this was done with the use of questionnaires and recorded under the findings of the study.

The second sub-objective was to determine if management was accurate in their assumptions on the causes of unsafe incidents. Management has attributed the large number of incidents to the following factors:

- Poor equipment;
- Non-adherence to procedures; and
- Inadequate training.

Management were partly accurate in their assumptions of the causes of the incidents. Poor equipment and training were predicted by management and a point on non adherence of procedures. The five other additional contributors that were identified are listed below:

1. Other;
2. Safety;
3. Planning & workload;
4. Communications; and
5. Behaviour & attitude.

This finding shows if the problems are not properly diagnosed, the proper solution cannot be found to solve them.

The third sub-objective was to determine if any relationships existed between staff perceptions and actual causes of the incidents. Staff perceptions and the actual causes are accurately matched as staff know first hand of the contributors that cause all the unsafe incidents.

Finally, many of unsafe incidents could have been avoided if management examined the issues on hand regularly and took the necessary action. This action is the normal

requirement of any organization. The said organisation is a listed ISO 9001-2000 company. The organization has a system of documenting all unsafe incidents and taking the necessary corrective actions. The process has failed due to it not being properly managed. Linked to corrective actions, there is also a root cause analysis to be done. This analysis was seldom done to establish what actually caused the unsafe incident. There is evidence of the system not working due to having so many repeat unsafe incidents. this finding shows that the corrective action put in place was not properly evaluated before implementation. The organization needs to study the findings of the research and implement the necessary corrective action. Therefore, the conclusion is that the aim and the sub-objectives of this study have been achieved .

Bibliography

American Institute of Chemical Engineers, 2003. *Guidelines for Investigating Chemical Process Incidents.*

Azapagic, A. Perdan, S. and Clift, R. 2004. *Sustainable Development in Practice.* West Sussex: Wiley.

Carson, P. and Mumford, C. 2002. *Hazardous Chemicals Handbook.* Woburn: Butterworth-Heinemann.

Cheremisinoff, N. 2002. *Handbook of Air Pollution Prevention and Control.* Woburn: Butterworth-Heinemann.

Christ, C. 1999. *Production-Integrated Environmental Protection and Waste Management in the Chemical Industry.* Weinheim: Wiley.

Cournoyer, M. and Maestas, M. 2004. Management Walkabout.[online] *Chemical Health and Safety Journal*,Vol.11 (6):12-16. Available at:(http://www.sciencedirect.com). [Accessed on 2006-10-11.]

Cournoyer, M. Maestas, M. Porterfield, D. and Spink, P. 2005 . Chemical Inventory Management.[online]. *Chemical Health and Safety Journal*, Vol.12 (5): 15-20 Available at: (http://www.sciencedirect.com). [Accessed on 2006-11-23.]

Cummings, T and Worley, C. 2005. *Organization Development & Change.* Ohio: South Western.

Das, T. 2005. *Toward Zero Discharge.* Hoboken, New Jersey: Wiley.

Eccleston, C. *2000. Environmental Impact Statements.* New York: Wiley.

Erickson, J. 2006. Survey Uncovering Employees Views about Safety. [online]. Occupational Hazards Journal: 4. Available at (http:www.occupationalhazards.com).[Accessed on 2007-3-10]

Erickson, S. and King, B. 1999. *Fundamentals of Environmental Management*. New York: Wiley.

Fivizzani, K.P. 2004. Transforming Employees into Safety Partners.[online]. *Chemical Health and Safety Journal*, Vol. 11 (3): 9-11. Available at: (http://www.sciencedirect.com). [Accessed on 2006-10-11.]

Fivizzani, K.P. 2005. Job Analysis for use of Correct Personal Protective Equipment.[online]. *Chemical Health and Safety Journal*, Vol.12 (6): 11-15
Available at: (http://www.sciencedirect.com). [Accessed on 2006-11-23.]

Fullwood, R. 2000. *Probabilistic Safety Assessment in the Chemical and Nuclear Industries.* Boston: Butterworth-Heinemann

Geller. 2005. Developing a Total Safety Culture.[online]. *Chemical Health and Safety Journal*, Vol.12 (2): 44. Available at: (http://www.sciencedirect.com).
[Accessed on 2006-11-23.]

Ghassemi, A. 2002. *Handbook of Pollution Control and Waste Minimization.* New York: Marcel Dekker, Inc.

Goehl. 2005. Importance of Information Sharing.[online]. *Chemical Health and Safety Journal*, Vol.12 (3): 5-8. Available at: (http://www.sciencedirect.com).
[Accessed on 2006-11-23.]

Hackman, L, E and M. 2002. *Hazardous Waste Operations & Emergency Response Manual and Desk Reference.* New York: McGraw-Hill

Holbeche, L. 2005. *The High Performance Organization*. Burlington: Elsevier Butterworth-Heinemann

Jordening, J. and Winter, J. 2005. *Environmental Biotechnology*. Weinheim: Wiley.

Kletz, T. 1999. *What Went Wrong?* Woburn: Butterworth-Heinemann.

Koolen, J. 2001. *Design of Simple and Robust Process Plants*. Weinheim: Wiley.

Lieberman, P. and T. 2003. *Working Guide to Process Equipment*. New York: McGraw-Hill Companies, Inc.

Marshall, V. and Ruhemann, S. 2001. *Fundamentals of Process Safety*. Rugby: Institute of Chemical Engineers.

McKinney, R, 2004. *Environmental Pollution Control Microbiology*. New York: Marcel Dekker, Inc.

Mizrahi, J. 2002. *Developing an Industrial Chemical Process*. Miami: CRC Press LLC.

Occupational Health and Safety Regulations 85 of 1993. 2001 Durban: Butterworth Publishers.

Rauch, J. 2003. *Multiproduct Plants*. Weinheim: Wiley.

Responsible_Care_Global_Charter. 1984.[online]Available at: www.ccpa.ca/files/Library/Documents/RC. [Accessed on 2006-10-11.]

Reeve, R. 2002. *Introduction to Environmental Analysis*. West Sussex: Wiley.

Robbins, S. 2001. *Organizational Behaviour*. Upper Saddle River: Prentice-Hall.

Schmidt, L. 2005. *The Engineering of Chemical Reactions*. New York: Oxford University Press.

Sekaran, U. 2000. Research Methods for Business. New York: Wiley.

Sullivan, P. Agardy, F and Traub, R. (2001). *Practical Environmental Forensics*. New York: Wiley.

Vogel, G. 2005. *Process Development*. Weinheim: Wiley.

Woods, D. 2006. *Successful Trouble Shooting for Process Engineers*. Weinheim: Wiley.

Appendices

a) Covering letter for the research questionnaire:

Dear Respondent

RESEARCH QUESTIONNAIRE ON ALL OPERATIONAL INCIDENTS TO DATE

I am currently conducting research for my Master's Degree in Business Administration at the Durban Institute of Technology. In terms of the programme, a research project needs to be conducted.

I have chosen to research the variables that contribute to the incidents that occur on our sites so that management can use the results in minimizing the incidents. Your participation in the study will take about 20 minutes and will involve completing a questionnaire.

I have listed all the likely variables that could have contributed to the unsafe incidents and would like you to carefully consider the incidents and then select a number from 1 to 4. Place a cross (X) in the box selected.

All of your answers will be kept confidential and anonymous. Your participation is voluntary. Should you have any questions about this study, please feel free to contact me.
Thank you in advance for your co-operation.

Sincerely

DRT Nayager

b) Research questionnaire

If your answer is "yes" please tick the appropriate box below in questions 1 to 7:

1. Gender:

Male	Female

2. Race group:

African	Indian	White	Coloured

3. Age:

Under 25	26 – 30	31 – 35	36 – 40	41 - 45
46 – 50	51 – 55	56 – 60	61 – 65	66 and older

4. Dept:

Operations	Logistics	Maintenance	Compliance

5. Position:

Superintendent	Supervisor	Operator 1	Operator 2	Operator 3
Customer Serv.	Ops Admin	W-bridge	Contractor	Other

6. Level of education:

Primary School	Std 6 – Std 9	Matric	Diploma	Degree

7. Years service:

1 – 5	6 – 10	11 – 15	16 – 20
21 – 25	26 – 30	31 - 35	36 - 40

Please indicate your level of agreement with the following statements by placing a cross (x) in the appropriate box. Please give careful thought before indicating your choice.

1- Strongly Disagree
2- Disagree
3- Agree
4- Strongly Agree

Statement: THE ACTUAL CONTRIBUTORS TO INCIDENTS AND UNSAFE WORKING CONDITIONS ARE:

ANSWERS	1	2	3	4
1) Behaviour and attitude:				
Poor attitude of staff towards their job				
Not following procedures when working				
Reportees treated like children by supervisors				
Reportees not empowered by supervisors				
Reportees not respected by our supervisors				
Supervisor does not listen to us				
I get victimized if I complain				
Faults are reported, management does little or nothing				
Operators copy unsafe methods from our supervisors				
Supervisor uses swear words on me				
Other personal problems affect my work				
Fellow workers treat me with no respect				
Short cuts are used to finish the job quickly				
Supervisor is not around when I need him				
The managers don't worry so why must I ?				
The supervisor is unapproachable				
The supervisor does not check my job				
The supervisors abuse contract operators				
Each race group helps their own kind				
One supervisor does not get along with the other				
The supervisor always blames us for all issues				
The supervisor does not recognize our achievement				

1- Strongly Disagree	2- Disagree	3- Agree	4- Strongly Agree			
				1	2	3	4
2) Communications:							
There are too many bosses							
Staff don't answer their radios							
Poorly written reports							
The computer programmes cause the problems							
Management takes decisions without consulting us							
Incidents are caused by incorrect work instructions							
3) Plant and equipment:							
I do not have the correct tools to do my job							
I have no input on plant design							
The company uses outdated equipment							
Contractors hand back poorly maintained equipment							
The lighting is very poor at night							
4) Training and development:							
I do not know everything about chemicals							
Too many inexperienced staff							
Managers running the company poorly							
Supervisors do not train us on the job							
Know more than our supervisor/manager							
I do not know how to use the computer							
Staff are promoted with little experience							
5) Planning and work load:							
I have no time to have tea or lunch							
As supervisor I have no time to use the computer							
I have no time for training							
I do not have enough time to do proper checks.							
I do not have the time to do a last minute risk assessment							
Too few people working with us							
Work very long hours							
I work very hard whilst others do very little							
Staff are regularly absent							

1- Strongly Disagree	2- Disagree	3- Agree	4- Strongly Agree

	1	2	3	4
6) Safety:				
I do not have safety meetings				
I have not done fire training				
I do not like to wear PPE because it is uncomfortable				
I use safety equipment only during the day				
The housekeeping is very poor				
Supervisor forces me to do a job that is unsafe				
7) Other:				
Truck drivers cause most of the problems				
There are not enough social activities for us to de-stress				
We are paid lower than the industry standard				

c) Analysis of research data using SPSS version 13

- **Frequency and percentage of responses in terms of the biographical variables.**

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	82	94.3	94.3	94.3
	Female	5	5.7	5.7	100.0
	Total	87	100.0	100.0	

Race

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	African	54	62.1	62.1	62.1
	Indian	25	28.7	28.7	90.8
	White	7	8.0	8.0	98.9
	Coloured	1	1.1	1.1	100.0
	Total	87	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under 25	13	14.9	14.9	14.9
	26-30	22	25.3	25.3	40.2
	31-35	19	21.8	21.8	62.1
	36-40	13	14.9	14.9	77.0
	41-45	7	8.0	8.0	85.1
	46-50	4	4.6	4.6	89.7
	51-55	4	4.6	4.6	94.3
	56-60	2	2.3	2.3	96.6
	61-65	3	3.4	3.4	100.0
	Total	87	100.0	100.0	

Department

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Operations	65	74.7	74.7	74.7
	Logistics	15	17.2	17.2	92.0
	Maintenance	4	4.6	4.6	96.6
	Compliance	3	3.4	3.4	100.0
	Total	87	100.0	100.0	

Position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Superintendent	1	1.1	1.1	1.1
	Supervisor	10	11.5	11.5	12.6
	Operator 1	19	21.8	21.8	34.5
	Operator 2	12	13.8	13.8	48.3
	Operator 3	9	10.3	10.3	58.6
	Customer Serv.	5	5.7	5.7	64.4
	Ops Admin	6	6.9	6.9	71.3
	W-bridge	3	3.4	3.4	74.7
	Contractor	14	16.1	16.1	90.8
	Other	8	9.2	9.2	100.0
	Total	87	100.0	100.0	

Level of Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Primary School	8	9.2	9.2	9.2
	Std 6 - Std 9	26	29.9	29.9	39.1
	Matric	37	42.5	42.5	81.6
	Diploma	10	11.5	11.5	93.1
	Degree	6	6.9	6.9	100.0
	Total	87	100.0	100.0	

Years of service

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-5	50	57.5	57.5	57.5
	6-10	14	16.1	16.1	73.6
	11-15	8	9.2	9.2	82.8
	16-20	5	5.7	5.7	88.5
	21-25	7	8.0	8.0	96.6
	26-30	1	1.1	1.1	97.7
	31-35	2	2.3	2.3	100.0
	Total	87	100.0	100.0	

- **Frequency tables for the contributing factors**
  BEHAVIOUR & ATTITUDE

	Strongly disagree		Disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%
BA1	12	13.8%	13	14.9%	44	50.6%	18	20.7%
BA2	7	8.0%	18	20.7%	46	52.9%	16	18.4%
BA3	7	8.0%	37	42.5%	20	23.0%	23	26.4%
BA4	8	9.2%	34	39.1%	29	33.3%	16	18.4%
BA5	11	12.6%	35	40.2%	25	28.7%	16	18.4%
BA6	7	8.0%	40	46.0%	25	28.7%	15	17.2%
BA7	14	16.1%	29	33.3%	28	32.2%	16	18.4%
BA8	7	8.0%	17	19.5%	36	41.4%	27	31.0%
BA9	17	19.5%	37	42.5%	25	28.7%	8	9.2%
BA10	24	27.6%	43	49.4%	15	17.2%	5	5.7%
BA11	31	35.6%	35	40.2%	16	18.4%	5	5.7%
BA12	24	27.6%	42	48.3%	13	14.9%	8	9.2%
BA13	20	23.0%	34	39.1%	26	29.9%	7	8.0%
BA14	16	18.4%	41	47.1%	24	27.6%	6	6.9%
BA15	24	27.6%	46	52.9%	13	14.9%	4	4.6%
BA16	15	17.2%	47	54.0%	20	23.0%	5	5.7%
BA17	17	19.5%	37	42.5%	27	31.0%	6	6.9%
BA18	21	24.1%	31	35.6%	22	25.3%	13	14.9%
BA19	12	13.8%	21	24.1%	22	25.3%	32	36.8%
BA20	9	10.3%	35	40.2%	34	39.1%	9	10.3%
BA21	7	8.0%	27	31.0%	37	42.5%	16	18.4%
BA22	6	6.9%	18	20.7%	39	44.8%	24	27.6%

COMMUNICATIONS

	Strongly disagree		Disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%
C1	11	12.6%	14	16.1%	42	48.3%	20	23.0%
C2	10	11.5%	36	41.4%	32	36.8%	9	10.3%
C3	17	19.5%	32	36.8%	30	34.5%	8	9.2%
C4	11	12.6%	36	41.4%	32	36.8%	8	9.2%
C5	1	1.1%	20	23.0%	31	35.6%	35	40.2%
C6	5	5.7%	36	41.4%	36	41.4%	10	11.5%

PLANT & EQUIPMENT

	Strongly disagree		Disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%
PE1	17	19.5%	33	37.9%	31	35.6%	6	6.9%
PE2	12	13.8%	16	18.4%	37	42.5%	22	25.3%
PE3	11	12.6%	31	35.6%	31	35.6%	14	16.1%
PE4	8	9.2%	24	27.6%	36	41.4%	19	21.8%
PE5	16	18.4%	18	20.7%	37	42.5%	16	18.4%

TRAINING & DEVELOPMENT

	Strongly disagree		Disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%
TD1	10	11.5%	18	20.7%	47	54.0%	12	13.8%
TD2	10	11.5%	21	24.1%	42	48.3%	14	16.1%
TD3	6	6.9%	32	36.8%	30	34.5%	19	21.8%
TD4	12	13.8%	34	39.1%	28	32.2%	13	14.9%
TD5	18	20.7%	39	44.8%	22	25.3%	8	9.2%
TD6	22	25.3%	27	31.0%	29	33.3%	9	10.3%
TD7	4	4.6%	21	24.1%	32	36.8%	30	34.5%

PLANNING & WORK LOAD

	Strongly disagree		Disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%
PW1	21	24.1%	31	35.6%	23	26.4%	12	13.8%
PW2	3	3.4%	8	9.2%	5	5.7%	4	4.6%
PW3	23	26.4%	31	35.6%	21	24.1%	12	13.8%
PW4	20	23.0%	30	34.5%	29	33.3%	8	9.2%
PW5	22	25.3%	29	33.3%	24	27.6%	12	13.8%
PW6	15	17.2%	22	25.3%	31	35.6%	19	21.8%
PW7	11	12.6%	36	41.4%	25	28.7%	15	17.2%
PW8	6	6.9%	30	34.5%	32	36.8%	19	21.8%
PW9	15	17.2%	25	28.7%	38	43.7%	9	10.3%

SAFETY

	Strongly disagree		Disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%
S1	29	33.3%	26	29.9%	22	25.3%	10	11.5%
S2	26	29.9%	18	20.7%	24	27.6%	19	21.8%
S3	30	34.5%	32	36.8%	19	21.8%	6	6.9%
S4	38	43.7%	37	42.5%	10	11.5%	2	2.3%
S5	26	29.9%	33	37.9%	23	26.4%	5	5.7%
S6	23	26.4%	37	42.5%	20	23.0%	7	8.0%

OTHER

	Strongly disagree		Disagree		Agree		Strongly agree	
	N	%	N	%	N	%	N	%
O1	23	26.4%	30	34.5%	24	27.6%	10	11.5%
O2	4	4.6%	11	12.6%	30	34.5%	42	48.3%
O3	2	2.3%	3	3.4%	19	21.8%	63	72.4%

- **Tables where Agree/Strongly agree and Disagree/Strongly disagree have been combined**

BEHAVIOUR & ATTITUDE

	Disagree		Agree	
	Count	%	Count	%
BA1	25	28.7%	62	71.3%
BA2	25	28.7%	62	71.3%
BA3	44	50.6%	43	49.4%
BA4	42	48.3%	45	51.7%
BA5	46	52.9%	41	47.1%
BA6	47	54.0%	40	46.0%
BA7	43	49.4%	44	50.6%
BA8	24	27.6%	63	72.4%
BA9	54	62.1%	33	37.9%
BA10	67	77.0%	20	23.0%
BA11	66	75.9%	21	24.1%
BA12	66	75.9%	21	24.1%
BA13	54	62.1%	33	37.9%
BA14	57	65.5%	30	34.5%
BA15	70	80.5%	17	19.5%
BA16	62	71.3%	25	28.7%
BA17	54	62.1%	33	37.9%
BA18	52	59.8%	35	40.2%
BA19	33	37.9%	54	62.1%
BA20	44	50.6%	43	49.4%
BA21	34	39.1%	53	60.9%
BA22	24	27.6%	63	72.4%

COMMUNICATIONS

	Disagree		Agree	
	Count	%	Count	%
C1	25	28.7%	62	71.3%
C2	46	52.9%	41	47.1%
C3	49	56.3%	38	43.7%
C4	47	54.0%	40	46.0%
C5	21	24.1%	66	75.9%
C6	41	47.1%	46	52.9%

PLANT & EQUIPMENT

	Disagree		Agree	
	Count	%	Count	%
PE1	50	57.5%	37	42.5%
PE2	28	32.2%	59	67.8%
PE3	42	48.3%	45	51.7%
PE4	32	36.8%	55	63.2%
PE5	34	39.1%	53	60.9%

TRAINING & DEVELOPMENT

	Disagree		Agree	
	Count	%	Count	%
TD1	28	32.2%	59	67.8%
TD2	31	35.6%	56	64.4%
TD3	38	43.7%	49	56.3%
TD4	46	52.9%	41	47.1%
TD5	57	65.5%	30	34.5%
TD6	49	56.3%	38	43.7%
TD7	25	28.7%	62	71.3%

PLANNING & WORK LOAD

	0		Disagree		Agree	
	Count	%	Count	%	Count	%
PW1	0	.0%	52	59.8%	35	40.2%
PW2	67	77.0%	11	12.6%	9	10.3%
PW3	0	.0%	54	62.1%	33	37.9%
PW4	0	.0%	50	57.5%	37	42.5%
PW5	0	.0%	51	58.6%	36	41.4%
PW6	0	.0%	37	42.5%	50	57.5%
PW7	0	.0%	47	54.0%	40	46.0%
PW8	0	.0%	36	41.4%	51	58.6%
PW9	0	.0%	40	46.0%	47	54.0%

OTHER

	Disagree		Agree	
	Count	%	Count	%
O1	53	60.9%	34	39.1%
O2	15	17.2%	72	82.8%
O3	5	5.7%	82	94.3%

SAFETY

	Disagree		Agree	
	Count	%	Count	%
S1	55	63.2%	32	36.8%
S2	44	50.6%	43	49.4%
S3	62	71.3%	25	28.7%
S4	75	86.2%	12	13.8%
S5	59	67.8%	28	32.2%
S6	60	69.0%	27	31.0%

- **Descriptive stats – to show overall attitude/perceptions regarding each factor**

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Behaviour & Attitude	87	1.14	3.55	2.4493	.45710
Communications	87	1.33	3.83	2.6284	.48804
Plant & Equipment	87	1.00	4.00	2.6023	.63794
Training & Development	87	1.43	3.71	2.5878	.46338
Planning & Workload	87	1.33	3.78	2.2273	.48960
Safety	87	1.00	3.17	2.0843	.49276
Other	87	1.00	4.00	3.0498	.62985
Valid N (listwise)	87				

The mean values give an indication of the level of perceptions for each factor. Values below 3 indicate that respondents strongly disagreed/Disagreed to the questions. Values of 3 or more indicate that respondents Agreed/Strongly agreed to questions.

The standard deviation values are low (ie below 1) and indicate that generally there a small amount of deviation from the mean ie respondents generally "had the same opinion"

Each of the overall factors were created by averaging the responses of the associated questions. For example, the value for Behaviour & Attitude is the average of all the questions that relate to Behaviour & Attitude.

- **Reliability – to test reliability of the data**

Reliability Statistics

Cronbach's Alpha	N of Items
.885	58

The cronbach's alpha value indicates the reliability of the data. A value of 0.885 shows a high degree of internal consistency and stability with the responses.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
BA1	139.70	357.212	.300	.884
BA2	139.67	358.225	.310	.884
BA3	139.80	359.554	.225	.885
BA4	139.87	353.809	.418	.882
BA5	139.95	353.765	.397	.882
BA6	139.93	351.111	.513	.881
BA7	139.95	355.137	.342	.883
BA8	139.53	351.252	.483	.881
BA9	140.21	351.282	.500	.881
BA10	140.47	360.647	.233	.885
BA11	140.54	361.042	.204	.885
BA12	140.43	361.643	.183	.885
BA13	140.25	353.261	.432	.882
BA14	140.25	355.075	.411	.882
BA15	140.52	357.904	.341	.883
BA16	140.31	355.775	.416	.882
BA17	140.23	353.644	.446	.882
BA18	140.17	347.284	.544	.880
BA19	139.63	350.119	.433	.882
BA20	139.99	357.500	.338	.883
BA21	139.77	351.133	.520	.881
BA22	139.55	352.390	.473	.882
C1	139.67	352.295	.441	.882
C2	140.02	357.534	.331	.883
C3	140.15	354.268	.402	.882
C4	140.06	361.287	.211	.885
C5	139.33	354.504	.440	.882
C6	139.90	362.722	.182	.885
PE1	140.18	351.361	.511	.881
PE2	139.69	354.682	.353	.883
PE3	139.93	356.623	.325	.883
PE4	139.72	351.179	.493	.881
PE5	139.87	348.461	.518	.881
TD1	139.78	361.498	.199	.885
TD2	139.79	356.422	.345	.883
TD3	139.77	350.807	.513	.881
TD4	140.00	350.953	.493	.881
TD5	140.25	361.703	.183	.885
TD6	140.20	360.066	.209	.885
TD7	139.47	354.554	.401	.882
PW1	140.18	359.105	.228	.885
PW2	141.91	362.224	.115	.887
PW3	140.23	362.226	.142	.886
PW4	140.20	354.415	.383	.883
PW5	140.18	351.756	.423	.882
PW6	139.86	367.190	.011	.888
PW7	139.98	364.488	.093	.886
PW8	139.75	357.517	.310	.884
PW9	140.01	356.384	.337	.883
S1	140.33	369.178	-.040	.889
S2	140.07	364.484	.066	.888
S3	140.47	359.740	.231	.885
S4	140.76	361.604	.225	.885
S5	140.40	358.825	.267	.884
S6	140.36	356.116	.345	.883
O1	140.24	361.488	.167	.886
O2	139.22	358.382	.294	.884
O3	138.84	357.416	.430	.883

- **Multiple Regression – to show which factors contribute more / impact more on Unsafe working conditions**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.776[a]	.602	.598	.21032
2	.875[b]	.765	.760	.16260
3	.932[c]	.869	.864	.12239
4	.964[d]	.929	.926	.09048
5	.977[e]	.955	.952	.07273
6	.989[f]	.978	.977	.05053
7	1.000[g]	1.000	1.000	.00000

Multiple regression was done to determine which variables contribute to Unsafe working conditions. The Table above (row 7) indicates that all variables entered in the analysis contribute to Unsafe working conditions (R-square = 1.000)

The Beta values in the table of coefficients below show which are the most influencing variables . From row 7, Plant & Equipment has the highest Beta value (0.275) showing that it impacts most on unsafe working conditions. The other factors, in order of impact, are Other, Safety, Planning and Workload, Communications, Training and development and, lastly, Behaviour and Attitude.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.469	.095		15.423	.000
	Plant & Equipment	.403	.036	.776	11.349	.000
2	(Constant)	.973	.098		9.902	.000
	Plant & Equipment	.354	.028	.680	12.522	.000
	Planning & Workload	.281	.037	.415	7.629	.000
3	(Constant)	.568	.089		6.368	.000
	Plant & Equipment	.275	.023	.529	11.767	.000
	Planning & Workload	.269	.028	.397	9.692	.000
	Behaviour & Attitude	.259	.032	.357	8.079	.000
4	(Constant)	.330	.072		4.587	.000
	Plant & Equipment	.247	.018	.475	14.002	.000
	Planning & Workload	.268	.021	.396	13.082	.000
	Behaviour & Attitude	.213	.024	.294	8.761	.000
	Other	.140	.017	.266	8.358	.000
5	(Constant)	.198	.061		3.240	.002
	Plant & Equipment	.220	.015	.422	14.919	.000
	Planning & Workload	.236	.017	.349	13.763	.000
	Behaviour & Attitude	.213	.020	.293	10.861	.000
	Other	.149	.014	.283	11.015	.000
	Safety	.119	.018	.177	6.776	.000
6	(Constant)	.096	.044		2.195	.031
	Plant & Equipment	.185	.011	.356	17.040	.000
	Planning & Workload	.173	.014	.256	12.673	.000
	Behaviour & Attitude	.187	.014	.258	13.489	.000
	Other	.149	.009	.283	15.885	.000
	Safety	.132	.012	.197	10.754	.000
	Communications	.139	.015	.205	9.370	.000
7	(Constant)	6.04E-017	.000		.000	1.000
	Plant & Equipment	.143	.000	.275	2E+008	.000
	Planning & Workload	.143	.000	.211	2E+008	.000
	Behaviour & Attitude	.143	.000	.197	2E+008	.000
	Other	.143	.000	.271	2E+008	.000
	Safety	.143	.000	.212	2E+008	.000
	Communications	.143	.000	.210	2E+008	.000
	Training & Development	.143	.000	.200	1E+008	.000

a. Dependent Variable: Unsafe Working Conditions

d) Additional information

Fullwood (2000)

Fullwood gives a summary of some of the most deadly and severe chemical accidents

- **Five hundred and seventy six die in Texas City disaster**

The port along Texas City was ripped apart on April 16, 1947 after a cargo ship, the SS Grandcamp, exploded during a shipboard fire. Fuelled by 2,300 tons of ammonium nitrate fertilizer, the tremendous blast triggered a series of explosions and fires that killed 576 people and injured 4000 more and damaged every building in Texas. The cause of the fire and explosion was a discarded cigarette on the ship in disregard of the "no smoking " signs posted on the wharf.

- **Twenty eight die at Felixborough**

On June 1, 1974, a vapour cloud explosion destroyed the 70,000 tons per year, Fleixboruogh Nyprocyclohexane oxidation plant killing 28 people. Other plants on site were seriously damaged or destroyed. One of the reactors developed a leak and the workers designed and installed a pipe from experience and did not use the services of a professional mechanical engineer. They did not cater for pipe stress working under 150 psi pressure and temperatures of about 150°c. This led to the bypass rupturing and releasing a 30 ton gas cloud which ignited from an unknown source.

- **Twenty-five hundred die at Bhopal, India**

December 2004 marked the 20th anniversary of the worst industrial accident in history: the chemical plant disaster in Bhopal, India, that killed thousands of people and injured tens of thousands more. (This is one unsafe chemical incident that the world would not once forget. Thousands of Bhopal victims suffered permanent, disabling injuries, which they must live with every day.) The tragedy changed public attitude toward the chemical industry in lasting ways. The United States Congress passed the Emergency Planning and

Community Right-to-Know Act (1986), followed by the Clean Air Act Amendments (1990). These laws have established a federal role in overseeing how companies manage the safety of chemical processes on a daily basis. South Africa also has similar bills passed to manage all chemical processes safely. (US Chemical Investigation Board. 2000. Bhopal Chemical Manufacturing Incident).

Research has been done over a long period on safety at chemical companies but there are still many incidents occurring all the time. Many incidents like the Bhopal disaster have claimed many lives and closed companies down. Some companies have followed safety and environmental programmes and have been successful in their business environments and satisfied stakeholders. On the other hand, those companies that did not follow such programmes or managed their non-conformances properly, are in major trouble with their stakeholders.

- **Three thousand evacuated hydrofluoric acid leak at Texas City**

October 31, 1987, a hydrofluoric acid leak occurred at a Marathon Petroleum refinery leading to the evacuation of 3,000 people over a 52 block area resulting in hundreds of injuries. A crane lifting a large piece of equipment failed and resulting in the equipment falling and severing the hydrofluoric acid lines. Hydrogen fluoride gas spewed from the broken pipes and formed a cloud over the city.