A STUDY OF CO-EXPOSURE TO CHEMICALS AND NOISE ON HEARING IN THE RUBBER INDUSTRY

By

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Dedicated to my wife

CARESSE

and daughters

KIARA and ALKA

DECLARATION OF CANDIDATE

I, Ivan Niranjan, hereby declare that except where acknowledged, this thesis is entirely my own work, that all resources used or quoted have been acknowledged and that this study has not previously been submitted for any degree to any other tertiary educational institution.

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ABSTRACT

Hearing conservation in the industrial setting has mainly focussed on the harmful effects of noise exposure on the auditory system. This study investigated the co-exposure to noise and ototoxic chemicals on the auditory system of workers engaged by labour brokers. It examined the adequacy of current occupational health and safety legislation to address chemically induced hearing loss and makes recommendations at a policy level to protect workers' hearing at the workplace.

This study is an exploratory cross-sectional field case study in an industrial setting. A sample of 300 workers was drawn from a rubber factory involved in the manufacture of components for the motor, shoe and plumbing industries in the metropolitan area of Durban. Purposive sampling was undertaken amongst a cohort of day shift workers which constituted the research subjects. The research tools used in the study included the completion of the NoiseChem questionnaire, conducting pure tone audiometric testing on research subjects, monitoring noise exposure levels and performing chemical air monitoring of the ambient environment.

This study confirms that a segment of the research subjects were exposed to both ototoxic chemicals and noise. Chemical exposure of research subjects was within legal permissible limits in most instances. Noise exposure exceeded the noise rating limit of 85 dBA in certain work areas. Multiple regression analysis revealed that there was a slight trend towards co-exposure to chemicals and noise being risk factors for hearing loss with an odds ratio of 1.7 (95% CI = 0.34 – 8.57) but the p value was not significant. No significant association with hearing loss was evident for workers exposed to chemical only with odds ratio of 0.41 (95% CI = 0.11 – 1.53, p = 0.19) and noise only with odds ratio of 0.87 (95% CI = 0.32 – 2.31, p = 0.78). The study indicated that workers exposed to both ototoxic chemicals and noise may be more susceptible to hearing loss in their current jobs. The study draws attention to policy gaps in the Occupational Health and Safety Act and proposes changes to address the shortcomings.

TABLE OF CONTENTS

ABBREVIATIONS

AIDS	Acquired Immune Deficiency Syndrome
AU	African Union
BS	British Standard
BCEA	Basic Conditions of Services Act, 1997
CEO	Chief Executive Officer
COIDA	Compensation for Occupational Illnesses and Diseases Act, 1993
COSATU	Congress of South African Trade Unions
dB	Decibel
dB HL	Decibel Hearing Level
DOH	Department of Health
DOL	Department of Labour
DME	Department of Mineral and Energy
EEA	Employment Equity Act, 1998
EMS	Environmental Management System
EU	European Union
HCS	Hazardous Chemical Substances
HIRA	Hazard Identification and Risk Assessment
HIV	Human Immunodeficiency Virus
HPE	Hearing Protective Equipment
ILO	International Labour Organisation
ISO	International Organization of Standardization
IMF	International Monetary Fund
kHz	Kilohertz
LRA	Labour Relations Act, 1995
LOAEL	Lowest Observed Adverse Effect Level
MBOD	Medical Bureau for Occupational Diseases
mg/m^3	Milli grams per cubic metre
NEDLAC	National Economic Development and Labour Council
NEPAD	New Partnership for Africa’s Development

NIOH	National Institute of Occupational Health
OHS	Occupational Health and Safety
OHSA	Occupational Health and Safety Act, 1993
OHSAS	Occupational Health and Safety Management System
OEL	Occupational Exposure Limit
RDP	Reconstruction and Development Programme
SABS	South African Bureau of Standards
SANS	South African National Standards
SF	Safety Factor
SIMRAC	Safety in Mines Research Advisory Committee
UN	United Nations
WHO	World Health Organisation

DEFINITIONS OF TERMS

Air Monitoring	Means the monitoring of the concentrations of airborne hazardous chemical substances.
Assessment	Means a programme to determine any risk from exposure to a hazardous chemical substance associated with any hazard thereof at the workplace in order to identify the steps needed to be taken to remove, reduce or control such hazard.
Audiogram	Means a chart, graph or table indicating the hearing threshold levels of an individual as a function of frequency namely 0.5, 1, 2, 3, 4, 6, 8 kilohertz, as determined during a measurement of a person's hearing threshold levels by means of a pure tone threshold test.
Audiogram	Means a chart, graph or table indicating the hearing threshold levels of an individual as a function of frequency namely 0.5, 1, 2, 3, 4, 6, 8 kilohertz, as determined during a measurement of a person's hearing threshold levels by means of a pure tone threshold test.
Audiometry	Testing of hearing ability. Pure tone audiometry records a individuals hearing level measured with certain pure tones at frequencies 0.5, 1, 2, 3, 4, 6, 8 kilohertz.
Decibel (dB)	A unit on the logarithm of the ratio of a measured sound pressure to a reference sound pressure
Frequency	The rate at which pressure oscillations are produced, expressed as cycles per second/Hertz.
Hertz(Hz)	Basic unit of frequency. 1Hz is equal to one vibration per second. A healthy young human ear is capable of detecting sound waves from 20 Hz to 20 000Hz.

Hazardous Chemical Substances	Means any toxic, harmful, corrosive, irritant or asphyxiant substance, or a mixture of such substances for which- • An occupational exposure limit is prescribed or • An occupational exposure limit is not prescribed, but which creates a hazard to health.
Impairment	The loss or loss of use, or derangement of any body part or system or function. Impairment including anatomic or physiologic deficits.
Intensity	The amplitude of the pressure fluctuations, expressed in decibels (dB).
Noise-rating limit	Means the value of the 8-hour rating level, 85 dBA at and above which hearing impairment is likely to result.
Notch	Permanent auditory threshold shift within a certain frequency range.
Occupational Exposure Limit	Means a limit value set by the Minister of Labour for a stress factor in the workplace as revised from time to time by notice in the Government Gaazette.
Occupational Hearing Loss (deafness)	A hearing impairment of one or both ears, partial or complete, arising out of and in the course of an individual worker’s employment.
Permanent Threshold Shift (PTS)	The prolonged exposure to noise causes permanent damage to the hearing mechanism.
Tinnitus	A ringing/buzzing/roaring/clicking sound in the ears.

STUDY DEFINITION OF NOISE INDUCED HEARING LOSS

Worker whose audiogram depicts the typical sign of noise induced hearing loss with the characteristic notch at 4 kilohertz (Taylor 1965:115). The degree and type of noise induced hearing loss was identified according to Goodman (1965:263); Cahart (1945:655); Gelfand (2001:157), Lustig *et al* (2003:67), Ackley *et al* (2007:101), Berger *et al* (2003:484) as follows:

CLASSIFICATION HEARING LOSS BASED ON THE PURE-TONE AVERAGE

Pure-tone average in db HL (decibel Hearing Level)	**Degree of hearing loss**
< = 15	Normal hearing
16-25	Slight hearing loss
26-40	Mild hearing loss
41-55	Moderate hearing loss
56-70	Moderately severe hearing loss
71-90	Severe hearing loss
> 90	Profound hearing loss

The type of hearing loss is inclusive of conductive, sensorineural and mixed hearing loss.

SCIENTIFIC CONFERENCE WHICH EMANATED FROM THIS STUDY

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CHAPTER ONE

INTRODUCTION

1.1 Study setting

This chapter focuses on the co-exposure to chemicals and noise in the industrial setting which enhances the risk for hearing loss. The risk from noise exposure is well established however the risk from chemicals is less understood. This study investigates four categories of workers at a rubber factory. The categories of workers include workers co-exposed to chemicals and noise, workers only exposed to noise, workers only exposed to chemicals and workers not exposed to chemicals and noise.

1.2 Background to the study

The study was conducted in a rubber manufacturing organization in Durban, KwaZulu Natal, South Africa, which employs four hundred and forty (440) workers. The organization is involved in rubber manufacturing for over seventy five years and more recently, in the last five years the holding organization relinquished its reins to a management take over. The organization is described as a world class rubber manufacturer supplying customers locally and internationally. The organization manufactures the full range of custom compounds natural rubber (NR), styrene-butadiene rubber (SBR), neoprene, ethylene propylene diene monomer (EPDM), nitrile, hydrin and hypalon and various blends. The organization also manufactures moulded products such as precured tread, sheeting, pipe seals, footwear components, automotive components and general mouldings from rubber and plastic. The organizations total annual sales volume ranges between R72million and R360million. The main trading market for the organization is Africa. The factory floor area is 16 000m^2. There are four employers in this rubber manufacturing organization, which is shown in Table 1. There are three labour brokers at the research location which employs approximately 90% of the workers the remainder 10% are employed by the principal employer in permanent positions.

Table 1: Employers at the rubber manufacturing organization studied

Categories of Employers and Labour Brokers		Chemicals and noise (n=122)		Chemicals only (n=29)		Noise only (n=70)		Unexposed (n=76)	
		Count	%	Count	%	Count	%	Count	%
Employer & Labour Brokers	Employer A	3	2.5%	8	27.6%	3	4.3%	17	22.4%
	Labour Broker B	47	38.5%	10	34.5%	1	1.4%	8	10.5%
	Labour Broker C	49	40.2%	7	24.1%	37	52.9%	48	63.2%
	Labour Broker D	23	18.9%	4	13.8%	29	41.4%	3	3.9%

Two workers were excluded from the sample on the account that they had pre-existing hearing impairment. These two workers were aggrieved about their exclusion and affected the participation of fellow workers in the research study, consequently for inclusiveness, they were considered. A third worker’s data had information missing and consequently was not used in the data analysis. Therefore, only 297 worker’s data sets was analysed for the study. However, for the data analysis purposes their data was not considered. The sample represented sixty six percent (66%) of the workers in the worker population. The six divisions are compounding and banbury mixing, milling, extruding and calendaring, component assembly and building, curing and vulcanizing and inspection and finishing.

This study presents data investigating hearing impairment at an industrial site in the Metropolitan area of Durban which is one of the most industrialized cities in South Africa. The main purpose was to examine how exposure to particular chemicals may contribute to hearing difficulties. There is limited data on this topic in either the occupational health and safety or quality management literatures, the epistemological context within which this thesis is located. This study uses the research instruments from the occupational hygiene and occupational medicine domains, which are applied to the quality management discipline.

The organization outsources its labour needs to three labour brokers mainly to reduce the wage bill and benefits, increase market flexibility and the avoidance of trade union involvement in the organization. There was a dual line of command in that workers reported to a labour broker co-ordinator on site for remuneration purposes and the principal employer's management representative for production requirements. The principal employer tracked all workers employed by labour brokers by using a biometric time clock and attendance system. Workers placed their finger on the fingerprint reader sensor each time they entered or left the factory premises and their remuneration was calculated accordingly. The biometric clock and attendance system excluded personnel employed by the principal employer.

The principal employer viewed occupational health and safety of workers employed *via* labour brokers as the responsibility of individual labour brokers in their individual capacity. The principal employer engaged the services of an occupational health and safety consultant whose mandate was to ensure that the principal employer was protected from criminal and civil liability in respect of occupational health and safety. The principal employer implemented an integrated quality, environment, health and safety management system. Occupational health and safety incidents and accidents were mainly minor in nature. Medical surveillance in the form of audiometric testing and lung function were contested between the labour brokers and the principal employer and was consequently not carried out. During the study the principal employer did not have an occupational health and safety policy.

The aspects and impacts register in respect of the environmental management system was generally managed well. Quality management system was also rigorously maintained on the account that the organisations customers demanded high quality final products.

Occupational environmental exposures include a number of hazardous agents such as noise, vibration, radiation, lighting, ventilation and heat. Noise arises from machinery used in the manufacturing process and represents physical noise. Chemicals such as gases, vapours, fumes, dust and aerosols are also hazardous to workers' health and well being. Vapours from certain chemicals have been known to cause hearing loss. This is evident from studies conducted by Johnson and Nylén, (1995) who investigated workers occupational health at rotogravure printing and paint manufacturing industries. Their research showed workers are at higher risk of hearing loss after exposure to certain chemicals.

The relationship between occupational exposure to chemicals and hearing impairment has only recently been suggested. The main reason for this assertion is that hearing loss was mainly attributed to physical noise. Chemical exposure was not considered to be a source of hearing loss. The co-exposure to both physical noise and ototoxic chemicals has an adverse interactive effect on hearing (Campo *et al.,* 2009). The interactive effect could be additive which would be the predicted sum of the effects of single exposure noise and single exposure to ototoxic chemicals or synergistic which would have a greater effect than the sum of the two single effects of noise and ototoxic chemicals (Calabrese, 1995).

Sliwinska-Kowalska *et al.,* (2005) state that numerous chemicals applied in industry have been shown to impair hearing in animals. Equally significant is that the ototoxicity of these substances in humans is still not fully accepted. Several other international studies have shown that the exposure to organic solvents in the workplace is related to the increased risk of hearing loss (Jacobsen *et al.,* 1993; Morata *et al.,* 1993; Sliwinska-Kowalska *et al.,* 2001)

International studies have investigated the effects of combined exposure to noise and industrial chemicals. The findings raised concerns in the printing industry where combined exposure to chemicals and noise frequently occurred (Cary, *et al.*, 1997) causing damage to the hearing of workers. Usually the chemicals damage the inner ear that contains the hearing mechanisms and the vestibulocochlear nerve, the nerve that sends hearing information to the brain. Damage to this nerve by chemicals affects the auditory (hearing) system thus causing hearing loss in workers. Consequently these chemicals are referred to as ototoxic (Fechter, 1995).

Morata, (2002) argues that the scientific and public health community should interrogate the issue of whether ototoxicity of environmental and occupational chemicals require further research. In view of the fact that ototoxicity impacts on the working population's quality of life, research in this area is paramount.

The total population of workers in the study was four hundred and forty (440) who worked from Monday to Friday, twenty four hours per day, over two shifts with the first shift commencing at 06H00 and ending at 18H00 and the second shift commencing from 18H00 and ending at 06H00. Shift changes occurred at the end of each work week. Convenient non-probability sampling was undertaken on all three hundred (300) day shift workers. In this study there were two categories exposed and unexposed groups. The exposed group comprised of three groups which included noise exposed, chemical exposed and both chemical and noise exposed.

1.3 Motivation for the study

This study is critical since there is evidence that occupational hearing loss may be caused not only by noise but also by certain chemicals in the work environment. Industrial chemicals are known to be ototoxic, hence it is reasonable to expect that if these chemicals occur in high enough concentrations in the workplace, they could affect hearing. Laboratory studies have indicated that when simultaneous exposure to noise and chemicals occur, the hearing loss observed was greater than the expected hearing loss from physical noise only. (Johnson *et al.*, 1988). On the African continent there is an absence of research relating to chemical exposure and occupational hearing loss. The problem is further compounded by management's lack of knowledge of the combined effect of chemical and physical noise on hearing loss. Consequently workers exposed to these chemicals are endangering their health and quality of life. Occupational hearing loss has a cumulative effect on workers. The effect of hearing is not apparent in the early stages however, as the hearing loss progresses to the permanent stage it is identified.

Morata, (2003) maintained that the National Institute of Occupational Safety and Health (NIOSH) together with other research agencies has identified the co-exposure of noise and chemical as a priority research area which will impact on future research planning and standard setting. Morata *et al*., (1994) pointed that ototoxic agents together with continuous and impact noise could occur in the rubber manufacturing industries. The association between occupational exposure to solvents and hearing impairment is seldom evaluated therefore this study will be significant in the South African context.

1.4 Problem statement

This study investigates the effects of combined exposure to chemicals and noise on the hearing mechanisms of workers in a selected rubber organization and provides appropriate interventions to preserve workers hearing.

1.5 Research objectives

The aim of the research is to study the combined exposure to noise and chemicals on hearing in a selected rubber industry in Durban. The objectives of the study are:-

- determine whether co-exposure exposure to chemicals and physical noise affects workers hearing;
- identify existing human resources management practices and the impact on occupational health and safety;
- ascertain the effectiveness of the existing quality and safety management systems at the research location and
- establish the adequacy of current legislation on hearing loss arising from chemical exposure.

1.6 The research design

The research design is an analytical cross-sectional field case study in an industrial setting. The sample was drawn from a rubber factory which consisted of the entire day shift worker compliment. The sample population was split into four parts which were workers only exposed to physical noise, workers only exposed to chemicals, workers exposed to both physical noise and chemicals, and the final segment, worker's neither exposed to chemicals nor noise.

1.7 Limitations of the study

This study was limited to one rubber manufacturing organization in the

Metropolitan area of Durban, KwaZulu Natal. Consent to conduct the study was granted on the proviso that the organization's identity was kept confidential. Research subjects were engaged for short duration with minimal effect to production. There may be the presence of healthy worker effect where the seriously affected workers are not in the sample and may have left the workforce. Alternatively those affected may be in the workforce but no longer exposed to noise and chemicals due to their affliction. This effect may influence the association between exposure to noise and chemicals and hearing loss. Workers HIV Aids status were not disclosed and those workers on antiretroviral treatment and opportunistic infection treatment may be taking ototoxic medication.

The total population in the study was 440 was split into exposed to chemicals, noise and chemical plus noise which made up 328, the remainder 112 were unexposed to chemicals and noise. The exposed group was further sub-divided into noise and chemical exposed group of 181, chemical exposed group 44 and the noise exposed group 103. Convenience sampling was undertaken and the entire dayshift workers were included in the study, excluded were the nightshift workers. The dayshift workers who participated in the study comprised of noise exposed group which was 71, the chemical exposed group which was 30, the noise plus chemical exposed 123 and the unexposed group was 76. Limitations of this approach are that nightshift workers were excluded and the noise plus chemical exposed group had the highest number of workers in the study.

1.8 Restriction of access to organizations

The study was intended to take place at two organizations, one being a large printing and packaging manufacturing organization, and the other a large rubber manufacturing organization with staff complements in excess of a thousand workers per organization. Planning was at an advanced stage with the printing and packaging manufacturing organization and the execution of the plans were a week away from commencement, when the study at the printing and packaging manufacturing organization had to be aborted. The study was declined on the grounds that it would be time consuming, resulting in production time being lost. Further probing into the organization established that the organization had a stable and static workforce with workers having twenty or more years of service in the organization and that workers may have acquired hearing impairment over this period. Senior management was of the view that the organization may become vulnerable to future civil and criminal litigation. The organization placed greater value on the highly sophisticated and expensive equipment and machinery which cost hundreds of millions of rands above the health and safety wellbeing of its workers.

The second organization was a rubber manufacturing organization and preliminary contact was established by the researcher. During these contact sessions it appeared to the researcher that the organization was willing to grant permission for the study to take place. Written communication with the organization however was to no avail, the organization ignored several electronic mail reminders and telephone calls. Consequently, the researcher proceeded on to other organizations on the account of time constraints.

The third printing and packaging organization was contacted with a view to conducting the study. This organization considered the request and subsequently declined the request on the grounds that the study will result in a loss of production time.

The fourth printing and plastic packaging organization was contacted to conduct the study. This organization did not respond to the written request or telephone calls from the researcher.

Finally, the fifth organization which was a rubber component manufacturing organization agreed to the study provided that it remained anonymous. This assurance was given by the researcher. The organization embraced the study and saw this as an opportunity to learn from the study and improve the working condition of its workers. During the study the recession adversely affected this organization, resulting in part of the manufacturing process being sold and retrenchment of a substantial part of the workforce.

Research in occupational health and safety is based predominantly in industrial settings. The restriction of access to these industrial settings makes research in this discipline very challenging. The majority of the employers are willing to employ undergraduates and post graduates in occupational health and safety, however they are not willing to facilitate the learning process of future graduates and post graduates in attaining their qualifications. Students who are not employed in industry have a distinct disadvantage in gaining access to these industrial settings for their research. Researchable problems are found in industrial settings, consequently the research has to be carried out in these settings. Higher learning institutions and industry should bridge this gap and facilitate the process of research and allay the fears and concerns of industry in order to go forward to a win-win situation. The Department of Labour who is the custodian of the Occupational Health and Safety Act, 1993 (Act 85 of 1993) and the Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993) is in an ideal situation to facilitate research in the industrial setting. Occupational health and safety research in industry will be beneficial to the researcher, industry and government.

1.9 Structure of the succeeding chapters

1.9.1 Chapter 2: Review of co-exposure of chemicals and noise on hearing

This chapter will review literature relating to the ototoxicity (ear poisons) of chemicals and their interaction with noise in damaging workers' hearing. Confounding variables considered including age, recreational activities, ototoxic medications and the healthy worker effect were discussed. The human resource management of organizations which includes labour brokers on the workforce and the impact of globalization on occupational health and safety.

1.9.2 Chapter 3: Global standards in the context of quality management

This chapter will provide a contextual framework of quality management systems (includes ISO 9001:2008, ISO 14001:2004, OHSAS 18001:2007, SANS 16001:2007 and SA 8000:2008) in the study. The review provides a systematic approach to managing ototoxic chemicals and noise in the occupational environment.

*1.9.3 Chapter 4***:** Legislation underpinning occupational health and safety in South Africa

This chapter will review existing and draft legislation pertaining to the Constitution of South Africa, Occupational Health and Safety, Compensation of Occupational Illnesses and Diseases, Noise and Chemical Monitoring and Audiometric Testing.

1.9.4 Chapter 5: Research methodology

This chapter will review the participants recruitment process to the study. The research tools used in the study include a structured NoiseChem Questionnaire, air sampling (NIOSH Method 1501), noise monitoring (SANS 10083:2012) and audiometric testing (SANS 10083:2012).

1.9.5 Chapter 6: Results of the study

The findings of the study are tabulated and presented in this chapter.

1.9.6 Chapter 7: Discussion of results

Results are interpreted and the significance of the results are discussed.

1.9.7 Chapter 8: Conclusion and recommendations

This chapter will summarize the main research findings and charter's a way forward with recommendations to improve the working environment of workers who are exposed to ototoxic chemicals.

CHAPTER TWO

CO-EXPOSURE TO CHEMICALS AND NOISE ON HEARING

2.1 Introduction

Franks and Morata in Axelsson *et.al.,* (1996) state that hearing conservation in occupational health has focused mainly on physical noise, and further points out that the literature on the effects of noise exposure on hearing from this source is extensive. Conversely the effect of chemical exposure to hearing loss has received comparatively little consideration (Humes, 1984, Boettcher *et.al.,* 1987, Franks *et al*., 1989, and Phaneuf and Hétu*,* 1990).

Chemicals that are inhaled or absorbed through skin contact can get to the inner ear through the blood stream. These chemicals are found in the inner ear fluids and may damage the inner ear function and structures. Exposure to such chemicals in acceptably high concentrations can affect hearing (Morata, 2003). Research on the above is essential given that occupational hearing loss may be caused not only by noise but by exposure to certain chemicals in the work environment. Sliwinska-Kowalska, *et al*., (2004) maintains that these chemicals are used in the manufacturing process of the rubber tyre and printing industries, and co-exist with noise.

The ototoxicity of chemicals and their interaction with noise are beginning to receive attention in the international literature. More studies on this topic are required because there is evidence that occupational hearing loss may be attributed not only to physical noise but also to chemicals in the work environment. Current occupational legislation does not consider chemicals as being hazardous to hearing. Consequently, there may be workers with unmet needs concerning hearing conservation (Rybak, 1992; Johnson, 1993; and Jacobsen *et.al.,* 1993). Hearing loss in workers may cause a number of psychosocial changes because hearing sensitivity deficiency affects workers' lifestyles. The ototoxicity of environmental agents such as metals, solvents and asphyxiants and their interaction with noise began receiving attention in the nineties (Rybak, 1992; Johnson, 1993; and Jacobsen *et al*., 1993). The vast majority of occupational environments consists of several physical and chemical agents that are potentially harmful to health. Morata and Little (2002) divided the ototoxins (chemicals that effect workers hearing) into high priority ototoxins and additional ototoxins. The high priority ototoxins are indicated in the table and the remainder are all additional ototoxins. The basis for allocating chemicals in the high priority category was the available evidence of ototoxicity, severity of the problem, accessibility and number of occupationally exposed workers. Table 2, below provides the major uses/sources of exposure to ototoxic chemicals and uncategorized chemicals.

Table 2: Major uses/sources of exposure to ototoxic chemicals

Chemical substance	Major uses/sources
Toluene High Priority	Production of benzoic acid, benzaldehyde, explosives, dyes and many other organic compounds; solvents for paints, lacquers, gums, resins, extracting agent; petrol naphtha constituent; additive; fabric and paper coating, artificial leather and detergent manufacture. Toluene is frequently found with other solvents.
Ethylbenzene High Priority	Almost exclusively used for the production of styrene. Only a small proportion is used as a solvent.
n-Propylbenzene	Textile dying, solvent for cellulose acetate.
Styrene High Priority	Manufacture of plastics, rubber articles, glass fibres; synthetic rubber ; insulators; used as a chemical intermediate, particularly in the resin and plastics production, component in agricultural products and stabilizing agent.
Methylstyrene High Priority	Manufacture of modified polyester and alkyd resins.Low-molecular polymers are viscose liquids that are used as softener in polymers, paints and waxes
Trichloroethylene High Priority	Solvent for a variety of organic materials. Trichloroethylene is a cleaning and degreasing agent and a means of extraction.
p-Xylene High Priority	Manufacture of resins, paints, varnishes, general solvent for adhesives; in aviation kerosene; protective coatings; synthesis of organic chemicals; solvent (example for paints, coatings, adhesives and rubber); used in production of quartz crystal oscillators, perfumes, insect repellents, epoxy resins, pharmaceuticals, and in the leather industry. Used as a solvent in phenoxyalkanoic herbicides.
n-Heptane- High Priority	Used as a solvent in laboratories and for quick-drying glossy paints and glues.
Bromates -	Used as powerful oxidants.
Organophosphorous compounds	Used as insecticides in agriculture.

Table 2: Major uses/sources of exposure to ototoxic chemicals continued

Chemical substance	Major uses/sources
Nitriles	Used for the preparative synthesis of carboxylic acids. Commercial importance of acetonitrile as a solvent, benzonitrile as an initial compound for melamine resins and acrylonitile as a monomer for polyacrylonitrile.
Carbon disulfide	Manufacture of rayon, soil disinfectants, electronic vacuum tubes and carbon tetrachloride. Used as solvent for lipids, sulfur, rubber, phosphorous, oils, resins and waxes.
n-Hexane High Priority	Used as a cleaning agent in textile, furniture and leather industries; laboratory reagent; component of many products associated with the petroleum and petrol industries; solvent, especially for vegetable oils; low temperature thermometers; calibration; polymerization reaction medium; paint diluents; alcohol denaturant. Used as a reaction medium in the manufacture of polyolefins, elastomers, pharmaceuticals and as a component of numerous formulated products.
Carbon monoxide High Priority	Component of exhaust fumes emerging from incomplete combustion processes, for example in motor vehicles or poorly ventilated stoves and furnaces, acetylene welding or in enclosed areas (mines, tunnels).
Halogenated hydrocarbons	Intermediate product for the synthesis of organic compounds. They are also used as solvents, anaesthetics, fire-extinguishing agents, refrigerants and propellants.
Cyanides High Priority	Used as an intermediate product in the organic synthesis of carboxylic acids, pharmaceuticals, dyes and pesticides. Substantial quantities are also required for the surface treatment of metals, galvanizing and the cyanide leaching process.
Lead High Priority	Manufacture of lead-acid batteries; ship breaking; manufacture of paint; also used in petrol and plastic manufacture, may be emitted during car radiator repair; welding; plumbing; smelting, refining and mining.
Mercury	Used in the chloralkali industry. Mercury compounds may be used in batteries (mercuric oxide), pigments, catalysts, explosives (mercury fulminate), laboratory-based research and in certain pharmaceutical applications.
Manganese	Manufacture of steel alloys, dry-cell batteries, electrical coils, ceramics, matches, glass, dyes, in fertilizers, welding rods, as oxidizing agents, and as animal food additives.
Tin, organic compounds	Tri-n-alkyltins are phytotoxic and can be powerful bactericides and fungicides.
Arsenic	Production of pesticides, smelters, semiconductors, antifouling paints, electroplating industry and pigments.
Cadmium	Protective plating on steel, stabilizer for polyvinyl chloride, pigments in plastics and glass, electrode material and component of various alloys.
Germanium (germanium dioxide)	Used as a semi-conductor in transistors, in light-emitting diodes, solar cells, thermo-generators, glass and alloys.

Source: Morata and Little, (2002), Campo, *et al.*, (2009)

2.2 International perspectives on chemically induced hearing loss

Berger *et al.,* (2003) maintain that there are substances that directly affect the auditory threshold these include industrial chemicals such as toluene, paint solvents, and carbon disulfate. Fechter *et al.,* (2002) argues that if chemicals occur in sufficiently high concentrations, hearing may be affected in the absence of noise. Chemicals that are inhaled or absorbed through skin contact can reach the inner ear through the bloodstream (Odkvist *et al.*, 1982).

According to Morata, (2003) recent animal experiments confirmed that chemicals such as toluene, styrene, tricholoroethylene, ethyl benzene, hydrogen cyanide, and carbon monoxide interacts synergistically with noise to damage the auditory system. Exposures to these chemicals in sufficiently high concentrations may affect hearing in the absence of noise. Chemicals inhaled or absorbed through the skin enters the bloodstream. These chemicals have been found in the inner ear fluids and have caused damage to some of the inner structures and functions. Chemicals affect the cochlear structures and the central auditory system (Odkvist, *et. al.,* 1982; Morata, et.al., 2002; and Teixeira *et.al.,* 2002).

The combined action of noise and chemicals on workers hearing loss impacts on the workers ability to detect sounds and to distinguish between different sounds. Consequently, sounds are perceived to be less loud but distorted (Morata, 2003). Industrial noise in the workplace is a known hazard that is linked to noise induced hearing loss. Research indicates that there is less consideration given to hearing loss caused by ototoxic chemicals. Ototoxins are chemicals that can damage the auditory nerve and cochlea hair cells in the inner ear. The routes of exposure to ototoxic chemicals for the worker include inhalation, ingestion and skin absorption. When ototoxic chemicals enter the body, it travels through the bloodstream into the circulatory system to the ears. The ototoxins can damage the hearing mechanism in a worker which can lead to tinnitus which is described as ringing in the ears (Morata, 2006).

Sliwinska-Kowalska *et al.*, (2007) maintain that organic solvents are the most hazardous chemicals in the context of hearing impairment. Recognition of the hazard is slow and occupational exposure limits have been set to protect the exposed workers in all European countries. Recognition of the link between organic chemicals and hearing impairment has not been realized in Africa. The use of occupational exposure limits and the integration of workers in health surveillance programs are the most efficient tools for controlling and assessing workplace exposures (Sliwinska-Kowalska *et al.*, 2007).

Sliwinska-Kowalska *et al,* (2007) points out that research on animals have shown that, when exposed to organic chemicals (styrene) at a level of 300ppm are ototoxic to active rats. Establishing a less severe safety factor (SF), SF = 10 for extrapolating these data to humans, revealed that the lowest observed adverse effect level (LOAEL) for the organic chemical (styrene) is 30ppm. On basis of these findings, France decreased the LOAEL from 50ppm to 30ppm plus the provision and use of hearing protective equipment (HPE) at a lower exposure of 80 dB(A).

Morata *et al.*, (1993) carried out a study on rotogravure printing worker's hearing, by using multiple logistic regression analysis. Multiple logistic regression analysis was carried out variables included in the model were exposure group, length of employment, previous occupational exposure to noise or to chemicals and exposure to non-occupational noise. Age was not included on the account that it correlated with the exposure variable length of employment, and the study population was relatively young (median age 33 years). The approach used was the step wise forward and backward logistic regression. The study did not indicate details on the cumulative exposure index model used in the study. A group of printers exposed simultaneously to noise (88-98 dBA) and toluene (100-365 ppm) were compared with a group of printers exposed to noise alone (88-97 dBA); a group exposed to a solvent mixture in which toluene was a constituent; and a group exposed neither to noise, nor toluene. The relative risk for hearing loss was 4 times greater for the noise group, 11 times greater for the noise and toluene group, and 5 times greater for the solvents group. Estimates of relative risk were 4:1 (95% CI = 1.4-12.2) for the noise-only group, 10.9 (95% CI = 4.1-28.9) for the noise and toluene group, and 5.0 (95% CI=1.5-17.5) for the solvent-only group. This study indicates that workers exposed to noise and solvents simultaneously are at a much higher risk of suffering hearing loss in these occupations. Noise and toluene exposed groups showed significant levels of mild hearing loss than the other three groups in the study. This finding was attributed to workers who participated in the study had relatively short exposure times (averaging 5-13 years) consequently were not exposed long enough for hearing loss to progress. The second reason for this finding is that pure tone audiometry was not the appropriate test to assess the extent of the hearing impairment.

Sliwinska-Kowalska *et al.*, (2003) studied yacht yard and plastic factory workers exposed to a mixture of organic solvents. The study showed that the odds of developing occupational hearing loss from exposure to organic solvents after adjusting for age, gender, current noise and prior noise exposure were considered confounder variables was 3.9 (95% CI = 2.4-6.22), higher than for unexposed research subjects. In another study involving dockyard workers the odds ratio of developing occupational hearing loss from noise only exposure was 3.34 (95% CI = 2.06-5.43) and combined exposure to noise and solvent exposure was 4.88 (95% CI = 3.09-7.68) (Sliwinska-Kowalska *et al.*, 2004). The results of an epidemiological survey conducted on 1117 workers of yacht, ship, paint and lacquer, plastic, and shoe industry revealed odds ratios of developing hearing loss of 2.4 (95% CI = 1.6-3.7) for solvent exposure, 3.9 (95% CI = 2.4-6.2) for styrene and 5.3 (95% CI = 2.6-10.9) for n-Hexane and toluene (Sliwinska-Kowalska *et al.*, 2005).

Kim *et al.*, (2005) studied 542 male workers in the aviation industry who were exposed to noise during grinding, hammering, riveting, trimming and engine operation driving and who were exposed to mixed organic solvents during cleaning, paint removal and painting tasks. Historical records of past work environment evaluations and audiometric levels were used to calculate the cumulative exposure index (CEI) for individual workers. Each occupational category was given a rating from zero to three for either noise or solvent exposure (EI*i*) which was then multiplied by the number of years worked (T*i*) at that occupational category. To assess lifetime cumulative exposure the formula used was: CEI = ∑(EI*i*) X (T*i*). The availability of the historical data made the cumulative exposure index calculation possible in this study. Multiple logistic regression analysis was carried out and adjustments were made for age, hypertension, diabetes, smoking and alcohol intake. The odds ratio obtained in this study was 4.28 (95% CI = 1.7-10.8) for noise only exposure, 8.12 (95% CI – 2-32.5) for the combined exposure to noise and solvent and 2.57 (95% CI = 0.6-10.3) for the solvent only exposure.

In South Africa, the Occupational Health and Safety Act, 1993 (Act 85 of 1993), Hazardous Chemical Substance Regulations, Table 1 and 2 prescribes 100ppm occupational exposure limit for the organic chemical (styrene). The occupational exposure limit for the organic chemical (styrene) therefore is well above the French requirements and favours industry. An additional reason for this situation is that the Occupational Health and Safety Act 1993 (Act 85 of 1993), Hazardous Chemical Substances Regulations came into effect on the 25 August 1995 with minor amendments made on 25 June 2003 and 27 June 2008. The Hazardous Chemical Substances Regulations need to be reviewed urgently in order to align the regulations to international norms. Boleiji *et al.*, (1995) maintains that compliance monitoring is a systematic activity designed aimed at corrective action. Monitoring in occupational health research is not a goal as such, but a tool that can be used to arrive at a reliable estimate of the health risk to exposed workers. Therefore, compliance monitoring methodology may also be used determine the potential health risk workers may be predisposed to in the work environment.

2.3 The human mechanism of hearing

Sound waves are received by the ear. The ear itself is divided into three segments: the external ear, the middle ear, and the inner ear (Plog and Quinlan 2002, Newby and Popelka 1992, Berger *et.al.,* 2003).

2.3.1 The external ear

The external ear is composed of the auricle or pinna, and the external auditory canal. The ear canal is prone to infection mainly due to high skin temperatures and humidity (Plog and Quinlan, 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.2 Auricle

The auricle (pinna) is the most noticeable part of the ear. It is a folded cartilaginous structure with a few small muscles covered by subcutaneous tissue and skin. The auricle collects sound waves from the air and funnels them into the ear canal to the tympanic membrane which is also the eardrum. The collected sound waves cause the eardrum to move back and forth in a vibrating mechanical motion that is passed on to the bones of the middle ear (Plog and Quinlan, 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.3 External auditory canal

The external auditory canal is a skin-lined compartment about 3.8 cm long, supported in its outer third by the cartilage of the auricle and in its inner two-thirds by the bone of the skull. The cartilaginous meatus is curled and lies at an angle to the bony part, shielding the tympanic membrane and middle ear lying beyond it from direct injury (Plog and Quinlan, 2002, Newby and Popelka, 1992; Berger *et.al.,* 2003).

The small hairs or vibrissae and ceruminal glands which give off a waxy substance termed cerumen, are located in the skin of the outer third of the ear canal. The hairs provide a protective function by filtering out particulate matter. Cerumen or earwax is naturally occurring substance that cleans, protects, and lubricates the external auditory canal (Roland *et al*., 2008). Cerumen is both sticky and bactericidal, stops smaller particles from entering the ear canal and keeps the canal healthy and free of infection. The external part of the ear collects the sound waves from the air and channels them into the ear canal from where they are transported to the eardrum. The collected sound waves result in the eardrum moving backwards and forwards in a vibrating mechanical motion that is passed on to the bones of the middle ear (Figure 1, on page 25 illustrates the hearing process) (Plog and Quinlan 2002, Newby and Popelka, 1992; Berger *et al.,* 2003).

2.3.4 Middle ear

The middle ear is the space between the eardrum and the bony wall of the inner ear. The middle ear is lined with mucous membrane similar to the lining in the mouth. The ossicles are the smallest bones in the body and are sited within the middle ear cavity. The ossicles connect the eardrum to an opening in the wall of the inner ear called the oval window (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.5 Eustachian tube

The eustachian tube serves to balance the pressure on either side of the tympanic membrane. An increase in pressure in the middle ear cavity, relative to atmospheric pressure is accommodated by the Eustachian tube. A decrease in pressure requires active ventilation by using muscles to open and close the eustachian tube by yawning and swallowing (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.6 Eardrum

The eardrum provides protection against invasion of the inner ears by foreign bodies. The eardrum is a membrane that separates the external ear canal from the middle ear. It comprises of an inner layer of mucous membrane, a middle layer of fibrous tissue and outer layer of squamous epithelium. It is shaped like a spider web, with radial and circular fibers for structural support (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.7 Ossicular chain

The ossicles are jointly called the ossicular chain which comprises the malleus, incus and stapes. The malleus or hammer is secured to the eardrum by the handle. The head lies in the upper area of the middle ear cavity and is linked to the incus. The incus or anvil is the second ossicle and has a long protrusion that runs down and joins the stapes. The stapes or stirrup lies perpendicular to the incus (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

The main function of the middle ear in the hearing process is to transfer sound energy from the outer to the inner ear. The eardrum vibrates when it transfers its motion to the attached malleus. The bones of the ossicular chain are linked to each other, consequently the movement of the malleus is passed on to the incus and then to the stapes which is embedded in the oval window. The stapes moves backward and forward in a rocking motion, when sound energy passes the vibrations on to the inner ear through the oval window. The mechanical motion of the eardrum is transmitted through the middle ear and into the fluid of the inner ear (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.8 Amplification

The sound-conducting mechanism amplifies sound by two key mechanisms. Firstly, the large surface area of the base of the stapes produces a hydraulic effect. The eardrum has a greater surface area than the oval window. All the sound pressure collected on the eardrum is sent out through the ossicular chain and is concentrated on the smaller area of the oval window thereby increasing its pressure. Secondly, the bones of the ossicular chain are located in such a manner that they act as a sequence of amplifying levers (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.9 Inner ear

The inner ear comprises of receptors for hearing and position sense. The main mechanisms of the inner ear include the vestibular receptive system and the cochlea housed within the compact temporal bone. This bony labyrinth is filled with fluid called perilymph. The inner ear mechanisms are made up of a membranous labyrinth structure which are balanced in the perilymph (Plog and Quinlan 2002; Newby, and Popelka, 1992; Berger *et.al.,* 2003). Workplace exposure to organic solvents may contribute to hearing loss induced by chronic ambient noise (Plog and Quinlan, 2002).

2.3.10 Cochlea

The cochlea is a tubular snail-shaped structure lined with the basilar membrane, which is surrounded by thousands of feathery hair cells tuned to vibrate to different sound frequencies. Nerve endings are contained in an elevated structure over the floor of the tube forming the cochlea. This structure of the organ of corti is the receptor end organ for hearing. Vibrations of the stapedial footplate set into action the fluids in the inner ear. When the basilar membrane is displaced a shearing movement occurs on the tectorial surface that pulls the hair cells attached to the nerve endings. This starts up the electrical impulses that are appropriately coded and sent to the brain *via* the auditory nerve. The pitch of the sound establishes which part of the cochlea responds when high sound is transmitted it stimulates the base of the cochlea near the oval and round windows, whereas the nerve endings that respond to low pitch are located at the small end of the cochlea (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

Fechter (1995) suggest that there are three mechanisms by which noise heighten the levels of chemicals reaching the sensitive inner ear called the cochlea tissues. Noise exposure increases cochlea blood flow thereby elevating the discharge of ototoxic chemicals to the ear structure. When noise and chemical exposure occurs simultaneously the uptake of ototoxicant into the cochlear fluid may be influenced by the noise exposure. The cochlea blood flow is increased when noise exposure occur, resulting in the rapid absorption of ototoxic chemicals into the hearing mechanisms. Noise exposure may damage the cochlea tissue such that ototoxicants which are normally excluded from this tissue layer are able to diffuse into the tissue. (Fechter 1995).

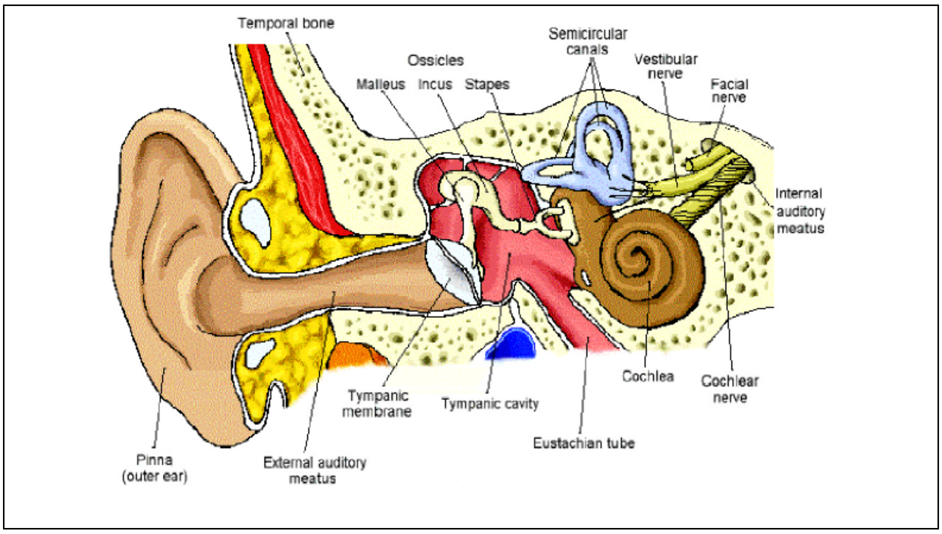
2.3.11 Vestibular system

The sense of balance in humans is dependent on organs of equilibrium. Close to the cochlea are three semicircular canals lying perpendicular to each other. The canals contain endolymph fluid that respond to movement of the head. The vestibular branch of the auditory nerve sends impulses to the cerebral cortex (Plog and Quinlan 2002; Newby and Popelka, 1992; Berger *et.al.,* 2003).

2.3.12 Hearing process

The external ear collects sound waves and directs them to the tympanic membrane through the ear canal. The tympanic membrane vibrates in response to the sound waves that collide with it. This vibratory movement in turn is sent to the ossicular chain in the middle ear. The vibration of the ossicles creates waves in the inner ear fluid that move the microscopic hair cells. The stimulation of these hair cells produces nerve impulses which pass along the auditory nerve to the brain for interpretation (Plog and Quinlan 2002). Figure 1, below illustrates the ear.

Figure 1: Illustration of the ear



Source: http://wwwearinc.com/HearingGuide.pdf (2001)

2.3.13 Measuring hearing

Hearing assessment depends on presenting a stimulus and measuring the response to that stimulus. Raising one’s hand when a sound is heard indicates acknowledgment. It is essential to have a stimulus-response situation in a manner that is valid which means that the procedure being undertaken accurately tests what is intended to be tested, and reliable in that the same results will be achieved if the test is repeated (Gelfand, 2001).

2.3.14 Audiogram interpretation

Sliwinska-Kowalska *et al.*, (2003, 2004 and 2005), classified audiograms as normal when none of the single hearing thresholds exceeded hearing loss of 25 dB for either ear. This study also uses this categorical hearing loss classification which is tabulated below in Table 3.

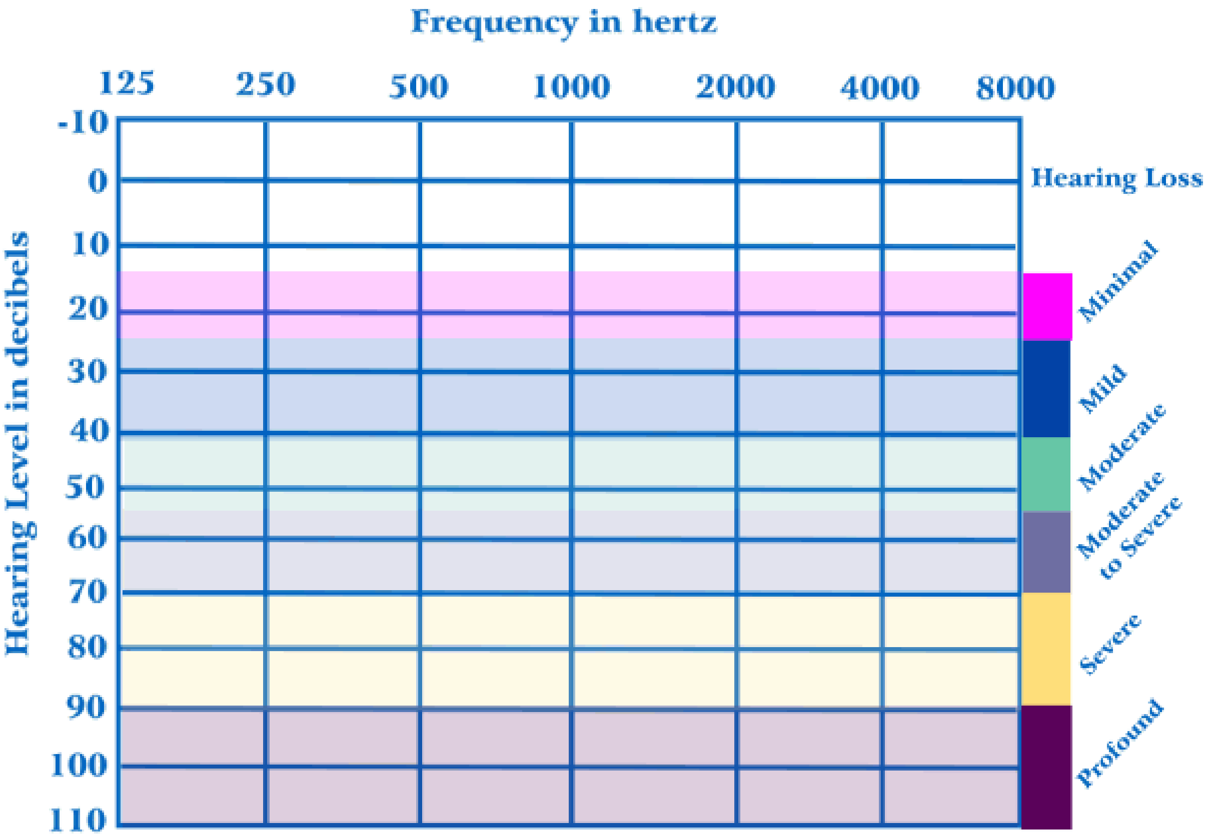
Table 3: Categories to describe the degree of hearing loss based on the pure-tone average

Pure-tone average in db HL (decibel Hearing Level)	Degree of hearing loss
< = 15	Normal hearing
16-25	Slight hearing loss
26-40	Mild hearing loss
41-55	Moderate hearing loss
56-70	Moderately severe hearing loss
71-90	Severe hearing loss
> 90	Profound hearing loss

Source: Goodman, (1965); Cahart, (1945); Gelfand, (2001), Lustig *et al.,* (2003), Ackley *et al.,* (2007), Berger *et al.,* (2003)

The audiogram in Figure 2 below illustrates the severity of hearing loss on an audiogram. McBride and Williams, (2001) points out that exposure to broadband, steady noise or impulse noise, the first sign was a dip or notch in audiogram at 4 kHz with recovery at 6kHz and 8kHz. The notch broadens with increasing exposure to noise.

Figure 2: Severity of hearing loss



SOURCE: www.clas.ufl.edu/users/sgriff/courses/SPA4302/2-PureTone-blanks.ppt (2007)

2.4 Origins of occupational hearing loss and the value of good hearing

Hearing loss originating from occupational and industrial exposure to noise goes back to the middle ages where workers in occupations such as blacksmithing, mining and church bell ringing were known to suffer from such an occupational disease (WHO, 1995). Today we have a much improved understanding of the mechanisms of Noise Induced Hearing Loss and noise control measures that can be implemented to conserve the hearing of workers. Notwithstanding this situation the prevalence of noise induced hearing loss is still in existence although it is a preventable injury (Berger *et.al.,* 2003).

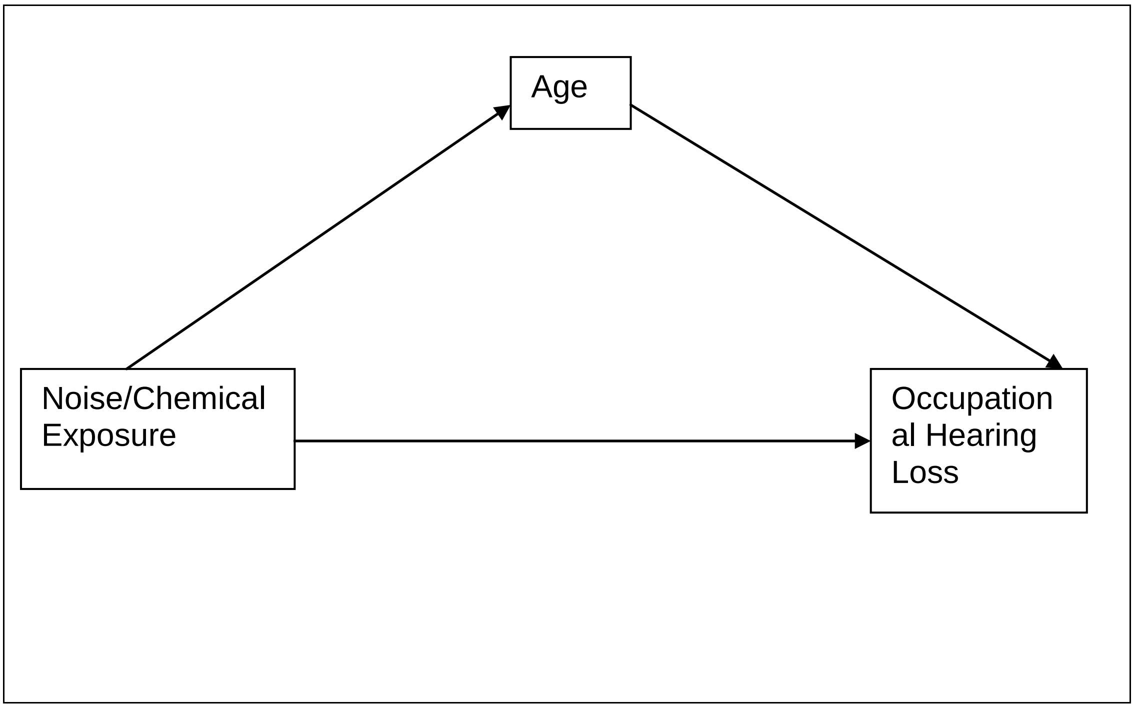
Hearing is essential to language, communication and socialization. The ability to hear is certainly a key quality-of-life issue from communication with co-workers, family, friends and loved ones to times of relaxation or appreciation to hearing warning sounds and other signals. The impact of hearing loss is felt by the family of the impaired person, as well as by the person himself or herself. For a worker, good hearing can mean the ability to detect changes in a machine spectrum distinctive of poor production quality or failure mode or the ability to distinguish a warning sound indicating the need for immediate action (Berger *et al.,* 2003).

Equally important to the ability to hear sound is the ability to hear silence. For many this is not possible. Workers suffering from tinnitus which is sounds heard within the head in the absence of actual sounds. Tinnitus can be experienced in many forms such as ringing, hissing, whistling, buzzing, or clicking. It disables and impedes the quality of life (Berger *et al.,* 2003).

2.5 Confounders to hearing impairment

Aschengrau and Seage III, (2008) define confounding as the mixing of effects between an exposure, an outcome, and a third extraneous variable known as a confounder. When present, the relationship between exposure and outcome is unclear because of the association between the confounder and the exposure, and between the confounder and the disease. Confounding may be considered as a failure of the comparison group to reflect the accurate experience of the exposed group. The exposure may therefore not have an effect on the disease occurrence to the exposed and comparison groups. Consequently, different disease rates will occur due to other risk factors for the disease. Risk factors apart from the exposure are spread differently between the exposed and unexposed groups when confounding is present. A person with a history of exposure to smoking and alcohol use, previous history of employment within a noise or chemical exposed environment, mode of transport, power tools used, recreational activities, chronic diseases and use of medication and history of physical injuries are at higher risk of suffering hearing loss. Confounding exists if an association exists between the confounder and occupational hearing loss among the exposed and unexposed groups, and between the confounder and the exposure (Aschengrau and Seage III, (2008). Figure 3 below shows the relationship between the confounder age, noise/chemical exposure, and occupational hearing loss which may have an influence on the hearing loss outcome in this study, other confounders are discussed in subparagraphs that follow.

Figure 3 Confounder association



Source: Adaptation from Aschengrau and Seage III, (2008)

2.5.1 Ototoxicity and medication-induced hearing loss

Medicines have improved the quality of life and longevity and have reduced the spread of several diseases. Contrary to this benefit, potential side-effects and complications are inherent in nearly all medicines. Ototoxicity in this instance refers to the ability of medicines to damage the inner ear causing a functional impairment and hearing loss. Selimoglu, (2007) states that ear drops have the potential to be ototoxic if used in incorrect dosages and for periods longer than recommended. Drug treatment developed to reduce HIV in the HIV-infected population frequently involves potentially ototoxic, government-approved antiretroviral medications along with experimental antiretroviral drugs with undocumented and unknown side effects (Marra *et al.,* 1997; Simdon *et al.,* 2001). Furthermore, a broad range of known ototoxic medications are also prescribed either as a prophylaxis or treatment for opportunistic infections (Bankaitis and Schountz, 1998). The potential for drug induced hearing loss in an HIV-infected individual at any stage of the disease is relatively high (Bankaitis and Schountz, 1998). Khoza, (2007) maintains that the continuous development in HIV therapies makes it challenging to acquire and maintain a comprehensive knowledge base on HIV-related drugs and associated ototoxicity. There are several categories of medicines known to cause ototoxicity which are listed in Table 4 below.

Table 4: Medicines with ototoxic potential

Aminoglycoside	**Antineoplastic Drugs**	**Loop Diuretics**
Amikacin	Cisplatin	Ethacrynic acid
Gentamicin	Carboplatin	Furosemide
Neomycin	Nitrogen mustard	Bumetanide
Kanamycin	Methotrexate	Azosemide
Netilmicin	Vincristine	Indapamide Triflocin
Streptomycin	Dactinomycin	
Tobramycin	Bleomycin	
Dibekacin	Platinum Compounds	
Sisomicin	Difluoromethylornithine	
Other Antibiotics	**Antimalarial Drugs**	**Salicylates**
Erythromycin	Quinine	Asprin
Vancomycin	Chloroquine	Nonsteroidal anti-inflammatory
Chloramphenicol	Hydroxychloroquine	
Furazolidone	Primaquine	
Polymyxin-sulfamethoxazole	Pyrimethamine	
Clarithromycin		
Azithromycin		

Source: Lustig *et al.,* (2003), Fausti *et al.*, (2005)

2.5.2 Salicylate ototoxicity

Salicylates such as acetylsalicylic acid is known as asprin is one of the earliest known ototoxic agents. In high doses acetylsalicylic acid causes sensorineural hearing loss, tinnitus, and vertigo. These side-effects necessitate further research to determine appropriate dosage of acetylsalicylic acid without side-effects (Lustig *et al.,* 2003).

2.5.3 Aminoglycoside ototoxicity

Aminoglycoside are highly effective against infections. This class of antibiotics affects the individuals balance and hearing when administered for a period longer than ten days. Hearing loss is partially reversible. However, if the loss is present for three weeks it is likely to become permanent (Lustig *et al.,* 2003).

2.5.4 Macrolide antibiotic ototoxicity

High doses of macrolide antibiotics are associated with high-frequency sensorineural hearing loss. Elderly individuals with liver and kidney diseases are more susceptible to the ototoxic effects of macrolide antibiotics. The ototoxic effect of this antibiotic is reversible once the medication is stopped (Lustig *et al.,* 2003).

2.5.5 Loop diuretic ototoxicity

The loop diuretics are medicines used to treat kidney disease. This category of antibiotics acts on the loop of Henlé in the kidney, and this prevents the re-absorption of sodium and chloride. The main site of injury is in the inner ear when loop diuretics are administered (Lustig *et al.,* 2003).

2.5.6 Platinum chemotherapeutic compounds

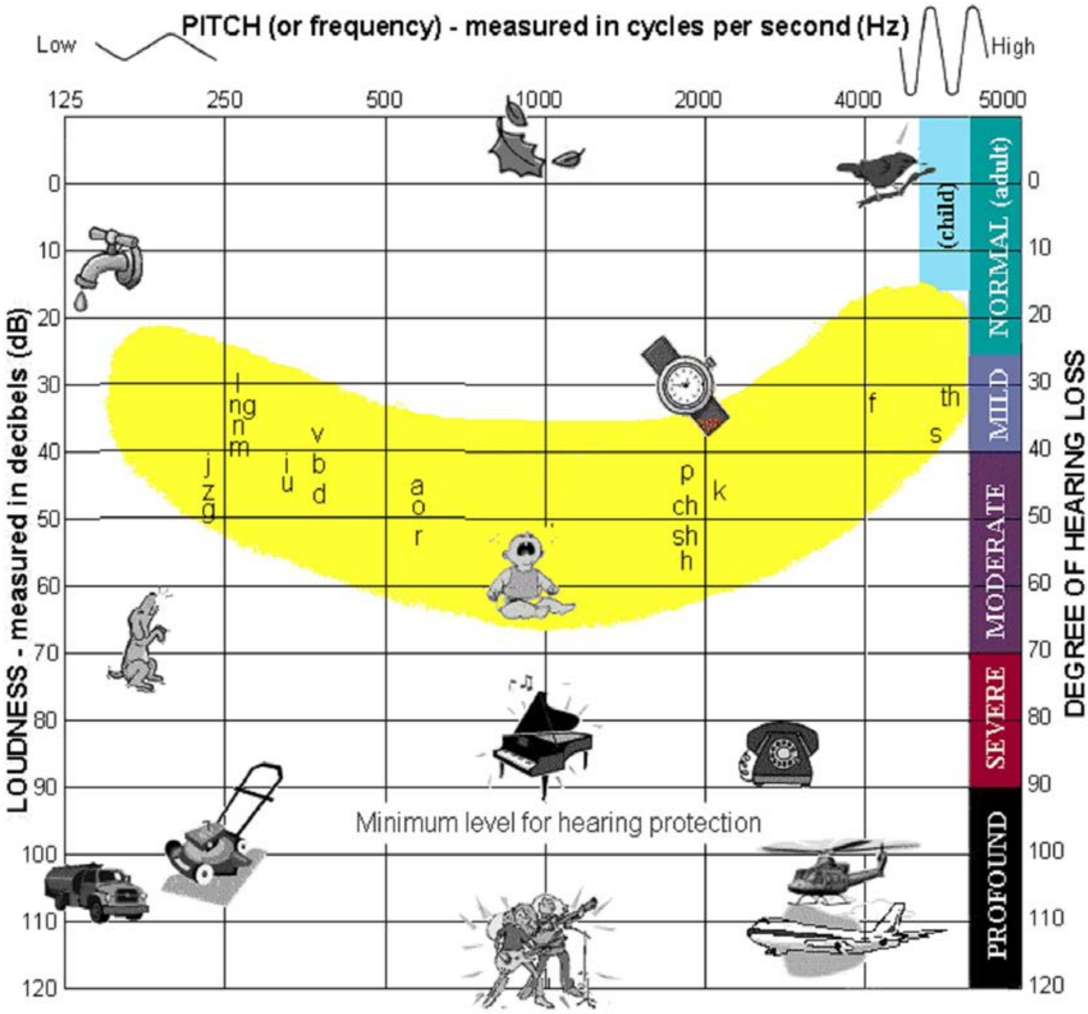
Platinum chemotherapeutic compounds are medicines that are used to treat a broad spectrum of malignancies. This lifesaving medicine is ototoxic in 7% of recipients. The hearing loss is in both ears and permanent (Lustig *et al.,* 2003).

2.5.7 Effects of aging on the hearing system

Presbycusis describes the sensorineural hearing loss (nerve-related hearing loss) emanating from age-related changes in the ear. Individuals experience a symmetric (involving both ears equally) high- pitched hearing loss. Typically conversations are perceived as being muffled or slurred in the setting of background noise. Specific sounds such as 'k', 's', and 'th' are difficult to understand. Presbycusis affects the high frequencies initially and may not affect speech comprehension but can produce tinnitus. Figure 4 depicts audiogram with environmental sounds and severity of hearing loss. Tinnutis is a 'ringing' or 'buzzing' sound perceived by the individual in the absence of an external sound (Lustig *et al.,* 2003). The contributors to presbycusis include family history, occupational or recreational noise exposure, alcohol and tobacco abuse, head trauma, and cardiovascular disease. Combined effects of medication used by individuals accelerate the degenerative changes in the inner ear (Lustig *et al.,* 2003). Age-related hearing threshold shifts are greater and begin sooner for the higher frequencies, and males are affected more than females on the account that males are generally exposed to more occupational and recreational noise Gelfand, (2001).

All parts of the auditory system undergo change as part of the aging process. Changes in the outer ear (pinna and external auditory canal) includes a loss of elasticity and thinning and dryness of the skin of the pinna (Ackley *et al*., 2007). Newby and Popelka, (1992) indicate that the aging process begins at the age of twenty and becomes increasingly noticeable with each succeeding decade.

Figure 4: Audiogram depicting environmental sounds and severity of hearing loss



Source: University of North Carolina http://firstyears.org/lib/banana-chart.pdf

2.5.8 Vibration white finger

Vibration white finger begins with cumulative trauma to the fingers and hands of exposed workers using diesel-powered, pneumatic, hydraulic, or electrically powered hand tools such as chipping hammers, grinders and drills (Rom and Markowitz 2007). The use of such hand tools has been causally linked to vibration white finger which is an irreversible medical condition. Vibration white finger is characterized by tingling, numbness and blanching of the fingers, loss of muscle control and decreased sensitivity to heat and cold with severe pain when blood circulation returns (Rom and Markowitz, 2007). Pyykkö *et al*., (1981) maintain that workers exposed to vibration white finger develop greater hearing loss given that the blood flow to the inner ear is restricted and vibration is transmitted to the upper body and to the skull which causes the hair cells in the ear to vibrate. Consequently workers exposed to hand arm vibration are more susceptible to noise induced hearing loss.

2.5.9 Effects of recreational exposure on hearing system

Morata, (2007) and Santos *et al.*, (2007) points out that the term 'music–induced hearing loss' is now used to describe a condition similar to noise induced hearing loss. Equally noise- and music-induced hearing loss are characterized by a notch in the 4000 to 6000 Hz region of the audiogram which is associated with chronic exposure to noise or music. Noise is defined as an unwanted sound whereas music is often the opposite (Morata, 2007). Santos *et al.,* (2007) and Williams, (2005) state that increasing attention is given to auditory effects of music or leisure noise exposure among musicians as well as among those who attend concerts and nightclubs or those who use cassette tape players, compact disc players and MP 3 players. Leisure refers to that time spent at one's own disposal away from the demands of work, Table 4 shows non-occupational activities and noise exposure (Williams, 2005).

Santos *et al.,* (2007) conducted a study in Brazil which revealed sound levels ranging between 93.2 to 109.7 dB(A) at five nightclubs. The sound levels were above the permissible exposure limit of Brazilian and South African Occupational Health and Safety legislation of 85 dB(A). The noise levels measured were cause for concern to the night workers, DJs as well as the audience and other staff such has waiters, bartenders, security personnel and the owners of these places. There were 11 cases of high frequency sensorineural hearing loss, despite the young age of the participants (mean age was 27 years) and their short time in the profession (mean music exposure as a DJ was 7 years) (Santos *et al.,* 2007). Consequently, workers employed in noise zones and who visit nightclubs frequently are at a higher risk of acquiring hearing loss.

Swanepoel and Hall III, (2010) state that spectators attending the 2010 FIFA World Cup in South Africa were at risk of acquiring noise-induced hearing loss from the sounds produced by sports fans blowing the horn-like instrument known as the vuvuzela. The vuvuzela forms part of the South African spectator accessory to soccer matches. The sound output from the vuvuzela is 131dB(A) at the horn opening and 113dB(A) at a 2-metre distance from the vuvuzela (Swanepoel *et al*., 2010). Pre- and post-match audiometric test of spectators who attended a soccer match with 30 000 spectators demonstrated a post-match deterioration at the hearing thresholds of 250, 2000, 3000, 4000 and 6000 Hz (Swanepoel and Hall III, 2010). Table 5 shows the non-occupational noise exposure that workers may be exposed to.

Table 5: Maximum sound pressure levels for non-occupational noises

	RANGE IN MAXIMUM SOUND PRESSURE LEVELS (DBA)								
CATEGORY	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**
Recreational									
Shooting									
Confined Shooting									
Model Aeroplanes									
Motorcycle									
Go carts									
Cockpit (private planes)									
Video Arcade									
Vehicle (Taxi) 'boom box'									
Hobbies/workshop									
Chain saw									
Power saw									
Workshop vacuum									
Lawn mower									
Blower									
Household									
Refuse Disposal									
Vacuum cleaner									
Washing Machine/Dryer									
Air conditioner									
Refrigerator									
Music									
Personal stereo									
Rock concert									
Symphony concert									
Home stereo									
Transportation									
Motor vehicle (15m)									
Passing truck (15m)									
Aeroplane flying over (305m)r									
Aeroplane cabin									
Train at (15m)									

Source: Bingham *et al.*, (2001)

2.5.10 Effects of smoking on the hearing system

Thun and Silva (2003) maintain that approximately 1.3 billion people smoke cigarettes. Tobacco affects cochlea blood supply causing peripheral vascular changes such as increased blood viscosity and reduced available oxygen

(Lowe et.al.,1980). Studies have reported positive association between smoking and hearing loss (Itoh *et al*., 2001; Nakanishi *et.al.,* 2000; Noorhassim and Rampal, 1998). Other studies among noise exposed workers observed more adverse effects on hearing in smokers than in non-smokers (Barone *et.al*., 1987; Virokannas and Anttonen, 1995, Starck *et al*., 1999). Cigarette burning releases organic solvents such as benzene, styrene, xylene, lead, mercury and carbon monoxide (Darral *et al*., 1998). Ferrite and Santana, (2005) proved that the combined effects of smoking, noise and ageing contribute to increased hearing impairment.

2.5.11 Healthy worker effect

The healthy worker effect (HWE) refers to the deficit of both morbidity and mortality attributed to various employment-associated factors when workers and the general population are compared (Li and Sung, 1999). Workers must be relatively healthy in order to be employable in a workforce, and both morbidity and mortality rates within the workforce, are usually lower than in the general population (McMichael *et al.*, 1986). HWE is considered to be a source of selection bias (Monson, 1987). Unhealthy workers are excluded from the workforce and this selection process leads to a difference in health status between workers and the general population. Therefore, in a work environment free of significant life shortening hazards, both morbidity and mortality rates within the workforce of interest are likely to be lower than in the general population (Li and Sung, 1999).

Radon *et al*., (2002) describe the healthy worker effect as the lower-than-expected age-standardized mortality rate observed in many occupational studies. The suggestion made by these authors in the workforce underlies three basic mechanisms, primary selection at the time of employ (healthy employ effect); secondary selection during employment (healthy worker survivor effect) and changes in life in association with employment. Healthier workers are more likely to stay in the workforce than those who are sick, which may give rise to a healthier cohort. Frequently workers with symptoms are transferred to jobs that do not require the same types of exposures experienced in the workers' original occupation (Radon *et al*., 2002). Good health is required of workers for continued employment and the tendency for those who develop diseases to leave their employment. Therefore, when comparisons are made between workers who remain in employment during the observation (study) period (that is active workers) and the general population the healthy worker effect may occur (Li and Sung, 1999).

Strategies to overcome the healthy worker effect include the use of external work comparison groups and the use of internal comparison groups are considered to be the most methodologically plausible. The appropriate population should consist of workers from certain occupations which are comparable with the index occupation in terms of extraneous effects on the outcomes of interest. Internal comparison groups is justifiable in that workers are from the same industry tend to experience similar selection process and are likely to share similar potential confounding effect. Consequently, the healthy worker effect can be effectively controlled (Li and Sung, 1999).

2.5.12 Effect of cellular phones on audiologic system

Kerekhanjanarong *et al.*, (2005) point out that digital cellular phones produce potentially harmful radiofrequency electromagnetic fields (EMF). Electromagnetic fields are composed of eaves of electric and magnetic energies that travel at the speed of light. The cellular phone transmits in bursts of microwave lengths of 900 milihertz (mHz). Brain tumors, including malignant brain tumors in humans are associated with electromagnetic fields from cellular phones. Typical symptoms experienced by cellular phone users include headaches, sensation of burning skin, fatigue, hot ears, increased blood pressure, ear pain and hearing loss. Kerekhanjanarong *et al.,* (2005) concluded that the hearing of cellular phone users are not significantly affected by electromagnetic fields from the cellular phones.

2.6 Rubber manufacturing process

The process commences with the preparation of master batches of rubber with Banbury mixers (Burgess, 1995). The constituents of rubber compound are categorized in Table 6.

Table 6: Rubber constituents

Agents	Chemical compound
Polymers	Natural or synthetic rubber hydrocarbons
Fillers	Reinforcing such as carbon black and silica Non- reinforcing such as clays and whiting
Processing aids	Extender oils and softeners
Rubber vulcanizing agents	Tetramethylthiuram disulfide, Tetrathiuram disulfide, Dipentamethylene thiuram tetrasulfide, 4,4-Dithiodimorpholine, Selenium diethyldithiocarbamate, aliphatic polysulfide polmer, Alkylphenol disulfides
Activators	Zinc oxide and stearic acid
Solvents (ototoxic agents)	n-Pentane, n-Hexane, Acetone, Toluene, Ethy-benzene, Xylene
Accelerators	Aldehyde-amine reaction products, Arylguanidnes, Dithiocarbonates, Thiuram sulfides, Thiazoles, Sulfenamides, Xanthates, Thioureas
Antioxidants	Arylamines, Aldehyde-amines, Aldehyde-imines, Ketones-amines, *p*-Phenylenediamines, Diarylamines, Ketone-diarylamines, Phenols: Substituted phenols, Alkylated bisphenols, Substituted hydroquinones, Thiobisphenols Wax, and antiozonants

Source: Burgess (1995)

2.6.1 Compounding and mixing

Natural or synthetic rubber is received at the workstation in bale form and is cut into weighable pieces with a guillotine cutter. Rubber chemicals specified in the formula are weighed out for specific batches. This operation entails opening bagged and drummed material and placing it in hoppers for weighing. The majority of the compounds are powders or grains which make the process very dusty. The chemical compounds described in Table 6 are weighed in plastic or paper bags and placed on the charging conveyor with the rubber (Burgess, 1995). A manual system sends a pre-weighed amount of carbon black directly to the mixer. After the mixing operation is completed, the Banbury mixer discharges to a mill positioned at a lower level to mix the constituents.

2.6.2 Milling

The milling process shapes the rubber into flat, long strips by forcing it through two set rolls (Stellman, 1998). The two-roll mill has rolls 60-90cm in diameter which rotate in different directions at different speeds. This process generates a significant amount of heat and the rolls must be cooled with water. At the drop mill the stock is blended, sheeted, cooled and cut for racking. The sheeted rubber stock is cut into slabs and the slabs are dipped in an anti-tack solution made from clay, soapstone and talc and is designed to prevent sticking. This rubber compound is referred to as a master batch and has all the ingredients except a vulcanizing agent (Burgess, 1995).

2.6.3 Extruding and calendering

The calender operation continues to shape the rubber. The calendar machine consists of four sets of rolls through which the rubber sheets are forced. The rubber sheets that come off the calendar are wound on drums. The extruder produces tube-like rubber components. The extruder functions by forcing rubber through dies of appropriate shape. Extruder and calendar operators are exposed to n-Pentane, n-Hexane, Acetone, Toluene, Ethy-benzene, Xylene (Stellman, 1998).

2.6.4 Curing and vulcanizing

Rubber curing or vulcanization involves heating the rubber in moulds under pressure, thus allowing the rubber to take up the shape of the mould which makes the final product less pliable, long lasting and greater strength and elasticity (Stellman, 1998 and Burgess, 1995). The curing press is heated to 100-200ºC for 20-60 minutes and curing takes place due to the action of the sulfur-based compound added in the milling process (Burgess, 1995).

2.7 Human resource management

In South Africa's, decent work programme 2010 to 2014 states that the labour market has witnessed a rise in atypical forms of work which exposes workers to unacceptable conditions of work and exploitation (NEDLAC, 2010). Trade liberalization, privatization and deregulation in South Africa was given impetus by the signing of various international agreements. The ratification of these agreements inevitably lead to globalization of the economy. The most significant agreements are the free trade agreements with the European Union and with the Southern African Development Community (Theron *et al.*, 2007). Globalization has hastened the restructuring of work and work modes and the introduction of flexible forms of work such as casualisation, outsourcing, subcontracting and temporary employment. Flexible employment has emerged as a threat to labour rights which invariably threatens human rights (Mathekga, 2009). The right to a safe and healthy workplace is under threat in the globalized economy which places downward pressure on occupational health and safety legislation and enforcement. The global race to the bottom affects developing and developed economies as transnational corporations travel the world searching for the lowest wages, the most vulnerable workforces, and the least regulated in respect of occupational health and safety (Brown, 2006).

2.7.1 Labour market

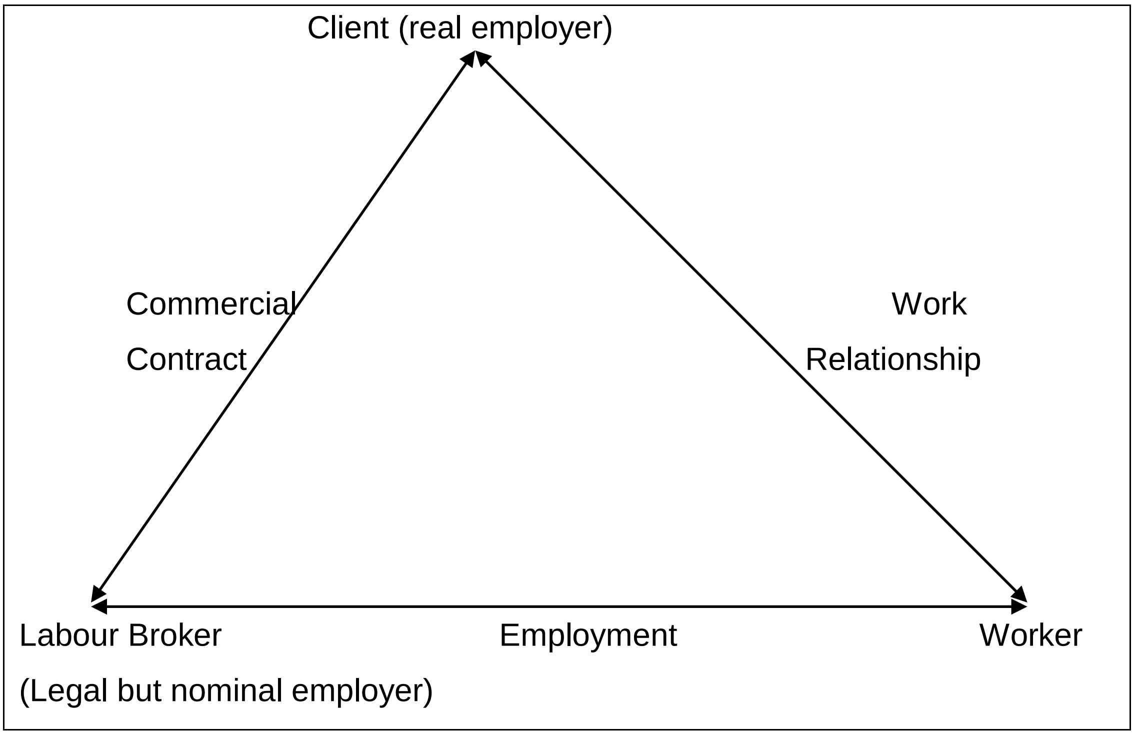
Standing, (1997) states that South African organizations are turning towards greater use of flexiworkers through casual labour, contract labour, sub-contracting to smaller organizations, home workers and other ‘out workers’, and agency workers. Horton and Langhinnerich, (2002) attribute the growth in these non-standard forms of labour to demand and supply factors in the labour market. Supply of labour in South Africa with high levels of unemployment makes job seekers willing to accept any form of employment as an alternative to unemployment. The changing demographic character of labour with more elderly people and women entering the labour market makes workers more vulnerable. Women prefer part-time work as it enables them to balance their career and family life (Horton and Langhinnerich, 2002). Internationally there is a move towards greater flexibility, decentralization and specialization of production. The focus on making profits and increasing shareholder values pushes employers to reduce the cost of production and more specifically labour with the consequent shift to non-standard patterns of employment (Horton and Langhinnerich, 2002).

2.7.2 Labour brokers

Riet, (2010) points out that labour broking or temporary employment services (TES) as referred to in the Labour Relations Act, 1995 (Act 66 of 1995) and the Basic Conditions of Employment Act, 1997 (Act 75 of 1997), are concerned with the placement of workers. When a labour broker places a worker at an organization to work for an indefinite period and over this period of employ the labour broker draws a remittance from the organization that is employing the temporary worker and then makes a substantially lower remuneration payment to the temporary worker (Ndunge, 2009). The labour broker remunerates the worker for the services rendered to the client. Labour brokers provide workers to organization which ranges from short to medium to long term period of employ for the temporary worker. Notwithstanding, the term “temporary” in the Labour Relations Act, 1995 (Act 66 of 1995), there is an absence of legal requirements regarding the duration of labour brokerage. Consequently, the duration of brokering is indefinite, ranging from days, weeks, and months to years. The relationship between the labour broker and the client is regulated by a commercial contract which is not subject to labour law.

Ndunge, (2009) explains that employing workers with the aim of making them available to a third party has created discontent amongst the major role players in South Africa, which includes organized labour and the chamber of business. In this contract the broker employs the worker but makes him or her available to a third party (the client) to carry out services. The client has a commercial contract with the labour broker who determines the tasks to be performed and the manner of performance of those tasks. The labour broker is the legal employer of the worker, but it is not the true employer and has nothing to do with the daily responsibilities of the worker. Figure 5 below illustrates the triangular employment relationship between the worker, the labour broker and the client.

Figure 5: Triangular employment relationship



Source: Ndunge, (2009)

Ndunge, (2009) points out that the worker has an employment relationship with the labour broker who is the legal but nominal employer, and an uncertain work relationship with the real employer who is the broker's client but who neither employs nor pays the worker and yet is the dominant entity in this arrangement. Workers are protected by the Occupational Health and Safety Act 1993, the Compensation for Occupational Injuries and Diseases Act 1993, and the Unemployment Insurance Act 2001. The legal fiction that the broker is the real employer means workers are powerless to enforce the rights enshrined in the Constitution and other pieces of legislation. The worker cannot take action against the *'real'* employer that is the client of the labour broker who the law declares is not the employer, but only against the labour broker should there be any labour violations. The labour broker is not present at the workplace, does not determine the tasks to be performed, and does not supervise the performance of such tasks (Ndunge, 2009).

Benjamin (2009) maintains that labour brokers placing workers with a client for an indefinite period or for a period of three months or longer should be considered an employee of the client. Consequently, the client is considered to be the employer for the purposes of compliance with health and safety legislation. This is true for both the Occupational Health and Safety Act, 1993 and the Mine Health and Safety Act, 1996 (Benjamin, 2009). The joint and several liability of the labour broker and client embraces all occupational health and safety standards. The client has the day-to day obligation to provide a healthy and safe workplace and the labour broker is required to observe the health and safety conditions in the workplaces to which they supply employees (Benjamin, 2009).

Crush *et al*., (2001) quote Rees who argues that South African employers use sub-contracting to cheapen costs, increase flexibility, disallow unions and avoid protective regulation and legislation. The pattern of employment of contract workers is highly unpredictable, irregular, insecure and unstable (Crush *et al.,* 2001). Workers and trade unions would like to see the removal of labour brokers, however, the labour broker system needs to be redressed by changing the unfair features of the system. Workers employed by labour brokers are required to work longer hours and under dangerous conditions. The majority of these workers are not provided with the standard industry non-wage benefits, such as medical schemes, sick leave or compensation in the event of injury and/or death (Crush *et al.*, 2001).

Labour brokering and retrenchments contribute to the decline in union membership and militancy. Hostility and conflict occurs amongst workers employed by the principal employer and labour broker workers on the account that conditions of service are substantially different. Employers use labour brokers as a means of avoiding trade unions and increasing profits (Crush *et al.,* 2001).

2.7.3 Labour brokers and the dynamics of control

Kenny and Bezuidenhout, (1999) point out that workers employed by labour brokers are seldom unionized and are discouraged from joining trade unions. They quote a worker's comments, *"The contractors (labour broker) do not allow contract workers to join the union. If a worker joins the union, he is fired. Contract labour is not unionized. They are using them to fight us (the union), because we cause strikes".* Labour brokers argue that most of the workforce is not unionized because it is difficult to organize them as the labour force moves around (Kenny and Bezuidenhout, 1999). Labour broker workers are considered to be different to non-labour broker workers, consequently are physically separated from each other and are prevented from building comradeship. The physical separation highlights a social separation of labour broker workers and non-labour broker workers (Kenny and Bezuidenhout 1999).

Kenny and Bezuidenhout, (1999) point out that labour brokering and other forms of casualization are used to evade health and safety legislations. Klerck, (1994) stated that factories in the petro-chemical industry used subcontracted workers for the most dangerous work. These subcontracted workers are not organized by trade unions and do not have knowledge of health and safety legislation.

2.7.4 South African - Department of Labour's perspective on labour brokers

Labour Minister, Membathisi Mdladlana (www.labour.gov.za, 05/08/09) stated that the exploitation of workers by labour brokers will cease once new legislation is promulgated to redress this practice. Mdladlana further describes labour broking as a form of human trafficking in this context and adds that the practice involves selling the labour of workers to the highest bidder. He points out that this is an extreme form of free market capitalism which reduces workers to commodities that can be traded for profit as if they are meat or vegetables. Minister Mdladlana reiterates that labour brokers are pro-employer and anti-trade unionism. Mdladlana concurs with the Manifesto of the African National Congress (ANC) which is the ruling party in South Africa which reiterates the avoidance of worker exploitation and ensures decent work for all workers. The Manifesto affords protection to the employment relationship by proposing legislation to regulate contract work and does not call for a total ban on labour brokers (http://www.anc.org.za/elections/2009/manifesto/manifesto.html).

The legislation that will be amended to regulate labour brokers are the Basic Conditions of Employment Act of 1997, the Employment Equity Act of 1998 and the Labour Relations Act of 1995 (www.labour.gov.za, 05/08/09). The planned amendment omits the Occupational Health and Safety Act, 1993. This omission will impact on labour broker workers in that their current plight will continue.

2.7.5 Implications for workers

Horton and Langhinnerich, (2002) state that workers employed by labour brokers are not protected under an employment relationship on the account that workers enter into a commercial relationship with a labour broker which precludes them from protection tabled under the countries labour legislation. Laws that provide anti-discrimination, employment equity, wage and hour protections are largely ineffective for such vulnerable workers. The contracting out of production and services to another organization undermines the position of existing employees in respect of job security and bargaining powers. Plant level rights that workers have such as breaks, work schedule control and consistency of job responsibilities are removed as vulnerable workers are deprived of basic benefits. The shifting of production to smaller and less viable organizations results in lower wages, fewer benefits and less job security. The presence in organizations of vulnerable workers with fewer rights and less power to defend their rights has a disciplining effect on the workforce as whole. Outsourcing has the effect of fragmenting conditions as workers within the same organization are covered by differing bargaining councils.

2.7.6 International labour organizations: decent work agenda

Rodgers *et al*., (2009) quoted former President Nelson Mandela's message to the 2007 International Labour Conference,

> *"Decent work is based on the efforts of personal dignity, on democracies that deliver for people, and economic growth that expands opportunities for productive jobs and enterprise development. Decent work is about the right not only to survive but to prosper and to have a dignified and fulfilling quality of life. This right must be available to all human beings. We rely on the International Labour Organization to continue its struggle to make decent work a global reality".*

Rodgers *et al.,* (2009) indicates that the rationale of "decent work" was introduced by the International Labour Organization's Director General Juan Somavia. The word "work" goes wider than labour or employment, reflects the variety of ways in which people provide to the economy and society, and covers both formal and informal economies. The word "decent" signifies the idea of a realistic ambition which meets social norms of income, conditions of work and security, rights and dignity. Decent work requires government departments to regulate and enforce conditions of service and workers' rights and security.

Rodgers *et al.,* (2009) indicate that the divide between law and economics is not easy to bridge and results in the economic discipline dominating. Economics is about trade-offs, economists will consider adverse economic effects of higher standards as well as the social impacts of economic policies and develop flexible policy response. The legal approach involves a framework of fixed principles and rights to which economic relationships are seen as less significant.

Rodgers *et al.,* (2009) states that the International Labour Organization's main focus is to promote opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. Rodgers *et al.,* (2009) quote, Jukka Takala, the former Director in the International Labour Organization, "progress requires a safe and healthy labour force; no country can achieve a high level of competitiveness and productivity without taking care of the safety, health and well-being of its workers".

2.8 Globalization and its effects on occupational health and safety

Holkeri, (2001) president of the 55th General Assembly of the United Nations, points out that new technologies and expansion of trade regimes have hastened the speed of globalization. Markets have become more open and inclusive. In the Northern hemisphere health and safety of workers are primarily related to their age, gender and type of profession, whilst in the Southern hemisphere poverty forces people to work in the informal economy without supervision and work safety assurances. Poor nutrition, long working hours and exposure to chemicals and work-related accidents make workers in developing countries unequal compared to workers in richer societies. In the formal sector, globalization leads to subcontracting and flexible employment contract which compromises the health and safety standards of the poor (Holkeri, 2001). In the informal sector, employment is increasing phenomenally and is actively supported by government policy, yet it is completely un-provided for in terms of occupational health and safety regulations and resources (Ryan, 2009).

Goldstein *et al*., (2001) reiterate that more flexible labour policies lead to weakened commitment to occupational health and safety. Global competition leads to employers viewing the prevention of occupational injuries and diseases not as part of the quality management system but as a barrier to trade (Glodstein *et al.,* 2001). Globalization creates the potential for movement of hazardous processes and substances to countries with less stringent regulatory systems (Ryan, 2009).

The Presidential Economic Joint Working Group (2009) comprising of labour, business and government state that the global financial crises was caused by diverse factors including gross imbalances and equities in the global economic system, the financialisation of economies, ineffectual regulation in several of the major world economies and poor business practices which has resulted in significant asset depreciation, closures of companies, rising unemployment and a slowing down of economic growth. South Africa is integrated into the world economy and has consequently been affected by a fall in demand for its export products and a fall in prices of key export commodities. Low income workers, the unemployed and the vulnerable groups are at a greater risk from this economic shock. The potential for the economic crises to destabilize the welfare of the vulnerable, including their jobs, health, education and to increase inequality and poverty is recognized (Presidential Economic Joint Working Group 2009). Ntshalintshali, (2010) cautions that the financial crises should not make government compromise the decent work agenda by acceding to pressure of not banning labour brokers.

Loewenson, (2001) argues that globalization under liberalized markets has benefitted the strong industrialized economies and marginalized the weak. Liberalized trade has been guided by the transfer of obsolete and hazardous technologies, chemicals, processes and waste including asbestos and pesticides no longer produced or used in industrialized countries. Occupational health under liberalized tax and trade systems can be seen in export processing zones (EPZ). EPZs have been associated with high levels of machine-related accidents dusts, noise, poor ventilation, and exposure to toxic chemicals.

Jauch, (2002) points out that in Mexico, employment in the EPZ (maquiladoras) grew by 10.4 percent in 1995, however it was accompanied by job losses of 9 percent in Mexico's manufacturing industries outside the zone. Employment in the manufacturing industries shifted towards the EPZ sector without increasing the total number of jobs. This process was described as the "maquiladorization" of the Mexican economy. Zimbabwe and Namibia suspended national labour laws as an incentive for investors when they passed their national EPZ laws in 1994 and 1995 respectively (Jauch, 2002). Zimbabwe Congress of Trade Unions (ZCTU) argued that Zimbabwe's Labour Relations Act should apply because:

- it is no longer viable to compete on the basis of cheap labour as the global emphasis is shifting to technological-capacity which requires skilled workers;
- cheap unskilled labour produces poor-quality products while high-value-added products from skilled workers are more competitive ;
- poor working conditions provoke dissatisfaction and labour unrest as well as lower productivity and poorer product quality; and
- it is morally unacceptable to remove the gains Zimbabwean workers have made since independence (Jauch, 2002).

The National Union of Metalworkers in South Africa (NUMSA) passed a resolution not to reject EPZs on the proviso that compliance with South African labour legislation is mandatory (Jauch, 2002). The Congress of South African Trade Unions (COSATU) opposes EPZs on the basis that they are not a workable industrial development strategy for South Africa (Jauch, 2002). The views of NUMSA and COSATU are understandable in view of potential human rights infringements and worker exploitation in the IDZs.

2.9 Summary of chapter

This chapter listed the major sources of exposure to ototoxic chemicals in the industrial setting and categorized the chemicals into high priority and additional ototoxins. International research conducted on chemically induced hearing loss both on humans and animals suggest that there is a link to certain types of chemicals exposure and hearing loss.

Confounding variables were discussed on the account that variables such age, recreational activities, smoking, medications, traditional healers, healthy worker effect and alcohol consumption may influence the study. Antiretroviral drug treatment for HIV and AIDS are potential ototxins. Recreational activities may accelerate the hearing loss if workers are also exposed to ototoxic chemicals and noise at the workplace. The rubber manufacturing process was discussed with particular reference to the ototoxic chemicals used in the manufacturing of rubber.

Globalization has contributed to the restructuring of work and the introduction of flexible forms of work such as outsourcing of employment through labour brokers. This type of employment does not receive the protection intended by labour law and workers are not allowed to join unions. Labour brokers argue that it is not possible for workers to organize themselves because their work location changes regularly.

Occupational health and safety may be compromised on the account that employers seek to outsource labour to reduce overheads and increase profits. Organized labour view the workers employed through labour brokers as victims of circumstances in that they need employment and the labour broking is the only alternative or else they will be in poverty.

CHAPTER THREE

GLOBAL STANDARDS IN THE CONTEXT OF QUALITY MANAGEMENT

3.1 Introduction

The Occupational Health and Safety Act, 1993, Section 8, states that the employer (management) must provide and maintain a system of work that ensures worker's safety and health at the workplace. Management is responsible for developing a system that embraces the domain of safety, health, environment and quality management at the workplace (Torp and Moen, 2006, Saksvik and Quinlan, 2003). The systematic action (at management level) ensures and documents the activities of safety, health, environment and quality are performed in accordance with the Occupational Health and Safety Act, 1993. This approach has proven to be successful in reducing occupational accidents and continuous pollution (Hovden, 1998).

Global standards ensure that organizations develop a formal and systematic approach to the management of occupational health and hygiene which is similar to the management of quality, environment and safety (Gardiner and Harrington, 2005). These standards promote harmony in organizations. Occupational health and hygiene concerns need to be explained and communicated at senior management level and should form part of top managements sets of business plans and targets (Gardiner and Harrington, 2005). When occupational health objectives form an integrated component within business planning, this ensures that the entire organization commits resources to protecting the health and well-being of workers in that organization. Embodying health and safety requirements for an organization within a formal, documented and auditable system removes the potential uncertainties in the organization. Conformance to ethical standards for social responsibility includes looking after the health of the workforce in its employ and taking adequate care for the environment in which it is located.

3.2 Overview of international standards

The Copenhagen Accord endorsed by the Heads of State and Heads of Government on the 18th December 2009, indicates that the global temperature should be below 2 degrees Celsius in the context of sustainable development to enhance our long-term cooperative action to combat climate change (http://unfccc.int/2860.php). Tsai and Chou, (2009) point out that the three Ps of sustainable development are People, Planet, and Profit. All three elements have to be satisfied before an entrepreneurial activity can be called sustainable (Crals and Vereeck, 2005). The first element, 'people' refers to the behaviour of organizations in social and ethical issues in the context of human resources. The concerns that need to be addressed are the protection of human rights, eliminating fraud and corruption, the use of child labour, the gender relationship and discrimination on the work floor, labour participation in management and profits (Crals and Vereeck, 2005). The second element, 'planet' raises concerns about the effects and remedy of the impact of organizations on natural resources and the landscape. Environmental care, chain management eco-efficiency, clean products, sustainable technology development and eco-design are substantial examples of these concerns. The inclusion of environmental concerns into business practices is driven by environmental legislation and self-regulation in the form of ISO 14000:2004 (Crals and Vereeck, 2005). The third element, 'profit' refers to the use and allocation of value added from employment, investments in machines and infrastructure (Crals and Vereeck, 2005).

Organizations applying the elements of people, planet and profit are referred to as managing the "triple bottom line" (Elkington, 1997). To achieve the goal of "triple bottom line of sustainability", the implementation and certification of quality (ISO 9001:2000), environmental (ISO 14001:2004) and occupational health and safety (OHSAS 18001:2007) systems has become an important activity. ISO 9001:2000 contributes to better quality, higher productivity, greater customer satisfaction, and greater profit. ISO 14001:2004 contributes to better environmental performance, greater eco-efficiency, greener products, and more transparency for environmentally concerned stakeholders. OHSAS 18001:2007 contributes to safer and healthier workplaces, more efficient work processes, improved worker insight into the working environment and greater recruitment attractiveness. Social Accountability 8000 (SA 8000:2008) is a product of the New York-based Council on Economic Priorities Accreditation Agency (CEPPA). This scheme is an auditable international standard for socially responsible organizations. SA 8000:2008 contributes to achieving higher social accountability and better quality of life for workers (Rohitratana, 2002). The implementation of global standards produces benefits for profit (quality), planet (environment) and people (health and safety and social accountability to become sustainable organizations (Tsai and Chou, 2009).

Nadvi and Wältring, (2002) state that international trade has bolstered interest in global standards. The standards include labour conditions, health and safety systems, quality management procedures and the environmental impact of production. The central reasons for these standards are the need for common standards in order to promote economic efficiency and international trade; concerns with the social and ecological dimensions of international trade; opportunities to be more competitive; and the erosion of regulatory functions of countries with the growing of global governance (Nadvi and Wältring, 2002). Standards set common and broad understanding of benchmarks which are critical in trade relations, promotes efficient markets and provides a basis to differentiate markets thus creating competitive niches. Conformance to standards ensures efficient transmission of information from business to consumers, business to business and improves co-ordination of global production and distribution systems. Adhering to standards upholds technical norms, management standards, product codes and promotes compatibility (Nadvi and Wältring, 2002).

3.3 The quality management system ISO 9001:2008

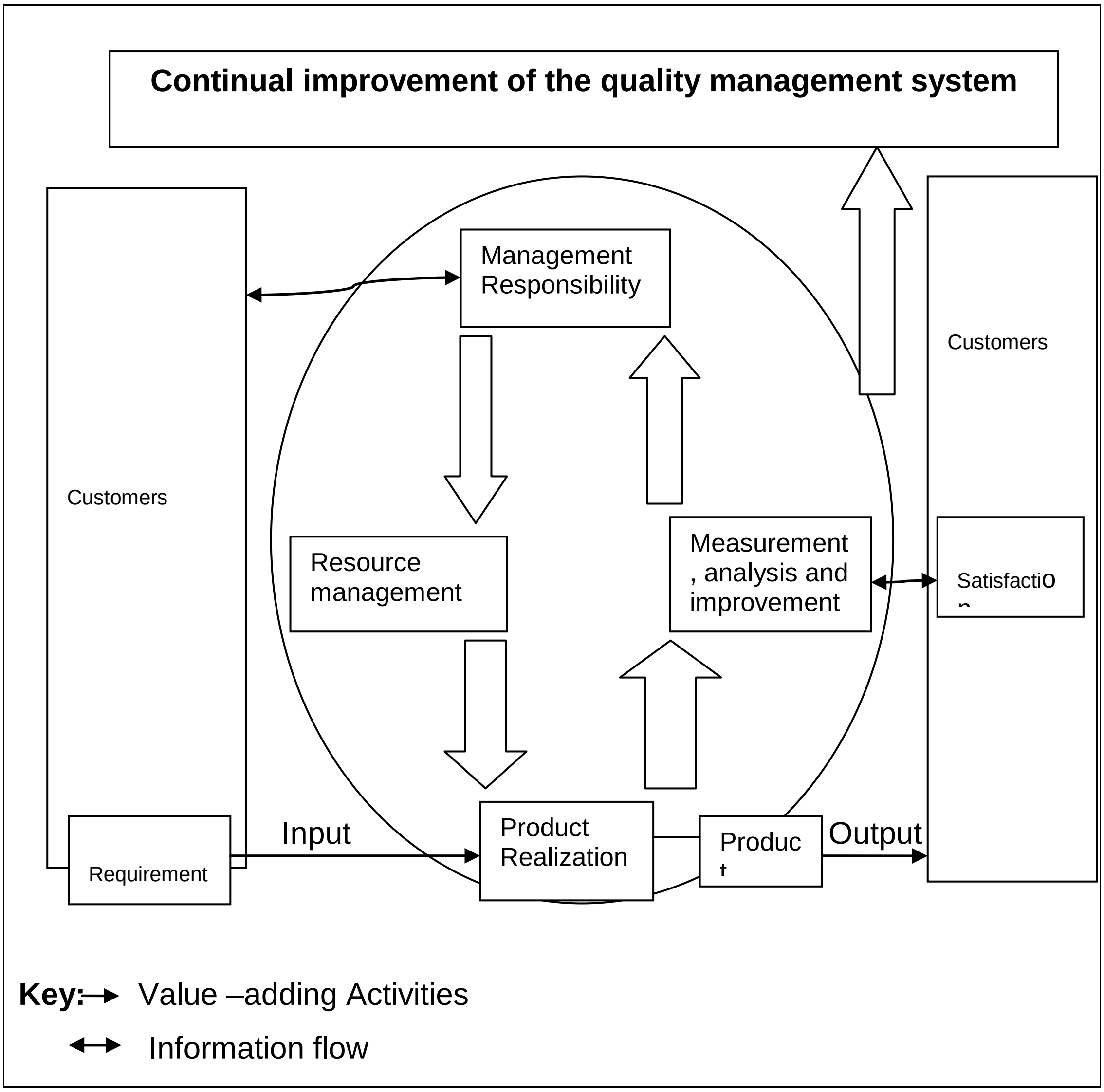
Nadvi and Wältring, (2002) maintain that globalization of production has expedited the demand for greater control over quality assurance in production processes. The ISO 9001:2000 standard provides assurance that a product conforms to established and specified requirements that controls quality within international supply chains thus improving market transparency. The ISO 9001:2000 standard is seen by the business communities in many developing countries as key to obtaining access and enhanced competitiveness in global markets (Nadvi and Wältring, 2002).

The ISO 9001:2000 standard contains guidelines for setting up a quality management system within an organization. It provides assurance that a certified organization has in place a well documented quality system including traceability of purchases from suppliers. Furthermore, it provides assurance that the quality management procedures of the organization are independently certified as conforming to accepted norms, and that the organization has in place a mechanism for responding to the needs and quality concerns of its customers (Nadvi and Wältring, 2002). The Quality Management System ISO 9001: 2000 focuses on customers and continuous improvement. The circles and arrows in ISO 9001:2000 in Figure 6, signify a dynamic and continuous process. The core focus of ISO 9001:2000 is customers, their demands and the satisfaction of those demands and orientation towards product chain (Jørgensen *et al*., 2006). The customer is the vital determiner of quality. Products may meet all specifications, however if it does not adhere to the customers performance requirements it will fail the quality test (Swiss, 1992).

Quality is required to be factored in the product early in the production process (upstream) instead of being added on at the end (downstream). Products go through the phase of design, production, inspection, reworking (for products), and then response to consumer complaints. Upstream phases of design and production are critical. When products are produced by workers who are trained to maintain consistently high quality then downstream inspections, re-workings and responses to consumer complaints become irrelevant. This saves money and appeases the customer (Swiss, 1992). Preventing variability is the answer to producing high quality products. Slippages in quality occur from excessive variation in the product. Important tools in overcoming this difficulty are process control charts. These charts are used to track quality by charting a product's deviation from the optimal, these deviations are then categorized and analyzed (Swiss, 1992). Quality results from committed people working within systems. It requires continuous improvement of inputs and processes. Quality is dynamic and constantly changing because it represents a content customer (Swiss, 1992).

Improvement of organizational processes results in improved quality which leads to customer loyalty and long range profits. Quality improvement requires profound worker participation. Quality is dependent on production workers doing it right the first time, consequently worker participation in the improvement process is key (Swiss, 1992). Quality requires total organizational commitment. Quality is attained only when management creates an organizational culture that focuses on consistently producing quality products with a quest to continuously improve on them. The organizational culture must be sustained by active and continuous participation from top management (Swiss, 1992).

Figure 6: The plan-do-check-act (pdca) framework of an integrated management system (ims).



Source: ISO 9001:2008

3.4 Environmental management system ISO 14001:2004

The ISO 14000:2004 series consists of five elements: environmental management system (EMS), environmental auditing, environmental labeling, environmental performance evaluation, and life cycle assessment (Tsai and Chou, 2009). ISO 14001:2004 is the nucleus of the series and its adoption is voluntary (Zeng *et al*., 2003). The Environmental Management System takes a systematic approach and provides a tool to enable organizations to control the impact of their activities on the natural environment

Rondinelli and Vastag, (2000) declare that ISO 14001:2004 provides guidance on Environmental Management System requirements, based on the 'plan-do-check' framework and comprises of the following elements:

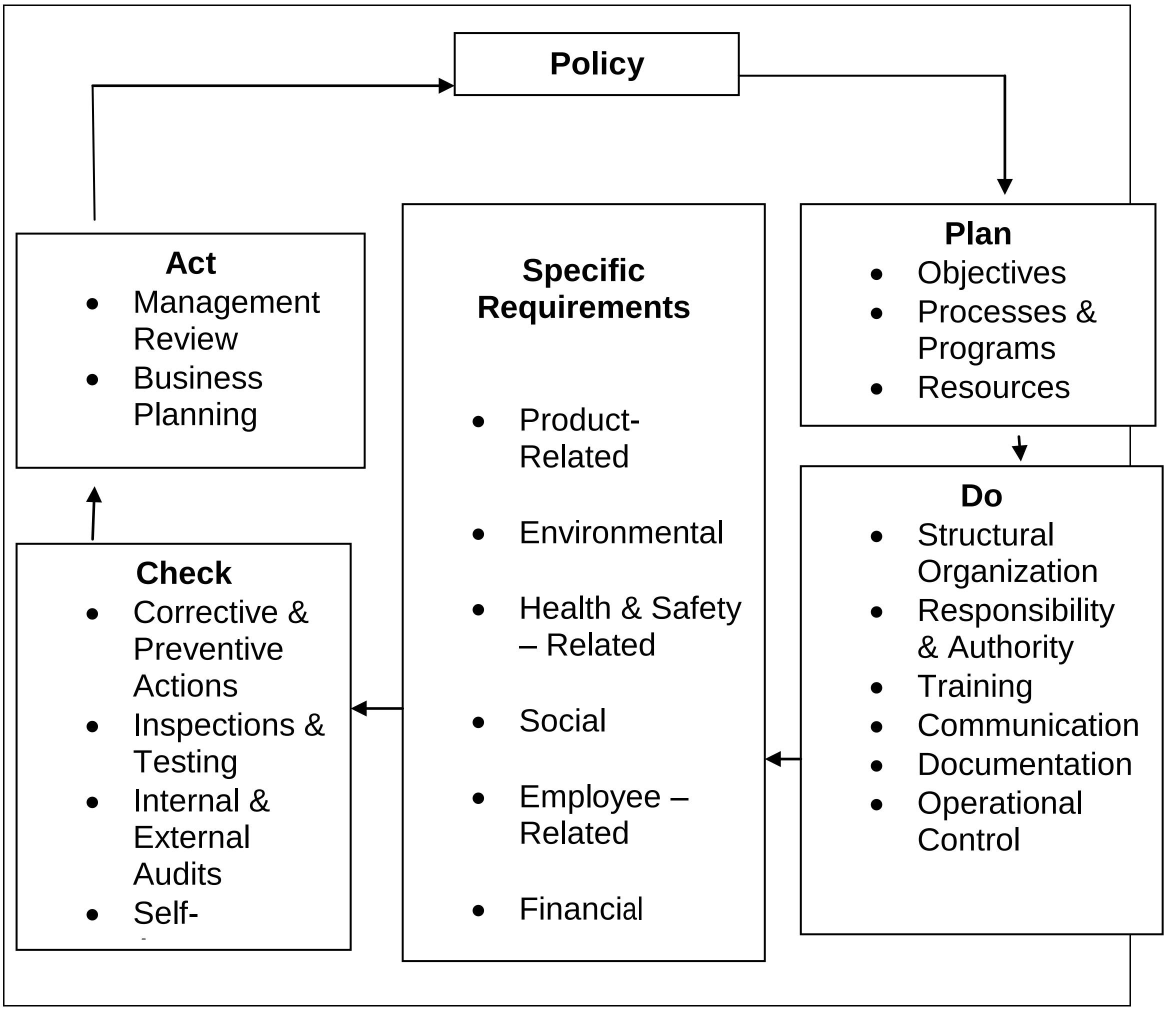
- the development and endorsement of an environmental policy to which senior management is committed to;
- establish a planning process that identifies all the environmental aspects including energy losses, air impacts, solid waste impacts, water impacts, recyclables, raw material and labour inputs of an organization's operations. Legal and other requirements, a set of clearly defined objectives and targets for environmental improvement, and a set of environmental management programs;
- provide a system of implementation and operation that includes a clear structure of responsibility for environmental management. Programs for training, awareness and competence among all workers of the organizations internal and external communication of the environmental management system. A system of environmental management documentation, a documentation control system, procedures for operational controls of environmental impacts, and emergency preparedness and response.
- develop a system of checking and corrective action that includes monitoring and measurement for reporting non-conformance and for taking corrective and preventive action, of record–keeping with regard to environmental management and environmental management audits;
- schedule management review process through which senior management reassesses the suitability, effectiveness and adequacy of the environmental management system at appropriate intervals to ensure continuous improvement.

The ISO 14001:2004 Environmental Management System enables organizations to reduce their environmental incidents and liabilities, increase efficiency of operations by removing waste from production and distribution processes, increase awareness of environmental impacts of operations among all workers and establish a strong image of corporate social responsibility (Rondinelli and Vastag, 2000).

3.5 Safety management system OHSAS 18001:2007

Beckmerhagen *et al*., (2003) assert that it is imperative for organizations to continuously improve their overall quality, environmental, safety and public accountability performance. The integrated management system comprises of quality management system (QMS: ISO 9001:2000), environmental (EMS: ISO 14001:2004) and occupational health and safety (OHSMS: OHSAS 18001:2007), which combines to form a lean system compliant to most regulatory and voluntary standards in any country of the world (Beckmerhagen *et al*., 2003). The approach based on the PDCA framework is illustrated in Figure 7.

Figure 7: Plan-do-check-act model of an integrated management system



Source: Beckmerhagen *et al.,* (2003)

3.6 Occupational health and safety management system OHSAS 18001:2007

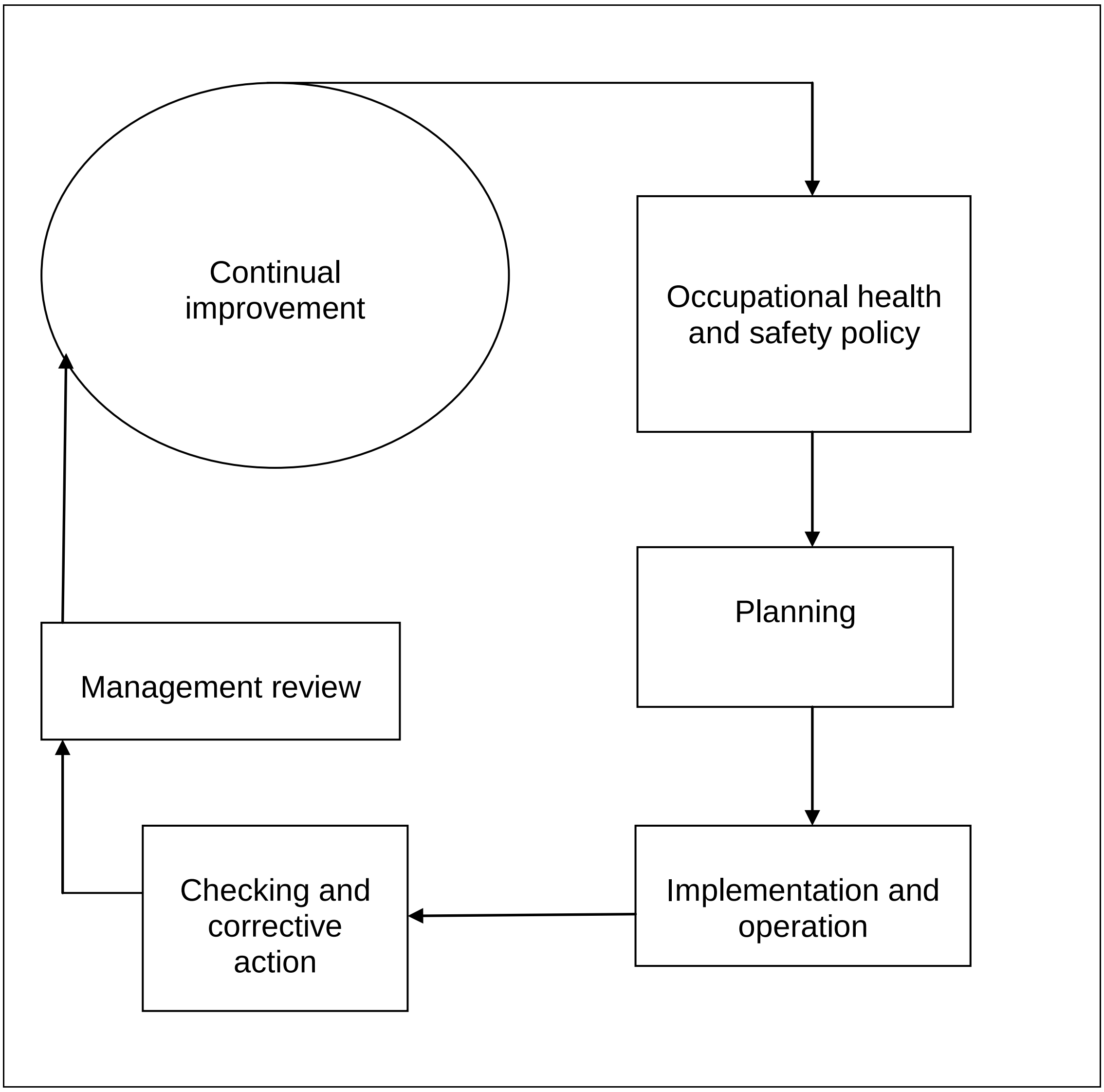
The Occupational Health and Safety Assessment Series (OHSAS) approach allows organizations to identify their hazards and determine those risks that are not acceptable and which need to be controlled (Smith, 2008). OHSAS 18001:2007 is not a compliance driven system although it requires organizations to establish which legislation applies within the organization's field of activities and to implement effective control measures. A risk management approach ensures identification of potential areas of harm which legislation may not address and provide for which is a system geared towards preventing occupational injury and disease based on legal compliance and drawing from international best practices (Smith, 2008).

The objective of OHSAS 18001:2007 is to protect the organizations workers from occupational injury and disease and workers carrying out work on behalf of the organization such as contractors to the organization. The risk-based approach of OHSAS 18001:2007 allows for balanced judgement to be made concerning health risks and accidents. Figure 8 illustrates the OHSAS 18001:2007 process approach to managing occupational health and safety. The structural aspect of the safety management system includes the occupational health and safety policy, occupational health and safety programme, implementation of a communication system, hazard identification and risk assessment methodology (Cambon *et al*., 2006). The operational aspects of the safety management system point out the actual practice on floor level which is vital for safety for example lock-out and tag out procedures where machines are electrically isolated to render it in-operative before commencing repairs or maintenance, confined space entry permit, refers to the entry into a vessel or reactor that may have contained noxious gases and vapours that has the potential to cause serious or fatal injury if not declared safe by management prior to permitting entry to a worker. Operational performance focuses on what the safety management system does rather than on what it has in the structural performance and is considered the intrinsic value of a safety management system (Cambon *et al.*, 2006).

The occupational health and safety policy should recognize the occupational health and safety management system as an integral part of the organization's business, achieving occupational health and safety performance targets, allocating resources, setting occupational health and safety objectives, worker involvement and participation, periodic review of policy and provisions of training to workers. Organizations are required to establish, develop and maintain occupational health and safety training awareness and competencies amongst workers and management (Santos-Reyes and Beard, 2002). Proactive and reactive monitoring of occupational health and safety objectives is required to determine if objectives are achieved. Routine monitoring and periodic audits provides a critical assessment of all elements of the OH & S management system (Santos-Reyes and Beard, 2002). Commitment to the prevention of injury and ill health must be articulated in the occupational health and safety policy. OHSAS 18001:2007 requires a systematic approach to identifying hazards, quantifying risks and implementing appropriate control measures.

The legal requirements provide information for determining an organization's objectives for the occupational health and safety management programme thereby ensuring continual improvement (Smith, 2008). The effective implementation of the policy and objectives requires the organization to establish accountabilities, roles, responsibilities and authorities and the provision of resources. Top management is responsible for the implementation of the occupational health and safety management system in the organization and is required to consult and involve workers throughout the implementation, operational and maintenance phases.

Figure 8: Occupational health and safety management system model – OHSAS 18001:2007:VI



Source: OHSAS 18001:2007

3.7 Social accountability 8000 (SA 8000:2008)

SA8000:2008 provides a standard based on international human rights norms and national labour laws that protect and empower workers within an organizations scope of control and influence to produce products or provide services for the organization itself as well as by its suppliers/subcontractors, sub-suppliers and home workers (SA8000:2008).

The standards are based on conventions and recommendations of the International Labour Organization, was cited in SA 8000:2008, Rohitratana 2002 and Sturm *et al*., 2000, are listed below.

- ILO Convention 1 (Hours of Work – Industry) and Recommendation 116 (Reduction of Hours of Work);
- ILO Convention Minimum 138 and Recommendation 146 Minimum Age – Employers must not hire children under the age of 15 years;
- ILO Convention 29 (Forced Labour) and 105 (Abolition of Forced Labour) – Employers cannot force workers to work against their will;
- ILO Convention 87 (Freedom of Association);
- ILO Convention 98 (Right to Organize and Collective Bargaining) – Workers must have the freedom to bargain with employers (create and become members of trade union of their choice);
- ILO Convention 131 Minimum Wage Fixing ;
- ILO Convention 29 (Forced Labour) and 105 (Abolition of Forced Labour);
- ILO Convention100 (Equal Remuneration) and 111(Discrimination Employment and Occupational) – Racial and other discrimination is forbidden;
- ILO Convention102 (Social Security – Minimum Standards)
- ILO Convention 135 - Workers' Representatives Convention;
- ILO Convention 155 – and Recommendation 164 Occupational Safety and Health Convention – Employers must take protective measures to guarantee workers' health and safety;
- ILO Convention 159 - Vocational Rehabilitation and Employment – Disabled Persons;
- ILO Convention 169 (Indigenous and Tribal Peoples)
- ILO Convention 177 - Home Work;
- ILO Convention 182 (Worst Forms of Child Labour);
- ILO Code of Practice on HIV/AIDS and the World of Work;

In addition to these conventions and recommendations, SA 8000:2008 requires more than legal compliance. The standard delineates how an organization should incorporate the following aspects: health and safety, freedom of association and the right to collective bargaining, disciplinary practices, working hours and remuneration.

3.7.1 Health and safety

Organizations are required to provide a safe and healthy workplace to its workers. Effective steps should be taken in identifying and preventing potential accidents and injury to workers' health arising out of the workplace by implementing reasonable practicable measures. Senior management must be appointed to take responsibility for health and safety. Frequent and effective health and safety instructions are required. Proactive systems are required to detect potential threats to health and safety. Worker may have the right to remove themselves from danger without requesting permission from the employer, when potential life threatening or serious injury may arise.

3.7.2 Freedom of association and the right to collective bargaining

Workers shall have the right to form, join and organize trade unions of their choice who will bargain collectively on their behalf with employers. There should be no discrimination of union members and there should be free access to workplaces by union members.

3.7.3 Discrimination

This requires banning the practice of discrimination in hiring, remuneration, access to training, promotion, termination, or retirement based on race, caste, national origin, religion, disability, gender, sexual orientation, union membership or political affiliation.

3.7.4 Disciplinary practices

Outlaw corporal punishment, mental or physical coercion, and verbal abuse of workers.

3.7.5 Working hours

Employment contracts are to have a maximum of 48 hours per week with 1 day-off for every 7 days worked. Overtime work should not exceed 12 hours per week. Overtime work is an exception and always paid at a higher rate.

3.7.6 Remuneration

Wages should be at least at the legal minimum requirement or at industry standard. No deductions can be made for disciplinary purposes. Wages and benefits must be detailed clearly and regularly. Compensation must be in monetary form. Organizations shall not use labour-only contracting arrangements, consecutive short-term contracts, or circumvent internships and apprenticeships to avoid meeting its obligations to applicable legislation.

3.8 International labour conventions

Benjamin and Greef, (1997) maintain that the main source of international standards on occupational health and safety are found in the International Labour Office (ILO) conventions. Conventions have the full force of a treaty in international law. In 1981 the International Labour Conference adopted its first general occupational health and safety standard in the form of the Occupational Safety and Health Convention (No. 155) which applies to all branches of economic activity (Benjamin and Greef, 1997). ILO Convention No. 176 pertains to Safety and Health in Mines (www.ilo.org). The Minister of Labour Mdladlana in South Africa signed the Occupational Health and Safety Accord collectively with organized labour and organized business on the 8

April 2002, ratifying ILO Conventions 155 and ILO 176 thereby making both these conventions binding to South Africa (www.search.gov.za/info/previewDocument). Minister Mdladlana explained that the provision of safe and healthy workplaces could be justified on moral grounds given the sacredness of human life and the ireplaceability of worker's fingers and limbs chopped by unguarded machines and lungs contaminated by corrosive and harmful chemicals. The provisions of ILO Convention 155 outlined below encompass employer responsibilities and worker rights:

3.9 International Labour Organization (ILO) 155: occupational safety and health convention, 1981

Countries ratifying ILO Convention 155 are required to consult with the representative organization of employers and workers to formulate, implement and periodically review a coherent national policy on occupational safety, occupational health and the working environment. In the South African context there remains an absence of a national policy occupational safety, health and environment, although the ILO 155 convention was ratified in 2002. Ratification of ILO Convention 155 means that it is incumbent on employers to provide the following core rights to workers in accordance with the convention's stipulations:

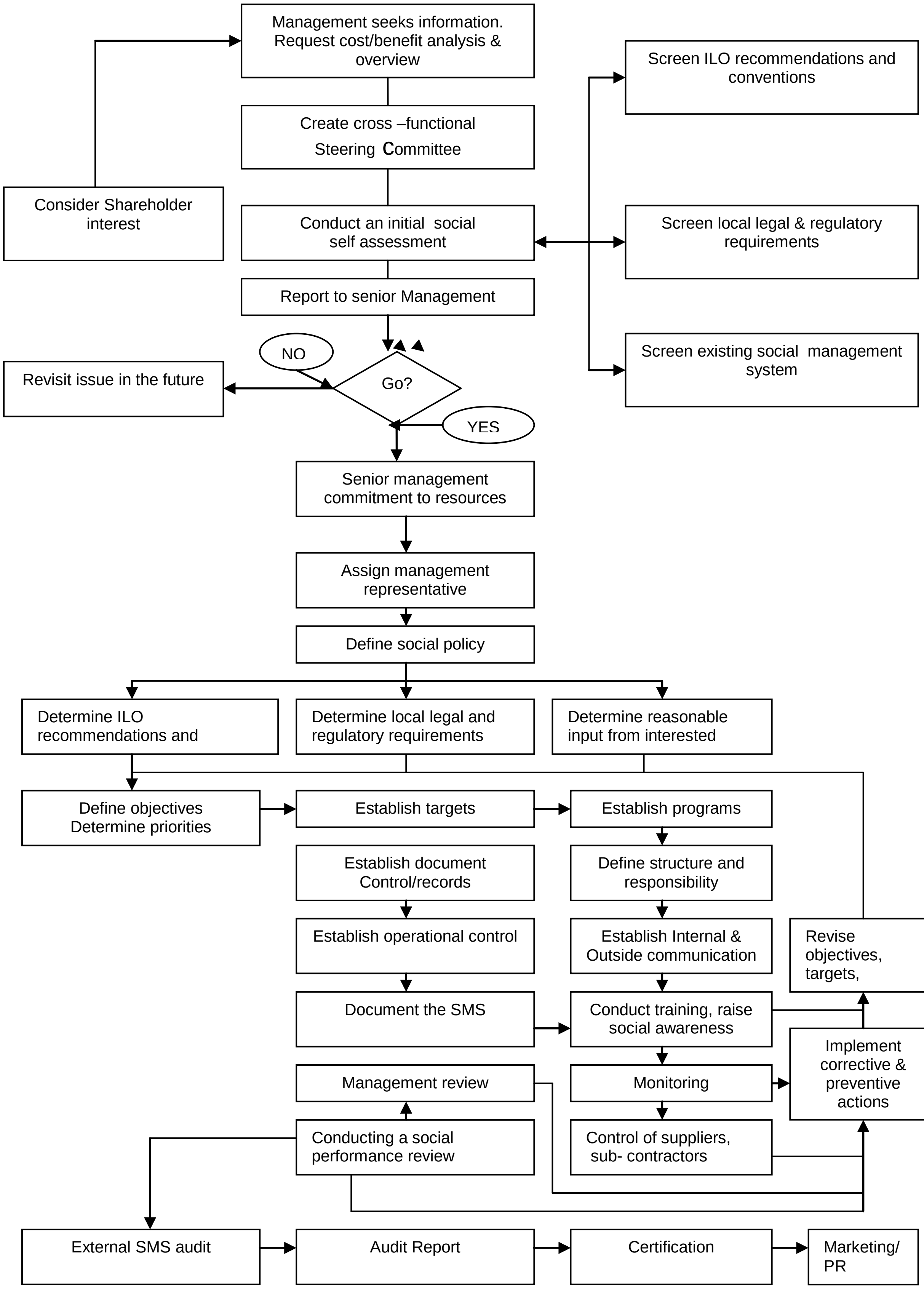
- *Article 12:* Reasonably practicable measures to be taken to ensure that machinery does not entail dangers for the safety and health of those using it correctly. Information concerning the correct use of machinery and dangerous properties of chemical substances and physical and biological agents.
- *Article 13:* Workers may remove themselves from a work situation provided there is reasonable justification that serious danger to life or health existed and are protected from any undue consequences.

- *Article 19:* Workers are to be given adequate information and training on measures taken by the employer to ensure a safe and healthy environment. Workers representative organizations (trade unions) should be permitted to enquire into and consult the employer on aspects relating to occupational safety and health. Workers may report unsafe conditions that present an imminent danger to life or health and workers may refuse to return to work until the conditions are made safe.
- *Article 21:* Workers shall not incur expenditure for occupational safety and health measures.

3.10 Social accountability management systems (SA 8000:2008)

Top management is required to present the organizations social accountability policy and labour conditions in writing, in workers' own language. Organizations are required to recognize that workplace dialogue is a vital component of social accountability. Workers have the right to representation with senior management on matters relating to SA8000:2008. In unionized environments such representation will be undertaken by the recognized trade union, alternatively workers may elect a SA8000:2008 representative. Top management is required to periodically review the adequacy, suitability, and continuing effectiveness of the organizations policy, procedures, and performance to SA 8000:2008 and other requirements to which the organization subscribe. Figure 9, illustrates the management of social accountability in line with SA8000:2008.

Figure 9: Managing social accountability SA8000:2008

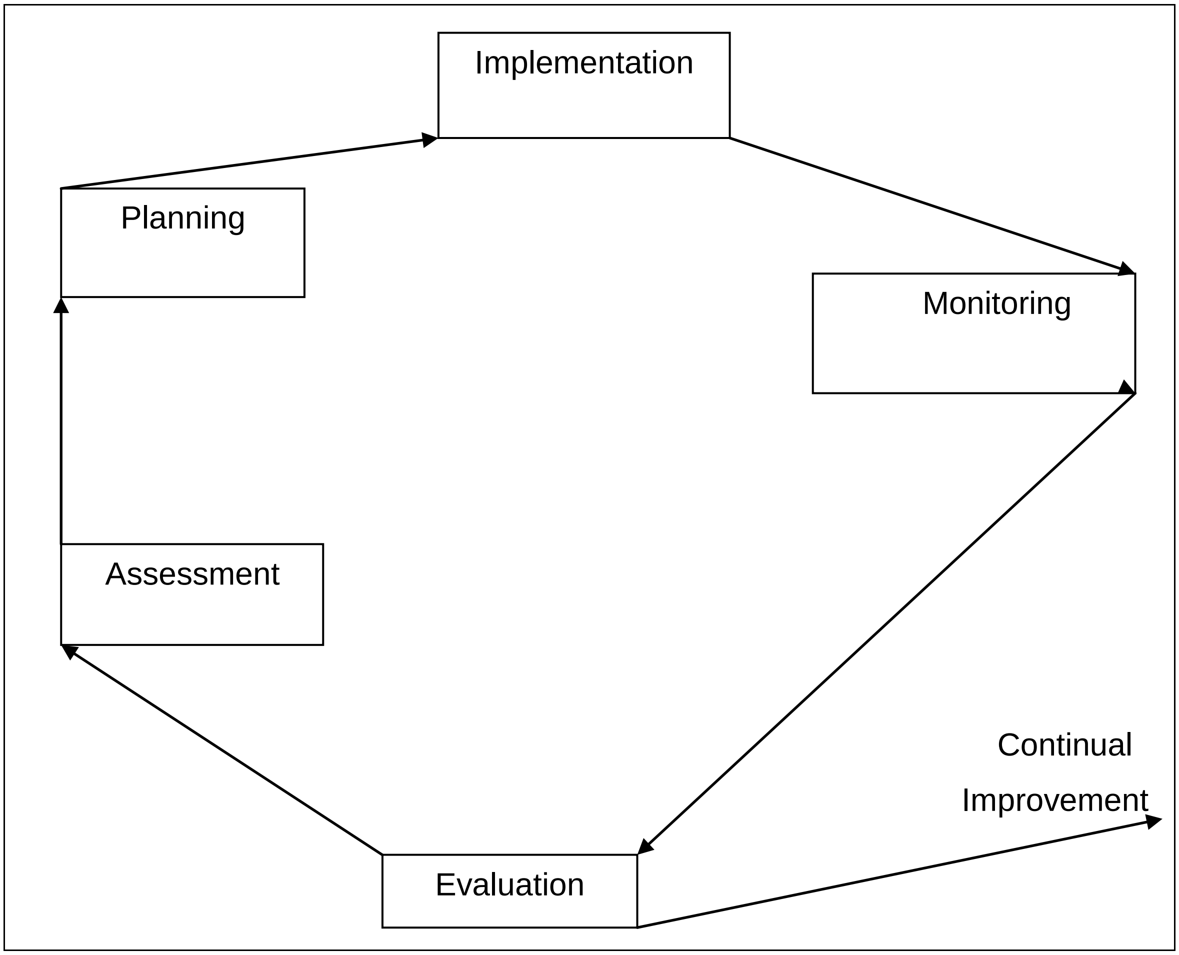


Source: Sturm *et al.*, (2000)

3.11 HIV and Aids management systems: SANS 16001:2007

Human Immunodeficiency Virus (HIV) and Acquired Immune Deficiency Syndrome (AIDS) Management System: South African National Standards (SANS) 16001:2007 provides for the management of HIV and AIDS in the workplace. HIV and AIDS is not classified as an occupational disease, HIV-positive workers may develop severe AIDS-related illnesses that impact on the work environment (Campbell and Williams, 1999). HIV/AIDS increases worker turnover, disruption of work schedules and workers will need time off to attend fellow workers funerals (Campbell and Williams, 1999). The SANS 16001:2007 standard is based on the methodology/cycle known as Assess-Plan-Implement-Monitor-Evaluate (APIME) which is illustrated in Figure 10.

Figure 10: The assess-plan-implement-monitor-evaluate (apime) method



Source: SANS 16001:2007

The APIME components (SANS 16001:2007) are described as follows:

- Assessment of organizational weakness to HIV and the identification of HIV determinants. Tools that can be used to assess the organization's situational analysis, needs assessment, actuarial economic impact surveys and prevalence surveys.
- Planning requires formulating an HIV and AIDS policy, procedures, processes, targets, objectives and success criteria based on the assessment of vulnerability, susceptibility and determinants in respect of legislation in South African.

- Implementation of targets and objectives contained within the HIV and AIDS policy.
- Monitor and measure the progress against the HIV and AIDS policy, objectives, targets, legal and other requirements, maintain records and report the results to all stakeholders.
- Evaluation of the achievement of targets and objectives for efficacy. Actions are taken to continually improve performance of the HIV and AIDS management system.

The HIV and AIDS policy should include a commitment to the prevention of work-related exposure to HIV and AIDS, and provision of information, education, communication, behaviour-change communication and promotion of the prevention of the spread of HIV. Other areas to be addressed are non-discrimination in recruitment, employee benefits, performance evaluation criteria, disciplinary measures, dismissal, testing, confidentiality and disclosure, and organizational death benefits.

Communication between the organization and relevant stakeholders, workers' spouses, life partners, children, orphans and immediate family is essential. Information informing workers who the HIV peer educators are, who the HIV counselors are, who the Employee Assistance Programme (EAP) practitioners are, and how to access HIV and AIDS care and treatment. The organization's operation control and impact mitigation shall identify operations that present potential risk in contracting HIV and AIDS and set appropriate objectives and targets to curb the risk. Specifying the operational procedures for voluntary testing and counselling is essential. Provision of resources to maintain and improve the HIV and AIDS management system includes human resources and specialized skills, organizational infrastructure, technology, and financial resources. Organizations are required to identify the training needs for HIV and

AIDS management and provide training to meet these needs. Both internal and external audits of HIV and AIDS management systems must be conducted at planned intervals to identify non conformance to the standard and to add value to the organization. Top management is required to review the organizations' HIV and AIDS management system at planned intervals to ensure its continuing suitability, adequacy and effectiveness. Review the HIV and AIDS policy management objectives and targets on an annual basis.

3.12 King III report on governance for South Africa 2009

The King III Report, (2009) focuses on corporate governance in South Africa and requires organizations to report on an annual basis the organization's financial results:

- how the organization has positively or negatively impacted on the economic life of the community in which it operated during the year under review and
- how the organization intends to enhance those positive aspects and eradicate the negative aspects in the year ahead.

The King III Report, (2009) is based on the principle of 'apply or explain' is cognizance of the fact that it is often not a case of whether to comply or not, but rather to consider how the principles and recommendations can be applied. Essentially an organization making a collective decision could conclude that to follow a recommendation would not, in the particular circumstances, be in the interest of the organization. The organization could apply the recommendations differently and still achieve the objectives of corporate governance principle of fairness, accountability, responsibility and transparency. Organizations form an integral part of society and is considered as much as a citizen as a natural person who has citizenship. It is apparent that organizations will be and will be seen to be a responsible citizen. This involves social, environmental and economic concerns, referred to as the triple bottom line under which organizations operate. Organizations should no longer make decisions based on the needs of the present because this may compromise the ability of future generations to meet their own needs (King III, 2009).

The basis for corporate governance is ethics. Consequently organizations are required to operate ethically at all times. Ethics is secured by the following ethical values:

- **Responsibility:** Organizations are required to take responsibility for their assets and actions and be willing to take corrective actions to keep the organization on a strategic path which is ethical and sustainable.
- **Accountability:** Organizations should be able to justify decision and actions to all stakeholders.
- **Fairness:** Organizations should ensure that they give fair consideration to the legitimate interest and expectations of all stakeholders.
- **Transparency:** Organizations should disclose information in a manner that enables stakeholders to make an informed analysis of the organization's performance and sustainability.

Top management is required to discharge the following moral duties:

- **Conscience:** Top management should act with intellectual honesty and independence of mind in the best interests of the organization and all its stakeholders. Conflict of interest to be avoided.
- **Inclusivity:** It is essential for top management to engage stakeholders in order to achieve sustainability. The legitimate interest and expectations of

stakeholders must be considered when decisions are taken and strategies are made.

- **Competence:** Top management should have the knowledge and skills required for leading an organization effectively which should be continually developed.
- **Commitment:** Top management should be diligent in performing its duties and devote sufficient time to organizational affairs. Ensuring organizational performance and compliance requires unwavering dedication and appropriate effort.
- **Courage:** Top management should have the courage to take the risks associated with leading and controlling a successful, sustainable enterprise, and also the courage to act with integrity in all management decisions and activities.

The King III Report, (2009) promotes ethical values and moral duties with employers to safeguard workers, stakeholders and affected and effected parties. Organizations are considered to be economic institutions, however, it is also deemed to be a corporate citizen. Consequently it has social and moral standards in society with all the responsibilities attached to that status. Organizations are responsible for their performance within the context of a triple bottom line. It operates under: economic, social and environmental spheres. The triple bottom line improves the organizations potential to create economic value. It ensures that the economic, social and environmental resources that the organization requires to remain in business are treated responsibly. Essentially the organization looks beyond short term financial gain, the organization safeguards its reputation and builds trust. Social and environmental concerns have financial consequences. It is unethical for organizations to require society and future generations to carry the economic, social and environmental costs and burdens of its operations. Organizations are required to respect the basic human rights of individuals and communities by creating and maintaining conditions in which human potential can develop.

3.13 Consolidation of national and international standards

The consolidation of OHSAS 18001:2007, ISO 14001:2004, King III:2009, ISO 9001:2008, SANS 16001:2007 and SA 8000:2008 provides safe and healthy work environment to workers, conforms to good corporate governance, provides effective AIDS management and appropriate social accountability as tabulated in Table 7.

Table 7: Safety, environment, corporate governance, quality, aids and social accountability (SECQAS)

SAFETY **BS OHSAS 18001:2007**	**ENVIRONMENT** **ISO 14001:2004**	**CORPORATE GOVERNANCE** **King III Report 2009**	**QUALITY** **ISO 9001:2008**	**AIDS** **SANS 16001:2007**	**SOCIAL ACCOUNTABILITY** **SA 8000:2008**
Policy	Policy	Policy	Policy	Policy	Policy
Planning	Planning	Planning	Planning (resource management)	Planning	Planning
Implementation and operation	Implementation and operation		Implementation and operation	Implementation and operation	Implementation and operation
Risk assessment	Risk assessment	Risk Assessment		Risk assessment	
Compliance and enforcement	Compliance and enforcement	Compliance and enforcement		Compliance and enforcement	
Corrective action and check	Corrective action and check		Corrective Action and check		Corrective Action and check
Internal/External auditing	Internal/External auditing	Internal/External auditing and accounting	Internal/External auditing	Internal/External auditing	Internal/External auditing
Management review	Management review	Management review	Management review	Management review	Management review

Source: Adapted from Singh, (2006)

Table 7 integrates the various management systems that exist in the workplace and points out the similarities to management of quality, environment, safety, corporate governance, social accountability and AIDS management. When organizations develop a formal and systematic approach to management of occupational health and hygiene there is likely to be significant reduction in the number of fatalities, lost time injury rates, occupational diseases rate, absenteeism rate and cost of health and safety losses (Gardiner and Harrington, 2005; Mansley, 2002). Health and safety needs to find new levers of influence to motivate organizations at boardroom level to improve health and safety. Socially responsible investment is a potentially powerful lever for health and safety which can establish an important dimension of corporate social responsibility. Good management of health and safety risks is a useful indicator of good organizational management (Mansley, 2002).

3.14 Summary of chapter

This chapter provides an overview of ISO 9001:2008, ISO 14000:2004, OHSAS 18001:2007, King III:2009, SA 8000:2008 and SANS 16001:2007. Conformance to the local and international standards is required if organizations intend trading with international organizations and achieving the goal of a triple bottom line of people, planet and profits. Conforming to international standards means placing health and safety requirements for an organization into a formal, documented and auditable system. Social accountability is based on conforming to the conventions and recommendations of the International Labour Organization. These include health and safety, working hours, freedom of association, discrimination, disciplinary practices and remuneration. The King III: 2009 Report highlights the ethical values that organizations should adhere to which include responsibility, accountability, fairness and transparency and the moral duties which includes conscience, inclusivity, competence, commitment and courage. These standards may be integrated to form SECQAS Model.

CHAPTER FOUR

LEGISLATION UNDERPINNING OCCUPATIONAL HEALTH AND SAFETY IN SOUTH AFRICA

4.1 Introduction

The Constitution of the Republic of South Africa 1996 (Act 108 of 1996), Section 24 pertains to the Environment in which it states in broad terms that everyone has the right to an environment that is not harmful to their health or well-being. The more specific and pre-existing legislation that provides credence to this section of the constitution in the occupational environment is tabled under Occupational Health and Safety, 1993 (Act 85 of 1993). In broad terms it is tabled under Section 8 of the said Act where provisions are made for the employer to take such steps as may be reasonably practicable to provide a work environment that is safe without risk to the health of its workers. In more specific terms provisions are tabled under the Noise Induced Hearing Loss Regulations of the said Act. However, these regulations make specific provisions for workers exposed to noise at or above the 85 dB(A) noise rating limit. Currently South African and international occupational health and safety legislation does not regard environmental chemicals as hazardous to hearing (Franks and Morata in Axelsson *et al*., 1996). This holds true in the South African context. The absence of provisions in the Noise Induced Hearing Loss Regulations potentially places workers at risk of chemically induced hearing loss.

The Compensation for Occupational illnesses and Diseases Act 1993 (Act 130 of 1993) makes provisions for the Compensation Commissioner to provide financial compensation to workers making claims for disability suffered during the course of employment. In the Annual Report of the Compensation fund for the year ended 31 March 2005 and 31 March 2010, the Compensation Commissioner reports that Noise Induced Hearing Loss continues to be the most frequent occupational disease and accounts for nearly 75% occupational diseases claims (Department of Labour, 2005 and 2010). This is an exceptionally high percentage and highlight the importance of the research topic. The figures in Table 8, are likely to contain both noise and chemically induced hearing loss claims, although they ostensibly only refer to the noise factor. Consequently the researcher in this study will highlight this anomaly and make recommendations to redress this situation.

Table 8:Statistics highlighting noise induced hearing loss trend

Occupational Disease	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Noise induced Hearing loss	1465	1952	2549	2724	1823	3228	2644	785	1123

Source: Department of Labour, Compensation Fund Annual Reports 2005 to 2009

The employers and the workforce in South Africa appear to be unaware that certain chemicals that are used in the rubber industry are ototoxic. Consequently employees are not afforded the protection to prevent hearing loss from chemical sources.

4.2 The South African Constitution Act 1996 (108 of 1996)

The Bill of Rights tabled under the South African Constitution Act, 1996 (108 of 1996), provides the framework within which organizations must legally operate (The King III Report, 2009). Geminiani, (2008) reiterates that Section 24 of the South African Constitution creates a constitutional foundation for the Occupational Health and Safety Act 1993 (85 of 1993). In the Bill of Rights Chapter the following clause outlines the rights of the citizens of South Africa:

Section 24: Everyone has the right –

(a) to an environment that is not harmful to their health or well-being; and through reasonable legislative and other measures that-

(i) prevent pollution and ecological degradation;

(ii) promote conservation; and

(iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

Section 24 provides for the protection of health and well-being of its citizens. Protection of health includes protection from pollution whether in the air, water, food or soil. It includes protection from dangers in the workplace, and from less noticeable dangers to health such as noise. It places a duty on the state, on business, and on all South Africans to prevent pollution and other damage to the environment and to promote conservation and sustainable development (Glazewski, 2005). Clause 24 creates a constitutional basis for the provisions of the Occupational Health and Safety Act of 1993 (Hermanus, 1999).

4.3 The Occupational Health and Safety Act, 1993 (Act 85 of 1993)

The Occupational Health and Safety Act, 1993 provides for the health and safety of persons at work, for users of plant and machinery and affords protection to persons from hazards emanating from activities of persons at work, essentially members of the public at large. Provisions are made for the establishment of an advisory council on occupational health and safety. The advisory council includes persons who represent the interest of employees such as trade unions, persons who represent the interest of employers such as employer bodies and representatives from various government departments that have interest in occupational health and safety.

The Occupational Health and Safety Act, 1993 (Act 85 of 1993) is underpinned by the definition of reasonably practicable where the following provisions shall be provided:

- Consideration shall be made on the severity and scope of the hazard or risk.
- The state of knowledge reasonably available in relation to that hazard or risk and the means of removing or mitigating that hazard or risk.
- The availability and suitability of means to remove or mitigate that hazard or risk.
- The cost of removing or mitigating that hazard or risk in relation to the benefits derived there from.

Benjamin and Thomson, (2003) maintain that in the Occupational Health and Safety Act, 1993 salient areas are:

- the Act regulates explicitly occupational health and hygiene;
- provides for re-orientation of employer's general duties so as to encourage a more active approach to the elimination or mitigation of hazards;
- extension of employer's obligations to supply workers with information on dangers present in the work environment and to provide training;
- remodels the system of health and safety representatives and committees to include trade union participation in the election of representatives, improved rights and functions for representatives and a requirement for consultation between employers and health and safety committees on safety matters;
- employers must prepare written health and safety policies when directed by the Chief Inspector;
- provides comprehensive protection of the public from safety and health hazards emanating from workplaces;

- ensures the carrying out of inquiries into accidents and other incidents that endanger health and safety; and
- provides for stringent penalties and conviction for contravention of the act and regulations.

Benjamin, (2005) points out that the principal responsibility for administering occupational health and safety legislation subsists in the Department of Labour which administers the primary preventive statutes, the Occupational Health and Safety Act, 1993 (Act 85 of 1993) and the Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993). (Benjamin, 2005). The Leon Commission recommendations led to the promulgation of the Mine Health and Safety Act, 1996 (Act 29 of 1996). The level of occupational injury and disease in the mining industry was unacceptable. Consequently recommendations for reform were made. The commission rejected arguments for a self-regulatory approach to health and safety, on the account that mines failed to effectively address occupational health and safety concerns (Benjamin, 2005). The Occupational Health and Safety Act, 1993 (Act 85 of 1993) remains unchanged and is based on the principle of self regulation, the employer in terms of Section 8, which follows is required to establish if a risk exist, and if it does exist take the necessary precautionary measures. Consequently, if the employer determines that a risk does not exist, no precautionary measures are implemented.

4.3.1 Section 8: general duties of employers to their employees

Darlow and Louw, (2003) state that this section of the Act is central to the Occupational Health and Safety Act, 1993. It embraces the employer's responsibility and accountability to the employees in its organization within the context of reasonably practicable. The employer is required to provide a working environment that is safe and without risk to the health of its employees. Darlow and Louw, (2003) indicate that this clause can be regarded as a broad health and safety policy. The employer is required to provide and maintain a system of work to ensure employees safety without risk to health.

Clause 8(2)(b) of the Occupational Health and Safety Act, 1993 (Act 85 of 1993), indicates that steps are to be taken to eliminate or mitigate any hazard or potential hazard to the safety or health of employees, before resorting to personal protective equipment. The hierarchy of control to be considered when mitigating risk commences with elimination of the hazard, substitution of the raw material, installation of engineering controls, implementation of administrative controls and as the last remedy, personal protective equipment (Smith, 2008). Plog and Quinlan, (2002) point out that engineering control are to be used as the first line of protection against workplace hazards wherever viable. Built-in protection, inherent in the design of a process is preferable to a method that depends on continual human intervention.

The employer is required to establish what hazards prevail to the health and safety of persons at the workplace and the precautionary measures taken to protect the health and safety of workers at their workplace. Darlow and Louw, (2003) suggest that the words ‘establish’ be substituted with ‘risk assessment’. Benjamin and Greef, (1997) point out that risk management is a central aspect of the Occupational Health and Safety Act, 1993. Employers are required to develop a systematic approach to the identification and control of hazards to workers as well as to members of the public who may be directly affected. Benjamin and Greef, (1997) quote Thomson and Benjamin, (1997) who state that the first priority is to avoid the risk, by designing new workplaces and processes without utilizing dangerous methods when safe or less dangerous equivalents are available. When hazards are identified in a workplace, they should be captured at the source and eliminated. However, if this is not reasonably practicable, the risk must be minimized. Collective measures to mitigate hazards that protect the entire workforce must be given preference over individual protective measures.

Personal protective equipment does not relieve an employer of its obligation to remove or mitigate hazards. At all stages there is a continuing obligation to replace the dangerous to the less dangerous and where reasonably practicable, the worker is safe from injury and risk to health (Thomson and Benjamin, 1997 cited in Benjamin and Greef, 1997).

The employer is required to provide information, instructions, training and supervision to employees with regard to health and safety at work. Work may not continue unless the stipulated precautionary measures are adhered to. Measures are to be taken to ensure compliance with the Occupational Health and Safety Act, 1993 (Act 85 of 1993), at all times. In the interest of health and safety it is vital that the employer enforces such measures as may be deemed necessary, essentially enforcing discipline in the workplace. Work performance and usage of machinery shall be under the supervision of a competent person who is *au fait* with the hazards that prevail in the workplace and as the authority to ensure that precautionary are implemented. Employees need to be informed of their scope of authority and what is expected of them at workplace which is typically a job description (Occupational Health and Safety Act, 1993). Table 9 below provides a synopsis of the salient features of the Occupational Health and Safety Act, 1993 (Act 85 of 1993).

Table 9: Synopsis of the Occupational Health and Safety Act, 1993 (Act 85 of 1993)

Provision	**Occupational Health and Safety Act, 1993**
Institution Responsible	Department of Labour, Occupational Health and Safety Directorate. Centrally controlled from the Head Office in Pretoria, via its ten Provincial Offices, Gauteng has two Provincial Offices and the rest of the country has one Provincial Office and several Labour Centres (satellite centre close to industry).
Worker Involvement	Representatives consult/negotiate/report over Occupational Health and Safety issues to the employer. No full-time Occupational Health and Safety representative prescribed.
Provision	**Occupational Health and Safety Act, 1993**
Risk Assessment	Requirement to assess risks, prevent exposures to hazards by implementing the hierarchy of controls – elimination, engineering, administrative and personal protective equipment as a last resort. The following regulations requires risk assessment to be conducted: • Hazardous Chemical Substance Regulations – Regulation 5: Assessment of Potential Exposure • Noise Induced Hearing Loss Regulations – Regulation 6: Assessment of Potential Noise Exposure
Occupational Health	Medical surveillance to be carried out by registered occupational medicine/health practitioners. Audiometric test are required for all workers employed in noise zone (areas where the noise exposure is equal to or above 85 dBA) set out in the Noise Induced Hearing Loss Regulations 8: Medical Surveillance.
Occupational Safety	Provisions are made to conduct Investigations (Section 31), Formal Inquiries (Section 32) and Joint Inquiries (Section 33) into occupational accidents and diseases.
Occupational Hygiene	Provisions are made to establish an occupational hygiene program. Hazardous Chemical Substance Regulations 6: Air Monitoring. Noise Induced Hearing Loss Regulations 7: Noise Monitoring.
Workers Rights	No explicit right to refuse dangerous work. Implied right to refuse to work in Section 14.
Trade Unions	No explicit role for trade unions.
General Duty of Care	Inclusive of employees and members of the general public who may be affected by activities (Section 8). Contractor safety and health is not the responsibility of site management but the contractor. The principal employer may contract out of the Occupational Health and Safety Act, 1993, excludes the provisions of the Construction Regulations.
Disputes	State courts. State considers merits of case, prosecutes if convinced to do so.

Source: Adapted Hermanus, (1999)

4.3.2 Noise induced hearing loss regulations

The above set of regulations was tabled by the Minister of Labour under Section 43 of the Occupational Health and Safety Act, 1993 in Government Gazette 307 on the 7th March 2003. The following sub regulations have relevance to the research undertaken: information and training, assessment of potential noise exposure, noise monitoring, medical surveillance, noise zones, control of noise exposures and hearing protective equipment.

4.3.2.1 Information and training

When employees are exposed to a noise-rating limit equal to or above a 8-hour rating level of 85 dBA (decibel on the A-weighting scale) an information and training programme needs to established. The programme will consist of the content and scope of these regulations. Berger *et al*., (2003) point out that top management should be educated, trained and motivated at the onset. The potential sources and types of noise need to be identified and pointed out. The potential risk to health and safety that may occur from noise exposure should be fully understood by employees. Typically the consequence of excessive noise exposure is partial or total hearing loss. Preventative measures are to be taken by the employer to protect the employee from the harmful effect of noise exposure.

Precautionary measure that are required from employees to protect themselves against the health risks associated with noise exposure such as the wearing and use of ear-plugs and ear muffs. Employees need to be aware of the correct use, maintenance and limitations of hearing protectors and the importance of engineering control measures. The purpose of noise monitoring and the necessity for medical surveillance should be explained to employees. The organization needs to develop a hearing conservation programme to protect employees by informing them about their responsibilities in complying with the noise rating limit. Work instructions and work procedures for reporting, correcting and replacing defective personal hearing protective devices. Refresher training on hearing conservation should be conducted annually. Mandatories or persons other than employees such as labour broker employees who may be affected by noise exposure at the workplace shall be given sufficient information, instruction and training (Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulations).

4.3.2.2 Assessment of potential noise exposure

Consideration has to be given to the source of the noise. Cognizance to be taken on the adverse health effects of excessive noise exposure to workers. Attention should be given to the duration and extent of noise exposure that employees may be exposed to. The work process and existing control measures need to be examined with a view to mitigating noise exposure (Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulations).

4.3.2.3 Noise monitoring

When the noise assessment establishes that employees may be exposed to noise at or above the noise-rating limit of 85 dBA, it then becomes incumbent on the employer to establish a noise measurement programme. Upon consultation and mutual agreement between the employer and the health and safety committee the noise measurement programme is implemented. In areas where similar activities are undertaken, at least three noise level readings which are representative of the positions occupied by employees are taken in accordance with the South African National Standard (SANS, 10083:2004), the measurement and assessment of occupational noise for hearing conservation purposes. Noise measurements are to be taken close to the workers ear to establish actual noise exposures. Results of measurements are recorded and kept for at least forty (40) years

(Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulations).

4.3.2.4 Medical surveillance

The Occupational Health and Safety Act, 1993 defines medical surveillance as the systematic planned programme of assessment and examination of workers exposed or potentially exposed to occupational stresses in the workplace. Medical surveillance entails collecting and interpreting data to identify changes in the health status of workers potentially exposed to hazardous agents in the workplace. It includes clinical examination, biological monitoring or medical test on workers. The information obtained from the medical surveillance programme is used to establish a baseline of worker's health and then monitor their future health as it indicates their potential exposure to hazardous agents (NIOSH, 2007). Workers exposed to noise at or above the noise-rating limit of 85 dBA are required to undergo medical surveillance. The medical surveillance comprises of a baseline audiogram which is recorded before commencement of employ or within thirty (30) days of commencement of such employment. Existing workers were required to have baseline audiograms conducted by the 16 November 2003.

The audiometric testing of workers is required to be conducted in accordance with the South African National Standard (SANS, 10083:2012), the measurement and assessment of occupational noise for hearing conservation purposes, paragraph 17, baseline audiometry and Circular Instruction 171 tabled under the Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993). The baseline audiogram of a worker remains as the reference for the entire working career of that worker. Subsequent to the baseline audiogram consideration to the frequency of audiometric testing may then be made periodically, annually and bi-annually. A maximum period of two years may be considered, if no referral threshold shift is evident. Referral threshold shift indicates a deviation or change for the worse from the baseline audiogram. (SANS, 10083:2012). Workers employed in noise zones where the noise exposure equals or exceeds an 8-hour rating level of 105 dBA shall undergo audiometric testing at 6-monthly intervals until it is established that no referral shift is evident and thereafter annual audiometric testing may be conducted. Upon termination of employ or transfer out of the noise zone, workers are required to undertake an exit audiometric test. The exit audiogram indicates the workers hearing status at that point of leaving the employer, consequently precludes claims of hearing loss suffered after leaving the noise zones (Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulation).

4.3.2.5 Noise zones

The Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulation, requires an employer to demarcate noise zones by means of notices in areas where the noise rating limit is equal to or above 85dBA. Workers are prohibited from entering a demarcated noise zone unless hearing protective equipment is worn. The employer is required to establish why noise exposure levels are above the noise rating limit of 85dBA and remedial action taken to reduce the noise exposure before resorting to hearing protective equipment. Berger *et al.,* (2003) argue that blanket classification of noise zones overstates the noise hazard. Therefore workers believe that the hazard is greater than it really is. Table 10, below tabulates an alternate classification system is suggested:

Table 10: Classification of time weighted average noise exposure

Time weighted average noise exposure (dBA)	**Classification**
84 or below	A
85-89	B
90-94	C
95-99	D
100 or above	E

Source Berger *et al.* (2003)

Berger *et al.,* (2003) point out that workers employed in classification A may have the discretion to be part of the hearing conservation programme. Workers employed in classification E which includes noise exposures equal to and above 100 dBA are at risk of suffering hearing loss, given that hearing protective equipment provides inadequate protection at this noise exposure level (Berger *et al.,* 2003).

4.3.2.6 Control of noise exposures

The Occupational Health and Safety Act, 1993 (Act 85 of 1993), Noise Induced Hearing Loss Regulation, states that if the noise exposure is at or above the noise-rating limit of 85dBA, other means must be identified to protect workers from the noise exposure before using personal protective equipment.

The provisions of the Noise Induced Hearing Loss Regulation stipulate that in order to reduce noise exposure the, following order of control shall be implemented:

I. Engineering control measures to eliminate or reduce noise at its source or modify the path by which noise reached the workplace;
II. Administrative control measures to limit the number of persons

exposed and the duration of exposure; and

III. The use of hearing protective equipment if engineering and administrative control measures fail to reduce noise exposure to below the noise-rating limit of 85 dBA.

Plog and Quinlan, (2002) point out that noise exposure can be split into three parts: a source that radiates sound energy; a path along which the sound energy travels, and a receiver such as the human ear. Controlling noise at the source requires modifying existing equipment and structures, and introducing noise-reduction measures at the design and commission stage of new machinery. Noise reduction along the path can be achieved by shielding or enclosing the source or by increasing the distance between the source and the receiver (Plog and Quinlan, 2002). Engineering controls reduce the noise levels at the source or in the hearing zone of workers. Administrative noise controls require a change in production and operating schedules, job rotation of workers noise exposure times. The Noise Induced Hearing Loss Regulations stipulate that only when engineering and administrative control measures cannot reduce noise exposure to below the noise-rating limit of 85 dBA, may hearing protective equipment be used. Contrary to this stipulation by legislation, industry frequently provides hearing protective equipment as the first form of control mainly on the stance that the cost to implement engineering and administrative control is excessive.

4.3.2.7 Hearing protective equipment

Hearing protective equipment is a personal safety product that is worn to decrease the damaging effects of noise. Hearing protectors are the last resort for controlling noise, after engineering and administrative control measures (Berger *et al.,* 2003). The attenuation of hearing protective equipment provided to workers shall be capable of reducing the noise exposure to below the noise-rating limit of 85 dBA (The Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulations Paragraph

12 :The South African National Standards 10083:2012; The Measurement and Assessment of Occupational Noise for Hearing Conservation Purposes, Paragraph 3. Hearing protective equipment shall be appropriately selected and properly used. Workers are required to receive the necessary information, training and supervision with regard to the use of the hearing protective equipment. Prohibit the re-use of hearing protective equipment unless the hearing protective equipment is decontaminated and sterilized. Separate storage facilities are to be provided for hearing protective equipment when not in use (Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulation).

Neitzel *et al.*, (2006) state that there are two techniques used to measure the real-world attenuation (reduction) performance of hearing protective equipment on workers. The Real-Ear-at-Threshold (REAT) technique makes psychophysical measurements of attenuation by evaluating audiometric hearing threshold levels on a worker with hearing protective equipment and without hearing protective equipment. The Microphone-in-Real-Ear ((MIRE) technique makes measurement of attenuation through the use of one microphone placed in the ear canal under the earplug and simultaneously placing a second microphone outside the ear. The difference in threshold measurement in both instances is equal to the attenuation of the hearing protective equipment. The attenuation performance of hearing protective equipment is critical to establish if workers are adequately protected from noise levels in excess of 85dBA.

4.4 Enforcement of the Occupational Health and Safety Act, 1993 (Act 85 of 1993)

Benjamin and Greef, (1997) point out that occupational health and safety legislation is inadequately enforced. This is attributed to under-resourcing of the inspectorates, the lack of enforcement policy and absence of appropriate sanctions. The inadequate numbers of inspectors, insufficient technical training and the inability to attract persons with engineering and other technical qualifications, inadequate investigations and inquiries into accidents and other dangerous occurrences, and the inefficiency of the criminal justice system as the primary mechanism in the imposition of sanctions, all contribute to a serious weakness in enforcement capacity Benjamin and Greef, (1997). The Occupational Health and Safety Act, 1993 is enforced through criminal sanctions. Criminal prosecutions have not been an effective deterrent against employers who ignore or violate occupational health and safety standards. The lack of effectiveness of criminal proceedings disempowers the inspectorate and reduces the obligation placed upon employers to improve health and safety (Benjamin and Greef, 1997). The decision to prosecute rests with the prosecuting authority and not with the Department of Labour inspectorate. Prosecution statistics supplied by the Department of Labour show that in less than one in ten cases referred to the specialist industrial prosecutors in Pretoria, prosecutions were instituted. In those instances where prosecution was instituted, the most frequent outcome was a small admission of guilt fine averaging between R735-00 and R1 145-00 (Benjamin and Greef, 1997). Prosecutors have limited knowledge of health and safety laws. Health and safety cases are frequently allocated to inexperienced prosecutors who often only receive the case on the morning of the trial leaving them unprepared for the case. This has a demoralizing and disempowering effect on the inspectorate and has led to a drop in recommended prosecutions (Benjamin and Greef, 1997).

The following fatal incidents were reported in various newspapers and appeared on specialist occupational health and safety attorneys Looch and Associates (2010) website: www.klasslooch.com:

- *Gas blast at exxaro zincor base metals kills three in Springs, Johannesburg: 10 September 2009.* An Argon gas explosion occurred in the maintenance contractors' storage area situated on the plant. Three workers were killed, five workers were hospitalized and further seven were treated for minor injuries.

- *Fire from dust explosion: 29 May 2009.* The fire that killed 13 workers at a Paarl Print factory resulted from a paper dust explosion. Build up of highly combustible paper dust in the plant caused the explosion.

- *Pretoria man drowns in paint container: 2 April 2009.* The man was working when he fell into the three by two metre paint container. The man inhaled and ingested as well as suffered chemical burns from the paint, consequently resulting in his demise.

- *5 Killed after trench collapses: 22 February 2009.* Five construction workers died in the North-Eastern Free State when the trench in which they were digging in collapsed on them. They were installing sewerage pipes, in a five metre deep excavation when the incident occurred.

- *Prohibition remains as labour inspectors probe epol fatality: 8 February 2009.* The worker was standing above a pit hole in the silo when a conveyor belt was started, resulting in the worker falling into the pit with fatal consequences.

4.5 Assmang manganese poisoning cases in Cato Ridge

It was reported in February 2007 that 30 cases of suspected manganism or manganese poisoning had been detected at the Assmang Smelter. It was suspected that workers may have been excessively exposed to manganese dust or fumes (Spadavecchia, 2007).

Kockott, (2007) maintains that owners of the Cato Ridge manganese factory Assmang planned to double production capacity and current revenue of R1,66-billion a year and increasing its work force who were apparently being poisoned by manganese fumes and dust. Ten workers were clinically diagnosed by Assmang doctors as suffering from manganism and more workers are believed to be suffering from the debilitating effects of the disease among the 700-strong Assmang labour force (Carnie, 2007). Manganism attacks the central nervous system, causing brain damage, loss of balance and memory, fitful tremors, shaky hands, slurred speech, stiffness, fatigue, impotence, difficulties in breathing or swallowing, fixed gaze or “dead-looking face”, headaches and other symptoms similar to Parkinson’s disease and multiple sclerosis. Manganese poisoning is also referred to as “manganese madness” which was first identified in Scottish manganese crushers in 1837 (Carnie, 2007). One worker died soon after he was diagnosed with manganism (Kockott, 2007 and Carnie, 2007).

Kockott, (2007) stated that the Department of Labour launched an enquiry into the manganese poisoning cases to establish if the company or its top management should be prosecuted for failing to protect its workers. The Chief Executive Officer (CEO) of Assmang was concerned about the health and safety of its workers and was investigating how the situation of its affected workers could be improved. The CEO’s strategy for the next two years included dust and fume alleviation measures costing more than R100 million. Assmang’s CEO had been unaware of medical surveillance tools to detect manganese poisoning. The occupational health and safety attorney points out that this omission provides *prima facie* evidence that there has been gross negligence in medical surveillance procedures and failure to maintain a safe and healthy workplace at Assmang (Carnie, 2007). However, the CEO defended this statement by maintaining that over the past ten years, manganese dust and fume measurements had complied with the prescribed Occupational Exposure Limit (OEL) for air, as determined by the Occupational Health and Safety Act, 1993 – Hazardous Chemical Substances Regulation.

The occupational health and safety lawyer representing the affected workers enquired from the CEO why Assmang had not subscribed to international best practice which sets limits of manganese exposure to as low as 0.3 microgram per cubic metre (mg/m^3) over an eight-hour period. The occupational health and safety lawyer enquired from the CEO, why Assmang conforms only to the Occupational Health and Safety Act, 1993 (Act 85 of 1993), requirements which allows manganese exposure of 5 microgram per cubic metre (mg/m^3) - fifteen times higher than the World Health Organization (WHO) recommendations. The lawyer inquired why complying with the South African legislation, did workers suffer manganese poisoning, and still maintain that Assmang is safe. The CEO responded by stating that Assmang endeavours to conform to South African legislation and will not always conform to the lowest (stricter) international standards (Kockott, 2007).

The occupational health and safety lawyer remarked that this was a surprising admission, considering that the CEO was unaware of the risks of neuro-toxicity from manganese but took all steps to prevent risks of exposure to manganese poisoning (Kockott, 2007). The CEO acknowledged that he had not undergone any formal training as required by the Occupational Health and Safety Act, 1993 (Act 85 of 1993), to identify potential risks and precautions that must be taken to prevent manganese poisoning. The CEO could not confirm whether any Assmang workers received training on manganese poisoning and risks associated with working with manganese (Kockott, 2007).

Carnie, (2007) reported that scores of factory workers who were shuffling about on walking sticks, congregated together to urge the Department of Labour to get to the bottom of the manganese poison scandal at Assmang smelter in Cato Ridge. The occupational health and safety lawyer maintained that it was unacceptable that more than thirty suspected cases of poisoning from manganese dust and fumes had been identified and that there were strong indications that many more people had been “simply discarded” by the company when they became ill. A social worker in the Cato Ridge area said that Assmang was directly across the road from Thor Chemicals (where several workers died or became sick from mercury poisoning more than a decade ago), and the Department of Labour now had a special responsibility to prove that it had learnt some lessons and was capable of safeguarding the health of factory workers. The occupational health and safety lawyer and trade union representatives urged workers to come forward and give evidence and make formal statements. Workers are afraid of losing their jobs, pension benefits and victimisation, therefore are reluctant to testify. The occupational health and safety lawyer maintained that it is unacceptable that a company can make people sick and not be held responsible, the lawyer urged Assmang to do the right thing (Carnie, 2007).

Carnie, (2007) reported that workers requested medical advice about the manganese levels found in their blood and whether they were adequately protected, following a prohibition notice that was served on Assmang for exceeding the regulated blood/manganese levels. Workers maintained that Assmang informed them that a level of less than 14 microgram of manganese per litre of blood (mg/l) was considered acceptable, whilst certain workers blood/manganese test revealed levels as high as 178 micrograms per litre. Elevated blood/manganese levels were an indication that the worker was required to be removed from the working environment promptly and also pointed to a breakdown in factory safety measures. Workers were dismissed on the basis that they could not walk in a straight line and were considered to be drunk. This symptom was consistent with manganese poisoning (Carnie, 2007).

The decline in occupational health and safety inspections and enforcement may have contributed to this incident. There appears to be a lack of occupational health and safety promotion and awareness. The concerns were reiterated in the Benjamin and Greef Report, (1997). Criminal proceedings are likely if *prima facie* evidence was established from the formal inquiry.

4.6 Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993)

Benjamin and Greef, (1997) maintain that the basis of the workers' compensation scheme is a trade off in terms of workers' acquired the right to compensation from a state–run compensation fund (regardless of fault) for injuries and ill health caused by work but lose the right to institute civil claims for damages against their employer. Employers on the other hand are protected against the possibility of damages claims being instituted against them, in return for the contribution they make to the Compensation Fund. The Compensation Commissioner administers the Compensation Fund for the benefit of employers. This approach neglects the fact that employees have made an equivalent contribution through the loss of their right to institute civil claims. The Fund must be administered in the interests of employers and employees (Benjamin and Greef, 1997). This trade off distinguishes worker's compensation from other forms of social insurance such as unemployment insurance, in terms of which workers do not lose any equivalent right (Benjamin and Greef, 1997).

The Compensation system in South Africa does not support effective control and prevention of health and safety hazards if their priorities are determined in isolation from those of prevention. When these priorities are jointly determined they can produce a synergy that enhances compensation and prevention (Benjamin and Greef, 1997). The Compensation Commissioner plans to promote prevention of occupational accidents, illnesses and diseases by the use of rebates and the variation of assessments (employers and workers contribution to the Compensation Fund) to promote health and safety and the use of the Compensation Fund to fund organizations that promote health and safety. These policies are not implemented in an optimal manner or as part of an integrated approach to health and safety. Rebates are given to employers in a three year cycle, similar to a no claim bonus for insurance premiums paid in a three year cycle, however it does not serve as an incentive to improve workplace safety (Benjamin and Greef, 1997).

The Compensation Commissioner should play a pivotal role in any health and safety system in the diagnosing and analysing trends in occupational accidents, illnesses and diseases. A holistic and integrative strategy is required. The carrying out of target inspections in high risk sectors of industry, improved communication strategies, identification of limitations in the regulatory framework and redressing by conducting research into these gaps. There is an absence of computer linkage between the data bases of the Compensation Office and the Occupational Health and Safety Inspectorate (Benjamin and Greef, 1997). The Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993) recognizes that a portion of the Compensation Fund should be utilized to fund preventive activities. This approach will facilitate directed expenditure on prevention activities which will reduce employer cost, improve occupational health and safety performance and reduce worker adversity (Benjamin and Greef,1997).

The Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993), provides for compensation for disablement caused by occupational injuries or diseases sustained or contracted by workers in the course of their employment or for death resulting from such injuries or diseases. Typically noise induced hearing loss is classified as an occupational disease. The Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993), Chapter VII, indicates that workers are entitled to compensation as per Section 65: Compensation for occupational diseases for hearing loss arising only from excessive exposure to noise. Chapter VI of the Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993), makes provisions for the determination and calculation of compensation, tabled under this chapter is Section 49: Compensation for permanent disablement, which equates hearing loss to an injury which is expressed has a percentage of permanent disablement as tabulated in Table 11 below:

Table 11: Classification of percentage of permanent disablement

Injury	**Percentage of permanent disablement**
Loss of hearing–both ears	50%
Loss of hearing–one ear	7%

Source: Compensation for Occupational Injuries and Diseases Act, 1993, Schedule 3

The Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993) does not distinguish amongst noise induced hearing loss, chemically induced hearing loss. Compensation for hearing loss is paid out when the compensation claim meets the requirements of Circular Instruction No 171, which is discussed below.

4.7 Circular Instruction No 171 - Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of 1993)

Circular Instruction No 171 provides for the determination of permanent disablement resulting from hearing loss caused by exposure to excessive noise and trauma. Claims for compensation from exposure to noise rating of equal to, or above 85 dBA over a number of years results in binaural (both ears) impairment of hearing. In the latter case of trauma, occupational injury is caused by blows to the head or acoustic trauma caused by exposure to acoustic energy such as explosions, gunfire or blasts.

When a worker lodges a claim for compensation, confirmation of occupational noise exposure rating of equal to, or above 85 dBA shall accompany the claim. Medical opinion is also required to confirm that the hearing loss is compatible with noise induced hearing impairment. Two audiograms conducted by the diagnostic audiologist on two separate sittings after 24 hours must elapse from the last exposure to noise. A copy of the baseline audiogram is also required. The baseline audiogram is subtracted from the better diagnostic audiogram to determine percentage loss of hearing (PLH) for each of the following frequencies: 0.5, 1, 2, 3 and 4 kHz. The frequency range for compensation claims exclude the 6 and 8 kHz which is required by the South African National Standards 10083:2012, the measurement and assessment of occupational noise for hearing conservation purposes, Paragraph 14, Audiometry. This is important since chemically induced hearing loss commences at the higher frequency range in excess of 8 kHz (Morata *et al*., 1993 and Morata *et al*., 1997).

4.8 The South African National Standards 10083:2012-the measurement and assessment of occupational noise for hearing conservation purposes

The South African National Standards 10083:2012, the measurement and assessment of occupational noise for hearing conservation purposes, is incorporated into the Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulations, equates to an additional set of regulations. The standard comprises of the measurement and rating of a working environment for hearing conservation purposes, the physical demarcation of an area where hearing conservation measures and medical surveillance have to be implemented.

4.8.1 Hearing conservation programme

The eight hour (8h) rating level should not be equal to or greater than 85 dBA.When this occurs the area must be demarcated a noise zone and hearing conservation programme must be established. The organizations layout plans and machinery used in each department are required to be labeled together with the noise rating levels. The introduction of engineering or administrative or hearing protective equipment to control noise exposure at the workplace conserves the hearing of workers. When it is not possible to reduce the noise rating limit to below 85 dBA these areas must be demarcated noise zones. All persons entering the noise zone must use hearing protective equipment, irrespective of how long they are to remain in the noise zone. Hearing protective equipment must be ergonomically suited to each worker to ensure proper fitting. Workers working in the noise zone must be issue with free of charge certified (SANS 1451-1:1991, Hearing Protectors – Part 1: Ear –Muffs, SANS 1451-2:1988, Hearing Protectors – Part 2: Ear – Ear-plugs and SANS 1451-3:1998, Hearing Protectors–Part 3: Ear–Muffs attached to an industrial safety helmet) hearing protective equipment. The use of hearing protective equipment must be supervised and monitored at all times. Information and training must be given to workers regarding the proper use and maintenance of the hearing protective equipment. Maintenance of hearing protective equipment needs to comply with the manufacturer's instructions. The cushions and seals of ear-muffs have a limited life span and should be replaced when necessary. Hearing protective equipment not in use must be stored in a dust proof container. The hearing conservation programme must be subjected to a review at intervals not exceeding two years.

4.8.2 Assessment of noise

Noise assessments are conducted to identify all workers likely to be exposed to noise at or above the noise rating limit of 85dBA for hearing conservation purposes. Information is gathered on noise sources, work practices and workplace layouts that contribute to noise exposure reductions. Establishing the effectiveness of existing noise control measures in the workplace and the appropriateness of the demarcated noise zones in protecting workers hearing is important to the hearing conservation programme. The noise assessment assists in identifying hearing protective equipment with the appropriate attenuation.

4.8.3 Determination of noise rating

The instrument used to determine the noise rating is the integrating sound level meter with a configuration that conforms to the accuracy requirements for a type 2 instrument in South African National Standards 61672-1:2003 and 61672-2:2003. The sound level meter is calibrated externally to ensure accuracy. The microphone is placed approximately 1.5m above the floor and 1.2m away from walls. The noise surveyor is required to take at least three or more readings of each work area in order to be representative of that area.

4.8.4 Pure tone audiometry

Workers exposed to a noise rating at or above 85dBA are required to undergo audiometric examination, to detect hearing changes of workers exposed to noise. Otoscopic examination is conducted on each worker prior to commencing the audiometric test. Essentially the otoscopic examination ensures that the test results are not influenced by conductive components such has ear wax, scar tissue in the ear drum or collapsed ear canals. During the otoscopic examination the workers must be questioned on previous ear surgery, head trauma, childhood diseases, or the use of ototoxic medication. The type 4 audiometer specified in IEC 60645-1: 1992 with test frequencies for pure tone audiometric tests ranging from 0.5, 1, 2, 3, 4, 6 and 8 kHz and hearing level of 70dB is required to conduct audiometric tests. The audiometer is required to be calibrated in accordance with SANS 10154-1:2004. Audiometric tests are conducted in a booth or a room that conforms with the provisions of SANS 10182:2004. Audiometric test should be preceded by at least 16h during which period workers should not be exposed to noise rating limit equal to or excess of 85 dBA.

4.9 The Draft National Occupational Health and Safety Policy and Bill, 2005

The draft policy opens with a quote from Kofie Annan, the General Secretary of the United Nations speech delivered in New York on the Worker's Memorial, 28 April 2002, "safety and health of workers is a part and parcel of human security. Safe work is not only sound economic policy but a basic human right" (Draft National Occupational Health and Safety Policy, 2005).

This draft Bill contains South Africa's national occupational health and safety policy. It is applicable to all sectors of the economy. Cabinet has decided that the institutions and laws regulating the prevention of occupational accidents and worker's compensation must be integrated and consolidated under the direction of the Minister of Labour. Loewenson, (1998) reiterates Cabinet's decision that current administrative division of inspection services, occupational health services, compensation services, mine safety and environmental health between Ministers of Labour, Health, Mines, and Environment, and between state and local government, deters a more integrated tripartite system. The King III Report, (2009) argues that the negative consequences of fragmentation include duplication of effort and missed opportunities for synergies. The development of a comprehensive occupational health and safety law that combines prevention, promotion, inspection and occupational health services roles will unify and co-ordinate the entire occupational health and safety system (Loewenson, 1998). The draft Bill gives effect to the Cabinet decision. The Bill recommends a National Occupational Health and Safety authority to administer an integrated national Occupational Health Safety system. The Bill will fulfil government's responsibility in terms of Section 24 of the Constitution to enact legislation to ensure an environment that is not harmful to health or well-being of people. The Bill gives effect to that responsibility within the workplace and protects all people from the harmful consequences of working activity.

The policy aims to reduce the number of work-related accidents and diseases in South Africa and to provide equitable compensation benefits to those who are injured in work-related accidents or who contract occupational diseases. The underpinning principles of the policy are:

- **Universal coverage** – Occupational health and safety legislation must cover workers and employers in all sectors of the economy and in all forms of employment relationship. This would include labour brokers in the capacity of employer, which is neglected area in the economy.

- **Universal application of basic rights and duties** – The basic rights and duties of employers and workers be clearly outlined in legislation.

- **The prioritization of prevention and the promotion of a culture of prevention –** The prevention of accidents and occupational diseases is a tripartite responsibility with the employer having the primary obligation for prevention measures in the workplace. The other two parties are the employees and trade unions.

- **Appropriate and fair compensation and rehabilitation benefits –** The provision of critical, accessible and equitable compensation and rehabilitation of workers in all sectors of the economy. Prompt compensation payouts are essential to sustain the quality of life of workers.

- **Application of the "polluter pays" principle –** Employers who are responsible for accidents and disease in their workplaces must bear the costs, including the cost of medical treatment, compensation and rehabilitation. Organizations that pollute the environment which adversely affects neighboring communities will be liable for the restitution of the environment to its original condition.

4.10 Magnitude of the occupational health and safety problem in South Africa

The Draft National Occupational Health and Safety Policy, (2005) makes reference to a study commissioned by the Department of Labour in 1997, on the estimated cost of occupational accidents and disease to be R17 billion, equating to 3.5% of the national Gross Domestic Product (GDP). The policy indicated that in respect of 2003 the cost was R30 billion. In view of these estimated costs of occupational accidents and diseases in 2009, this figure may be as high as R60 billion, considering the current economic crisis experienced in South Africa. Costs to employers include property damage, lost of production time, lost of skills plus the cost of employing and training replacement workers (Draft National Occupational Health and Safety Policy 2005).

Employers who employ unskilled workforces are more likely to view expenditure on Occupational Health and Safety as a cost to be avoided wherever possible. Injured and sick workers are returned to the homelands or neighboring countries with minimal compensation to be replaced by others recruited through the labour broker system. Compensation for injured workers with permanent injuries that reduce their earning capacity was inadequate and inequitable. Rehabilitation service was accessible to a limited proportion of the injured workers. The burden of occupational accidents and disease has shifted disproportionately from employers to workers and their families mainly in rural areas (Draft National Occupational Health and Safety Policy, 2005).

The Draft National Occupational Health and Safety Policy, (2005) indicates that approximately 10 000 cases of occupational disease are reported annually to the two compensation authorities. The Compensation Commissioner forms part of the Department of Labour which administers the Compensation for Occupational Injuries and Diseases Act, 1993 (Act 130 of

1993). The Compensation Commissioner for Occupational Diseases in the Department of Health administers the Occupational Diseases in Mines and Works Act, 1993 (Act 78 of 1993), which provides compensation for mineworkers who contract occupational lung diseases. Compensation claims are attributed to inadequate management of occupational risks in maintaining working environments. Occupational diseases can be eliminated by implementing effective engineering controls (Draft National Occupational Health and Safety Policy, 2005).

The growth of the Small Medium and Micro Enterprises (SMME) sector heightens occupational health and safety crises as smaller firms have been shown to have higher accident rates than larger firms in the same sector. The use of non-standard and sub-contracting arrangement and the growth of the informal sector have increased occupational health and safety problems (Draft National Occupational Health and Safety Policy, 2005, Benjamin, 2005).

4.11 Benefits of an integrated occupational health and safety system

The Draft National Occupational Health and Safety Policy, (2005) calls for improved working conditions to ensure higher labour productivity, better quality work, healthier labour relations and compliance with quality standards. The economic gains linked to occupational health and safety improvements include:

- increased productivity and workers morale;
- a reduction of working time lost due to injury and disease;
- reduced equipment down-time, reduced damage to materials and machinery, and savings in the cost of recruiting and training replacement workers;
- a reduction in transaction costs such as insurance costs and legal fee.

The Draft National Occupational Health and Safety Policy, (2005) reiterate the need for occupational health safety policy and standards for integration into the world economy. International investors who pledge to world-class occupational health and safety standards are hesitant to invest in markets in which local organizations are able to compete unfairly through reduced occupational health and safety standards. South African exporters who export to developed economies are persuaded to comply with international quality management standards in order to conduct business. These standards include ISO 9001:2008 which is the quality management system, ISO 14001:2004 which is the environmental management system and OHSAS 18001:2007 which is the occupational health and safety management system.

4.12 Overcoming institutional and policy fragmentation of occupational health and safety

The Draft National Occupational Health and Safety Policy, (2005) states that before 1994, the regulation of occupational health and safety was marked by government's lack of interest, employer neglect and widespread disregard for the fundamental rights of workers and their communities. There was minimal investment in the government agencies charged with regulating occupational health and safety. They lacked the personnel, the resources and the skills to implement effective prevention strategies.

Since 1994, government departments responsible for regulating occupational health and safety lacked the personnel, the resources and the skills to implement effective prevention strategies. Developments have not taken place in a co-ordinated framework and have intensified inconsistencies between different sectors. Responsibility for occupational health and safety remains fragmented with the result that there is a lack of co-ordination and integration of policy (National Occupational Health and Safety Policy, 2005).

Hermanus, (1999) shares a similar view that the occupational health safety system in South Africa is complex, fragmented and inter dispersed predominantly in three government departments, namely: Labour, Minerals and Energy, and Health. Table 12, illustrates the disjointed occupational health and safety systems that exist in South Africa. The three government departments have their own ministers therefore adhere to separate policies with their own *modus operandi.* Loewenson, (1998) asserts that it has proved extremely difficult to take responsibilities for occupational health and safety from one ministry and give them to another furthermore it has also been difficult to achieve co-ordination between ministers.

Table 12: South African occupational health and safety systems

Name of Government Department	**Legislation Administered by the Department**
Department of Labour (DOL)	• The Occupational Health and Safety Act 1993 • The Compensation for Occupational Diseases and Injuries Act 1993 • The Basic Conditions of Employment Act 1997 • The Labour Relations Act 1995
Department of Minerals and Energy (DME)	• The Mines Health and Safety Act 1996 • Nuclear Energy Act 1993
Department of Health (DOH)	• The Occupational Diseases in Mines and Works Act 1973 • The Hazardous Substances Act 1973
Department of Environmental Affairs and Tourism (DEAT)	• The National Environmental Management Act 1998
Department of Water Affairs and Forestry (DWAF)	• The Department of Agriculture Fertilizer, Farm Feed, Agricultural Remedies and Stock Remedies Act 1947 • The National Water Act 1998
Department of Safety and Security (DOSS)	• Explosives Act 1956
Department of Transport (DOT)	• The Aviation Act 1974 • The Merchant Shipping Act 1951 • The Road Traffic Act 1989

Source: Hermanus, (1999)

Benjamin (2008) states that South African labour legislation provides extensive labour rights to employees. The statutes that provide protection for labour are outlined in Table 13.

Table 13: Statutes and protection afforded to labour

Statute	**Labour protections**
Labour Relations Act 66 of 1995	Freedom of association, organizational rights, collective bargaining; right to strike; and protection against unfair disissal
Basic Conditions of Employment Act 75 of 1997	Hours of work, annual leave, sick leave, maternity leave, severance pay, notice pay; sectoral determinations
Employment Equity Act 55 of 1988	Anti-discrimination and affirmative action
Skills Development Act 97 of 1998	Skills development and training
Unemployment Insurance Act of 2001	Unemployment and maternity benefits
Compensation for Occupational Diseases Act 130 of 1993	Compensation for work-related injuries and diseases
Occupational Health and Safety Act 85 of 1993; Mine Health and Safety Act 29 of 1996	Health and safety in the workplace

Source: Benjamin, (2008)

Benjamin, (2008) reiterates that the only statutes that apply to working activities are the two health and safety statues that apply to all work, irrespective of the contractual provisions under which they are carried out. The formation of an integrated national occupational health and safety policy and institution is aligned to international standards and practice. South Africa has recently ratified the International Labour Organization's Occupational Health and Safety Convention 155 of 1981 which calls for governments of ratifying countries, after consultation with organized business and labour, to develop and implement a national occupational health and safety policy. The trend internationally is to establish a single authority with responsibility for determining an overall health and safety policy and harmonizing standards and legislation (Draft National Occupational Health and Safety Policy, 2005).

The Draft National Occupational Health and Safety Policy, (2005) points out that the State's constitutional responsibility to protect the environment inclusive of working environment requires it to take reasonable legislative and other measures to secure sustainable development. The formation of a national authority allows for a national occupational health and safety strategy to be adopted to prioritise major occupational health and safety problems and for resources to be utilized in the most beneficial manner.

4.13 Major occupational health and safety challenges

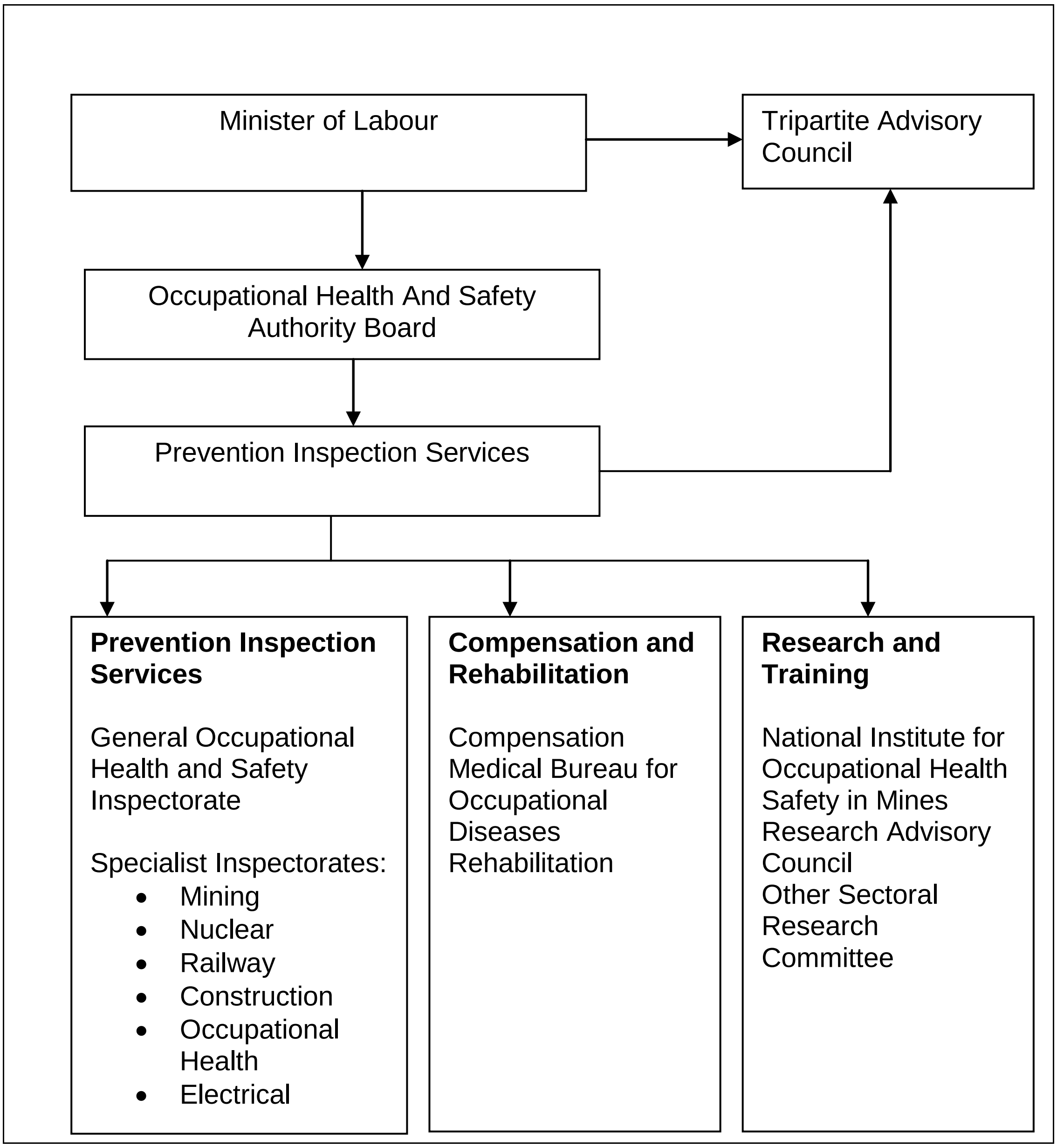
The Draft National Occupational Health and Safety Policy, (2005) argues that no institution has overall responsibility for developing and implementing occupational health and safety policies in South Africa. The principal agency responsible for prevention of work-related accidents and diseases is the Chief Directorate: Occupational Health and Safety in the Department of Labour which administers the Occupational Health and Safety Act, 1993. The Chief Directorate: Occupational Health and Safety in the Department of Labour is accountable for regulating occupational health and safety for 7.5 million workers employed in the formal sector. This Chief Directorate responsibility extends to public safety including the regulation of electrical installations in domestic and public buildings and control of major hazard installations.

The two principal occupational health and safety enforcement agencies namely the Chief Directorate: Occupational Health and Safety in the Department of Labour and the Chief Directorate: Mine Health and Safety in the Department of Minerals and Energy are located within the public service. In contrast, regulators such as the National Nuclear Regulator, the National Energy Regulator and the Rail Safety Regulator are constituted as organs of state within the public administration but outside of the public service. Their legal status is equal to that of the South African Revenue Services (SARS). Both organizations are unable to attract or retain sufficient numbers of suitably qualified and experienced staff. They are unable to offer remuneration that is comparable to that offered by the industries they regulate, consultancies or organs of state related areas. This is reflected in high turnover rates, high levels of vacancies and a lack of specialized skills. Both organizations are constrained by public service remuneration structures, however if consideration was given to increased remuneration packages for both inspectorates, retaining inspectors in the inspectorate will improve (Draft National Occupational Health and Safety Policy, 2005).

The establishment of a cohesive occupational health and safety structure will retain specialist inspectorates in hazardous sectors such as mining, nuclear, construction and railways. Figure 11, illustrates the proposed integrated occupational health and safety organizational structure. This system can operate in combination with a generalist labour inspectorate responsible for monitoring compliance with administrative aspects of occupational health and safety (Draft National Occupational Health and Safety Policy, 2005). The Draft National Occupational Health and Safety Policy, (2005) intends to promulgate national legislation to establish the national occupational health and safety authority as an organ of state located within the national public administration but outside of the public service. This administrative autonomy will enable the occupational health and safety authority to attract and retain competent staff. The principal function of the Authority will be to implement the integrated national occupational health and safety system. The Authority will consist of:

- national policy-making and standard setting authority accountable to the Minister of Labour who will be responsible for occupational health and safety for all sectors of the economy;
- a national tripartite advisory board;
- occupational health and safety inspectorate including specialist inspectorates in hazardous and technologically demanding sectors;
- compensation and rehabilitation institutions;
- dedicated research and training institutions.

Figure 11 Structure of the integrated occupational health and safety system



Source: The Draft National Occupational Health and Safety Policy (2005:20)

4.14 White paper on transformation of the health system

The need for forming a National Occupational Health and Safety Authority and legislative structure is expressed in the White Paper on Transformation of the Health System 1997. The White Paper calls for a new legislative framework where improved co-ordination of the various components of occupational health and safety is required. It suggests the formation of a co-ordinating body similar to a health and safety agency with national and provincial divisions. It may contribute towards policy-making and standard setting that are equitable, accountable and dependable.

4.15 International best practice

Internationally there has been a move to a single authority with responsibility for all health and safety policies, standards and legislation. The British Health and Safety Executive established by the 1974 Health and Safety at Work Act is a well known example of this type of authority (Draft National Occupational Health and Safety Policy, 2005). Similarly Canada, Australia, Continental Europe, Scandinavia, Zimbabwe and Namibia have single institutions responsible for occupational health and safety policies (Draft National Occupational Health and Safety Policy, 2005).

The Draft National Occupational Health and Safety Policy, (2005) claims that a close link between prevention and compensation agencies can improve prevention by integrating policy and decision-making on prevention and compensation. This may be achieved by improving the quality of information available to target occupational health and safety problem areas, and by making compensation assessments amenable to employers’ occupational health and safety performance. The financial sanctions that can be enforced *via* the compensation system can serve as an incentive for improved employer performance.

4.16 Summary of chapter

Section 24 of the South African Constitution stipulates that everyone has the right to an environment that is not harmful to their health and wellbeing. The specific legislation which enables this right is the Occupational Health and

Safety, 1993 (Act 85 of 1993), which includes the Noise Induced Hearing Loss Regulations. This legislation only makes provision for hearing loss caused from a physical noise source. The Compensation for Occupational Illnesses and Diseases Act, 1993 (Act 130 of 1993) provides for compensation for occupational injuries and occupational diseases. Provisions are only made for noise induced hearing loss. The Draft National Occupational Health and Safety Policy and Bill, 2005 may replace existing legislation. The Bill appears to be stymied in that five years have lapsed and the status remains unchanged. The inadequate enforcement of occupational health and safety legislation may be attributed to under-resourcing of inspectorate, insufficient technical and inexperienced prosecutors. The fragmentation occupational health and safety in various government departments weakens the enforcement and advocacy of occupational health safety in South Africa.

CHAPTER FIVE
RESEARCH METHODOLOGY

5.1 Introduction

Sekaran, (2003) states that studies involving in-depth, contextual analyses of an authentic environment can be classified has a field study. Field study, as a problem-solving technique is frequently not undertaken because organizations are reluctant to participate in such studies and prefer to guard proprietary data. In this field study the participating organization consented on the basis of anonymity. An opportunity was created in understanding the effect of combined exposure to chemicals and noise on workers hearing. Leedy and Ormrod, (2010) maintain that cross-sectional studies involve people from several different age groups, occupational classifications and employer types. Researchers' are able to conduct the data collection process in cross-sectional studies in shorter time frames when compared to longitudinal studies which may take several months or years to collect.

Sekaran, (2003) states that exploratory studies are undertaken to better understand the nature of a particular problem. Studies conducted to establish cause-and-effect relationships using the same natural environment in which workers normally function are described as field experiments (Sekaran, 2003). This study can be described as a cross-sectional field study into the combined effects of chemicals and noise on workers' hearing in a selected rubber industry.

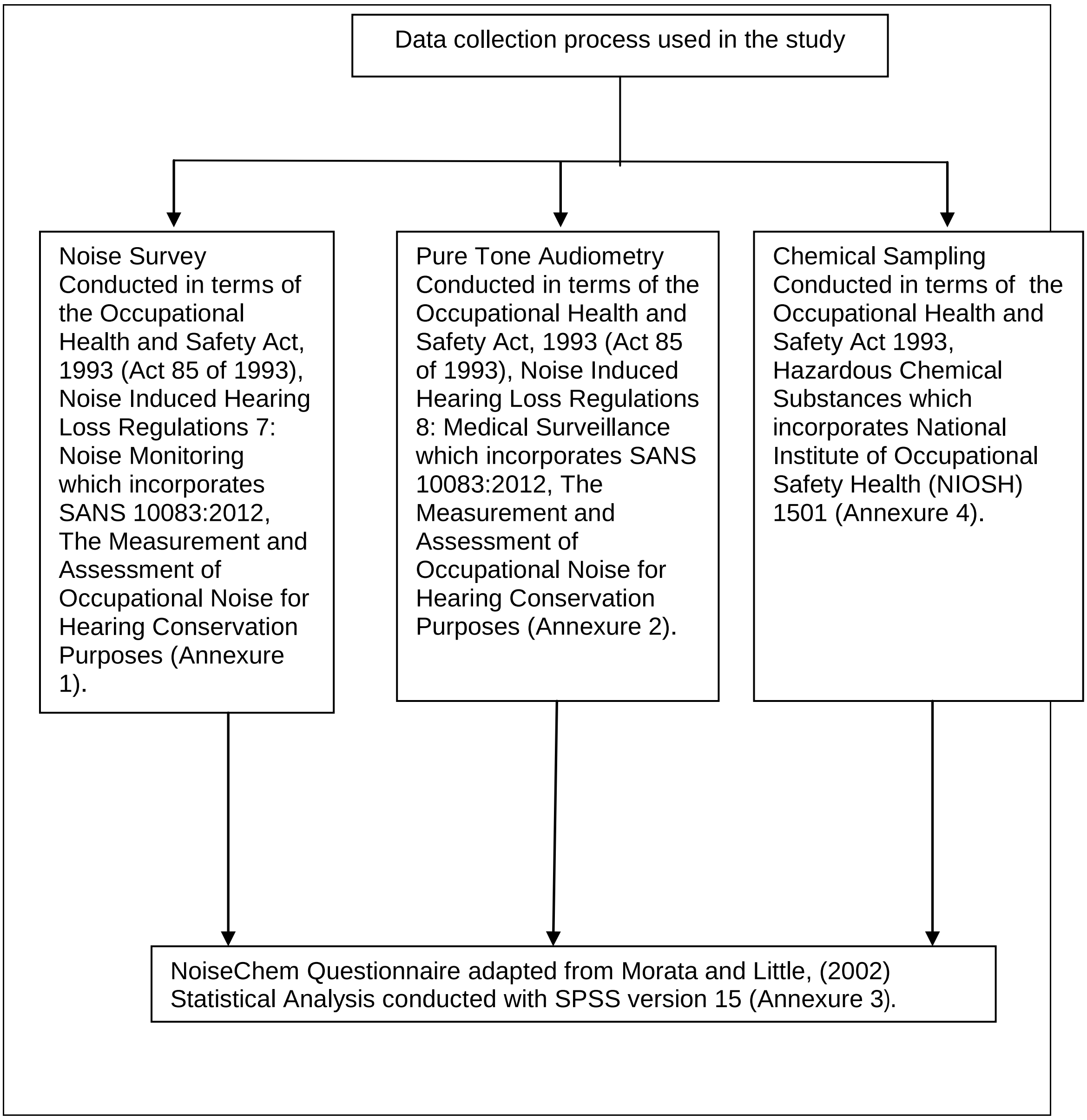
5.2 Research methodology and design

The aim of the study was to investigate the combined exposure to noise and chemicals on hearing in a selected rubber industry. The objectives of the study are:-

- determine whether co-exposure exposure to chemicals and physical noise affects workers hearing;
- identify existing human resources management practices and the impact on occupational health and safety;
- ascertain the effectiveness of the existing quality and safety management systems at the research location and
- establish the adequacy of current legislation on hearing loss arising from chemical exposure.

In view of the foregoing objectives, Figure 12, illustrates how the data collection process was undertaken to meet the study objectives. A noise survey was conducted on the entire rubber factory where the study was undertaken (refer to Annexure 1). Noise levels readings were taken and audiometric tests were conducted in accordance with Occupational Health and Safety Act, 1993 (Act 85 of 1993), Noise Induced Hearing loss Regulation 7: Noise Monitoring, and Regulation 8: Medical Surveillance respectively, which incorporates SANS 10083:2012: Chemicals samples were also taken at the workplaces in accordance with the Occupational Health and Safety Act, 1993 (Act 85 of 1993), Hazardous Chemical Substance Regulations, Regulation 6: Air Monitoring which incorporates the National Institute of Occupational Safety Health (NIOSH) 1501 method for measuring hazardous chemical substances (refer to Annexure 4). Morata and Little, (2002) compiled the NoiseChem Questionnaire which was adapted for the study (refer to Annexure 3). The NoiseChem questionnaire which included health history, work history, chemical and noise exposure, demographic data, health history (focusing on hearing), was completed by all workers participating in the study (Morata and Little, 2002). Informed consent was requested prior to commencing the data collecting process on an individual basis (refer to Annexure 9).

Figure 12: Illustration of the data collection process used in the study



5.3 Request to conduct study at the rubber manufacturing organization

The owner of the rubber factory was approached for permission to conduct the study (as per Annexure 8). Verbal permission was granted on the proviso that the factory remains anonymous. This assurance was given and during 2008 and 2009 the data collection process was completed.

5.4 Informed consent

Each participant voluntarily participated in the study by signing a consent form prior to conducting the audiometric test and completion of the NoiseChem questionnaire, (refer to Annexure 9 for sample of consent form). Participants were given the undertaking that no harm would come to them and there was no risk involved in participating in the study. Assurance was given to participants that the data collected was confidential and their jobs would not be affected by the results of the study. The objectives of the study were briefly explained to each participant on an individual basis. Essentially participants were informed that the audiometric test was to establish their current hearing status and the information required on the NoiseChem questionnaire, related to medical history pertaining to hearing, hobbies, medication taken and chronic illnesses. Informed consent is an ethical requirement which is required from participants (Babbie, 2007, Mouton, 2005, Struwig and Stead, 2007, Welman *et al*., 2005:201 and Leedy and Ormrod, 2010).

5.5 Study design

The research conducted was an exploratory cross-sectional field case study and the population was in their natural environment (Gravetter and Forzano;

2003, Sekaran 2003; Mouton, 2005; Babbie 2007). The sample in the selected rubber industry comprised of two hundred ninety seven (297) workers from a total population of four hundred and forty (440) workers (refer to Figure 12 in page 125). The entire day shift workers were recruited into the study and excluded night shift workers. These night shift workers were in the minority and constituted 32% (or 140 workers) of the workforce. The sample population constituted sixty-eight percent (68%). The sample population was split into four segments. The first segment of the sample population was workers only exposed to physical noise, the second population was workers only exposed to chemicals and the third population was workers exposed to both physical noise and chemicals and the fourth segment of the population was neither exposed to chemicals nor noise.

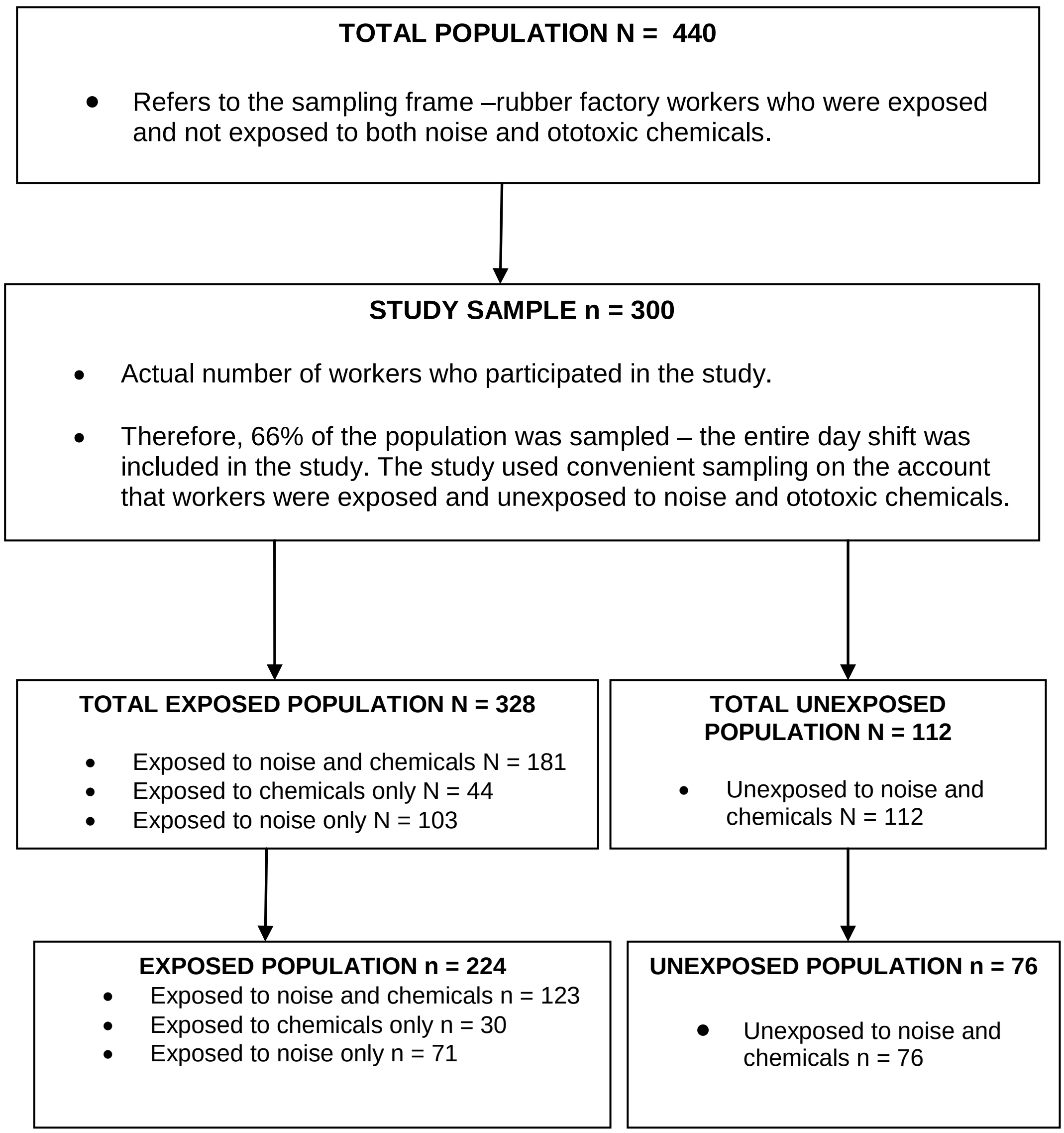
5.6 Sampling

The total population of workers in the study worked from Monday to Friday, twenty four hours per day, over two shifts with the first shift commencing at 06H00 and ending at 18H00 and the second shift commencing from 18H00 and ending at 06H00. Shift changes occurred at the end of each work week. Leedy and Ormrod, (2010) and Sekaran, (2003) state that convenience sampling indicates identifying a representative subset of a population. Convenience sampling was implemented in the study.

Watters and Biernacki, (1989), Sekaran, (2003), Leedy and Ormrod (2010), Babbie (2007) describe purposive sampling as a systematic method by which controlled lists of specified populations within the designated geographical areas are developed and detailed plans are designed to recruit adequate numbers of cases within each of the target groups. In this study the four sections of the study population were targeted and workers who were comparable of the entire study population that participated in the study.

Reference is made to both the day and night workers. Figure 13, illustrates the population hierarchy in the study.

Figure 13: The population hierarchy in the study



The sample size was based on a ten percent (10%) prevalence of hearing loss in the unexposed (no chemicals or noise) group and thirty percent (30%) in the exposed (noise or/and chemicals) group. At ninety five percent (95%) confidence and eighty percent (80%) power the required sample was seventy-one (71) per group with a total of one hundred and forty two (142). Adjustment for multivariate analysis adds ten percent (10%) to the sample size for each confounder. The confounders provided for were age, medications, family history, mode of travel, and chronic disease, consequently the sample was increased to 50% of the total workers employed, actual sample taken was three hundred (Esterhuizen 2008 and Aldous *et al*., 2011).

The World Health Organization maintains that 8.8% of manufacturing workers are exposed to noise levels of 85-90dBA (Concha-Barrientos *et al*., 2004). This indicates that at least 10% of workers in the manufacturing sector are predisposed to occupational induced hearing loss. This estimate is similar to the United States Bureau of Labor Statistics which states that hearing loss rate in the Plastics and Rubber Products Manufacturing was 11.3% in 2010 (Martinez, 2012).

5.7 Statistical analysis

Statistical analysis of the collected data was carried out with SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA) software. Descriptive statistics such as mean, standard deviation and range were used to summarize quantitative data while frequency tabulations and percentages were used to report categorical data (Pallant, 2011).

Bivariate associations between categorical exposures or confounders versus the outcomes were assessed. Means were compared between the two groups using independent t-tests.

Generalized linear regression models were used to estimate relationships between exposures to noise and chemicals and the hearing thresholds after controlling for confounding variables.

Logistic regression was used for the multivariate analysis with hearing loss serving as the categorical dependent variable and noise exposure, chemical exposure, noise plus chemical exposure and non exposure to chemical plus noise served as the independent variable. Covariates included age, taking the bus to work, high blood pressure, white finger, jaundice, colour vision problems and regularly taking painkillers were used in the regression models. The categorical dependent variable hearing loss was categorized Table 14 below:

Table 14: Classification hearing loss based on the pure-tone average

Pure-tone average in db HL (decibel Hearing Level)	**Degree of hearing loss**
< = 15	Normal hearing
16-25	Slight hearing loss
26-40	Mild hearing loss
41-55	Moderate hearing loss
56-70	Moderately severe hearing loss
71-90	Severe hearing loss
> 90	Profound hearing loss

Source: Goodman, (1965); Cahart (1945); Gelfand, (2001), Lustig *et al.,* (2003), Ackley *et al.,* (2007), Berger *et al.,* (2003), Taylor, 1965)

5.8 Research instruments used in the study

Combined exposure to chemicals and noise occur in the workplace, consequently the research instruments used in the study measured the ambient noise and chemical exposures in the work environment and on an individual worker basis. Each worker's hearing was individually tested by means of pure tone audiometry and the NoiseChem questionnaire was completed prior to the audiometric test. Table 15 shows the research instruments used in the study.

Table 15: Research instruments used in the study

Environment	Health	NoiseChem questionnaire
Conducted in the ambient work environment.	Conducted on an individual worker basis.	Conducted on an individual worker basis.
Noise Exposure Monitoring conducted in accordance with Occupational Health and Safety Act, 1993 *Instrument Used*- Sound Level Meter *Annexure 1* – Outlines the procedure to conduct noise exposure survey *Annexure 10* – Calibration certificate for the sound level meter	Audiometric testing carried on individual worker basis in accordance with Occupational Health and Safety Act, 1993 *Instrument Used* - Audiometer *Annexure 2* – Outlines procedure to conduct pure tone audiometry *Annexure 5* – Calibration certificate for the audiometer	NoiseChem questionnaire completed on individual worker basis (Morata and Little 2002:78). *Instrument Used* - NoiseChem Questionnaire Annexure 3 – NosieChem Questionnaire used in the study
Direct observations and recordings were made of the safety, environmental and quality management systems in place at the research organization		
Chemical Exposure Monitoring conducted in accordance with Occupational Health and Safety Act, 1993 *Instruments Used* - Charcoal tubes and Casella Sampling Pumps *Annexure 4* – Outlines procedure to conduct chemical sampling. *Annexure 6* – Calibration certificate for Casella pumps		

Source: Adapted from Prasher *et al.*, (2002)

5.8.1 NoiseChem questionnaire

The NoiseChem questionnaire designed by Morata and Little, (2002) was adapted and contextualized to the South African setting for the study (Annexure 3). The additions to the NoiseChem Questionnaire included questions on the category of employers/labour Brokers and the mode of transport included mini bus taxis. These were minor changes and all the original questions in the NoiseChem Questionnaire were retained. The questionnaire remained in English and four Environmental Health graduates who spoke isiZulu and English were trained by the researcher to administer the questionnaires. The designers of the questionnaire are well known world authorities in the field of ototoxicity and combined effects of physical noise and chemicals on hearing. The questionnaire was applied in studies in Europe (Sliwinska-Kowalska *et al.,* 2004) and the United States (Morata *et al.,* 2002). The questionnaire is universally accepted as reliable and valid research tool in the study of ototoxicity. The questionnaire included inquiries on present and previous work exposures to chemicals and noise, medical history, physical features, lifestyle, military service and exposure to ototoxic elements outside the work environment.

Medical history considered signs and symptoms of hearing disorders, previous ear infections, diseases and surgery, hereditary disorders, chronic diseases, head injuries and current and past medications having ototoxic potential (Sliwinska-Kowalska *et al.,* 2003). The occupational history pointed out changes in job description, place of work and the use of hearing protective equipment. The non-occupational history focused on the ototoxic factors, including previous noise exposures during army service, recreational exposures such as target shooting and hobbies such as flying miniature planes. The lifestyle section of the questionnaire identified the indulgence of research subjects which included smoking and alcohol consumption. The physical data included questions on age, height, body weight, eye and hair colour.

5.8.2 Method for estimating noise exposure

This section points out the legislation and procedural requirements used to conduct noise monitoring. Area surveys were performed to estimate noise exposure. The noise exposure was conducted in accordance with the Occupational Health and Safety Act 1993 (Act 85 of 1993), Noise Induced Hearing Loss Regulations and SANS 10083:2012. The prescribed exposure limit of 85dBA in the said regulations served as the reference limit in the study. The noise monitoring survey identified workers likely to be exposed to noise at or above the noise rating limit for hearing conservation. The noise rating limit in South Africa is 85dBA (decibel on the A-weighting Scale). The instrument used to measure the noise exposure was a type 2 integrating sound level meter. The instrument was calibrated to ensure reliability and validity. Annexure 1 outlines the procedure followed when the noise surveys were conducted. Calibration certificate for the sound level used in the study is marked Annexure 10.

5.8.3 Method for conducting pure tone audiometry

This section outlines the audiometric test procedure used in the study. Pure tone audiometry was conducted on all four groups of workers. Workers who had wax or inflammation were excluded from the study. Four Environmental Health graduates who spoke isiZulu and English were trained by the researcher to conduct ototscopic examinations and pure tone audiometry. The purpose of conducting this test was to establish the workers hearing levels. The audiometric test conducted on workers was carried out in accordance with the Occupational Health and Safety Act 1993 (Act 85 of

1993), Noise Induced Hearing Loss Regulations and SANS 10083:2012. Audiometric test were preceded by at least 16h during which period workers were not exposed to noise rating limit equal to or excess of 85 dBA. Provisions of the SANS 10083:2012 were adhered to. The audiometer was used to test workers hearing in a room that conformed to SANS 10083:2012 requirements. The audiometer was calibrated to ensure reliability and validity of the research. Annexure 2 outlines the procedures followed when the audiometric test were carried out. Calibration certificates for the audiometers used in the study are marked Annexure 5.

5.8.4 Air-sampling methods for the selected chemicals

This section outlines the air monitoring test carried out in the rubber industry. Personal air sampling was the most appropriate method of evaluating individuals' exposure to chemicals in the workplace (Plog and Quinlan, 2002, Bisesi, 2004). Exposures to chemicals are determined by task-based assessment measurements. It entails the collection of chemicals in the workplace *via* an air-sampling device worn by the worker. The sampling device was positioned as close as possible to the worker's breathing zone so data collected would closely approximate the concentration inhaled by the worker. Active monitoring with the use of air sampling pumps was carried out. The NIOSH Manual of Analytical Methods (1994) specified the analytical procedures to be adhered to (Annexure 4).

The Occupational Health and Safety Act 1993 (Act 85 of 1993), Hazardous Chemical Substance Regulations prescribed the NIOSH Manual of Analytical Methods Standards. By conforming to the NIOSH method it ensures international creditability. The instruments used in the monitoring of the chemicals were charcoal tubes attached to low flow sampling pumps which were calibrated to ensure reliability and validity. Results from the chemical monitoring survey was compared to the occupational exposure limits tabled under the Hazardous Chemical Substances Regulations, in the Occupational Health and Safety Act 1993 (Act 85 of 1993). The detailed procedure for air sampling chemicals in the workplace is marked Annexure 4. Calibration certificates for the sampling pumps used in the study are marked Annexure 6. On completion of the monitoring, the charcoal tubes were removed, sealed and sent to an approved laboratory for gas chromatography for analysis. The research location limited the breathing zone air samples to six.

5.8.5 Direct observation of the safety, environmental and quality management systems was carried out at the research location. The manufacturing process and production operation were observed in its natural setting and documentations that were permissible to be perused by the management of the research location were thoroughly examined.

5.9 Summary of chapter

The research conducted was an explorative cross-sectional field case study and the sample population were in their natural environment, Purposive sampling method was used at rubber factory where 300 workers participated in the study. The study participants were day shift workers. The sample was segmented into four groups namely workers only exposed to physical noise, workers only exposed to chemicals, workers exposed to both physical noise and chemicals and workers not exposed to chemicals or to noise. NoiseChem Questionnaire was administered to all participants in the study. Audiometric test was also carried out on all participants in the study. Noise and chemical monitoring was carried out at the research location. Data was collected in accordance to the Occupational Health and Safety Act, 1993 requirements. Statistical analysis of the collected data was carried out with SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA) software.

CHAPTER SIX

RESULTS OF RESEARCH

6.1 Introduction

This chapter presents the results of the study which was collected from the NoiseCehm Questionnaire, noise and chemical monitoring surveys, audiometric results of workers and existing human resources management practices. The data analysed the demographic profile of research subjects in terms of key variables such as race, gender and age profile.

The employment history of research subjects is presented on their risk predisposition to hearing loss impairment especially in light of their precarious labour contract with brokers. This is followed by an analysis of the different forms of ototoxic risks that research subjects are exposed to in the workplace. Volatile organic chemicals (VOCs) exposure was investigated at the research location. Exposure to noise and risk of hearing impairment measured using pure tone audiometry which highlighted potential risks that the research subjects faced within the research locality. A last set of analysis was undertaken based on confounding variables residing both within the research subjects and outside of the workplace that may potentially predispose and exacerbate hearing loss impairment. Here the research subject’s history of exposure to smoking and alcohol use, previous history of employment within a noise or chemical exposed environment, mode of transport, power tools used, recreational activities, chronic diseases and use of medication and history of physical injuries as confounding variables are analysed.

6.2 Statistical methodology

SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA) was used to analyse the data. Descriptive statistics such as mean, standard deviation and range were used to summarise quantitative data, while frequency tabulations and percentages were used to report categorical data. Bivariate associations between categorical exposures or confounders vs. the outcomes were assessed.

Means were compared amongst the four groups using independent t-tests. Generalized linear regression models were used to estimate relationships between exposures to noise and chemicals and the hearing thresholds after controlling for confounding variables. In order to control for confounding, two-block multiple logistic regression models were constructed for each definition of hearing loss as two separate outcomes. The first step contained all the confounders which were found to be significantly associated with hearing loss on bivariate analysis as independent variables, and a backwards stepwise method of model selection based on likelihood ratios was used in this block.

The second block contained the exposures of interest (noise, chemical exposure and the association between noise and chemical exposure) as independent variables, and an enter method of model selection was used in this block to force these to remain in the model. The final model was a combination of the first and second blocks. Odds ratios, p values and 95% confidence intervals were reported. A p value <0.05 was considered as statistically significant.

6.3 Demographic profile of research subjects

A population of three hundred research subjects was admitted to the study originating from one research locality. All participants in the study were day shift workers with a wide range of demographic characteristics. The vast majority of the research subjects were male (80.9%) and of African origin (83.9%) as depicted in Table 16.

Table 16: Demographic profile of research subjects

CHARACTERISTICS	N (%)
Male	242 (80.7%)
Female	57 (19%)
African	251 (83.7%)
Coloured	4 (1.3%)
Indian	33 (11.0%)
White	11 (3.7%)
Employer A	31 (10.4%)
Labour Broker B	67 (22.3%)
Labour Broker C	141 (47.3%)
Labour Broker D	59 (19.7%)
*Age	32.48 (9.68)

*Mean (Standard Deviation)

On the racial distribution of research subjects one finds that its composition reflects the same characteristics as the South African population with Africans making up the majority as shown in Table 16. One would note that a significant number (11%) of the research subjects belonged to the Indian racial category as compared to their White and Coloured counterparts. Considering that this study was conducted in the Province of KwaZulu-Natal which has a significantly higher presence of Indians as compared to all other provinces, it is expected that this racial category will be significantly represented in the study population.

It will be noted from Table 16 that a very small percentage (10.4%) of research subjects were in full time permanent employment in the study locality. The remaining comprised outsourced labour to the principal employer through the services of three labour brokers of which Labour Broker C provided almost half (47.3%) of the workforce in the study locality. Cumulatively, 89.3% of the research subjects in the study were on temporary work contracts with no permanent job benefits accruing to them. Table 16 indicates that the mean age for the research subjects was 32.48 years (SD 9.68 years) ranging from 19 to 64 years.

6.4 Consolidation of demographic variables

Demographic variables by the four categories of exposure are shown in Table.20. There was a statistically significant association between gender and exposure ($p<0.001$) where males tended to be more exposed to chemicals and females were relatively more exposed to noise. Race was also significantly associated with exposure, in that the Africans tended to be noise exposed while the other races tended to have chemical exposure. Age was also significantly associated with exposure. The noise exposed was younger than both the chemical exposed group and the unexposed group. The noise exposed group was shorter than both the chemical and noise exposed group.

Of note is that research subjects belonging to the principal employer were least (2.5%) exposed to chemical and noise ototoxic conditions. This latter finding confirms the assumption that employees originating from labour brokering arrangements within the manufacturing sector are more exposed to occupational health safety risk factors compared to those employed by companies on a permanent basis.

Table 17: Consolidated demographic variables

Demographics Characteristics		**Chemicals and noise (n=122)**		**Chemicals only (n=29)**		**Noise only (n=70)**		**Unexposed (n=76)**		**P value**
		Count	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**	
Sex	Male	104	85.2%	27	93.1%	42	60.0%	67	88.2%	<0.001
	Female	18	14.8%	2	6.9%	28	40.0%	9	11.8%	
Race	African	106	86.9%	21	72.4%	68	97.1%	55	72.4%	<0.001
	Colored	4	3.3%	0	.0%	0	.0%	0	.0%	
	Indian	9	7.4%	6	20.7%	2	2.9%	15	19.7%	
	White	3	2.5%	2	6.9%	0	.0%	6	7.9%	
Employer	Employer A	3	2.5%	8	27.6%	3	4.3%	17	22.4%	<0.001
	Labour Broker B	47	38.5%	10	34.5%	1	1.4%	8	10.5%	
	Labour Broker C	49	40.2%	7	24.1%	37	52.9%	48	63.2%	
	Labour Broker D	23	18.9%	4	13.8%	29	41.4%	3	3.9%	
Age – Mean (SD)		32	9	35	10	29	8	34	10	0.005

6.5 Chemical exposures in the workplace

In the study, half of the research subjects as depicted in Table 18 reported that they were exposed to certain ototoxic chemicals only or ototoxic chemicals in combination with occupational noise in the workplace. Within this category, a small sample of workers were tested for exposure to Volatile Organic Chemical (VOCs). A total of six highest exposed (worst-case sampling) workers were tested to form an exposure profile for Volatile Organic Chemicals (VOCs) in the study which is tabulated in Table 19. Two were employed in the occupational category of Ripping Operator that is those that apply adhesive solvents to bond rubber treads, two in the category of Buffing Operator that is those that remove excess rubber after moulding, one in the category of Painter that is those that apply solvents to the rubber treads and one as laboratory technician, that is those that test the quality of the processed rubber. Table 18 and 19 show that all four of the workers tested for volatile organic chemicals (VOCs) showed very low exposure to ototoxins and Workers A and B showed substantially high exposures for n-Hexane, well in excess of the Occupational Exposure Limits stipulated in the Occupational Health and Safety Act, 1993.

Table 18: Results for volatile organic chemicals (voc's)

Sample Taken	**Area**	**Job Title**	**Sample Type**	**Duration of Sample**	**Date**
Worker **A**	Treadline	Buffing Operator	VOC's	102 minutes	08/12/08
Worker **B**	Treadline	Ripping Operator	VOC's	102 minutes	08/12/08
Worker **C**	Treadline	Ripping Operator	VOC's	90 minutes	08/12/08
Worker **D**	Treadline	Buffing Operator	VOC's	97 minutes	08/12/08
Worker **E**	Treadline	Painter	VOC's	90 minutes	08/12/08
Worker **F**	Laboratory	Laboratory Technican	VOC's	246 minutes	10/12/08

Table 19: Results for volatile organic chemicals (voc's) continued

Chemical VOC's	**Worker A**	**Worker B**	**Worker C**	**Worker D**	**Worker E**	**Worker F**	**OHS Act 1993**
Acetone	0.245 mg/m³	0.354 mg/m³	0.716 mg/m³	0.008 mg/m³	0.008 mg/m³	0.008 mg/m³	1780 mg/m³
n-Pentane	0.5 mg/m³	0.413 mg/m³	0.008 mg/m³	0.008 mg/m³	0.45 mg/m³	0.008 mg/m³	1800 mg/m³
n-Hexane	158.833 mg/m³	134.458 mg/m³	10.458 mg/m³	2.279 mg/m³	135.5 mg/m³	0.304 mg/m³	70 mg/m³
Toluene	1.263 mg/m³	1.325 mg/m³	1.417 mg/m³	0.013 mg/m³	0.983 mg/m³	0.075 mg/m³	188 mg/m³
Ethyl benzene	0.01 mg/m³	0.00056 mg/m³	0.01 mg/m³	0.01 mg/m³	0.01 mg/m³	0.01 mg/m³	435 mg/m³
Xylene	0.01 mg/m³	0.00056 mg/m³	0.01 mg/m³	0.01 mg/m³	0.01 mg/m³	0.04 mg/m³	435 mg/m³

6.6 Noise exposure monitoring

In the study, half (50%) of the research subjects were exposed to noise levels about 85dBA in the workplace as depicted in Table 20 and Annexure 7 which contains floor plans and noise maps of the research location. The noise monitoring results tabulated below were carried out in accordance with the Occupational Health and Safety Act 1993, Noise Induced Hearing Loss Regulations, and SANS 10083:2012. There were 32 noise measurements taken throughout the factory and the actual positions are indicated in Annexure 7.

Table 20: Noise exposure results taken during the study

Areas/machinery/ processes	Measured noise levels in decibels on the a-weighting dB(A)	Existing noise control measures
Rema injection mouldings	82dB(A)	Within the legal permissible limit of 85dB(A)
Ruftil injection	83 dB(A)	Within the legal permissible limit of 85dB(A)
Stores rack	82dB(A)	Within the legal permissible limit of 85dB(A)
Dezma/rema injection	81dB(A)	Within the legal permissible limit of 85dB(A)
Crowe performer diefenbacher	83dB(A) 79dB(A) 97dB(A) 80dB(A)	Exceeds the legal permissible limit of 85 dB(A). Absence of Engineering, Administrative and Hearing Protective Equipment.
Under foot wear: Air blasting/sand blasting Grinding plastic	86dB(A) 87dB(A) 94dB(A)	Exceeds the legal permissible limit of 85 dB(A). Absence of Engineering, Administrative and Hearing Protective Equipment.
Pipe seals and plastic moulding: Battenfeld	73dB(A) 75dB(A) 76dB(A)	Within the legal permissible limit of 85dB(A)
Compression moulding	79dB(A) 81dB(A)	Within the legal permissible limit of 85dB(A)
Atlas compressor COPCO: mould Washing area	99dB(A)	Exceeds the legal permissible limit of 85 dB(A). Absence of Engineering, Administrative and Hearing Protective Equipment.
Calender and rolls: Mill/presses	82dB(A) 84dB(A) 90dB(A)	Exceeds the legal permissible limit of 85 dB(A). Absence of Engineering, Administrative and Hearing Protective Equipment.
Electrical boiler: John Thomson	80dB(A)	Within the legal permissible limit of 85dB(A)
K4 calenders Rolls/mills	80dB(A) 79dB(A) 78dB(A) 82dB(A)	Within the legal permissible limit of 85dB(A)
Trimming department: Table/GP machine/corax Mixing/Air receiver/baler/cutter/ Conveyor	75dB(A) 93dB(A) 90dB(A) 101dB(A) 91dB(A) 90dB(A) 87dB(A)	Exceeds the legal permissible limit of 85 dB(A). Absence of Engineering, Administrative and Hearing Protective Equipment.

6.7 Workers exposed to chemicals

Table 21, below shows that 50.8% of the participants were exposed to chemicals and 49.2% of the workers were unexposed to chemicals. The table indicates that the majority (64.6%) were exposed to noise levels above 85dB(A) in the workplace, whilst 35.4% were exposed to noise levels below 85 dB(A). The Occupational Health and Safety Act, 1993, Noise Induced Hearing Loss Regulations prescribes noise exposure limit of 85dBA.

It is evident that research subjects (40.7%) were exposed to both chemical and noise whereas only 23.3% and 9.7% were respectively exposed to noise and chemicals. A quarter of the research subjects (25.3%) were found not to be exposed to any forms of ototoxic hazardous substances or factors. These comprised mainly office workers located a distance away from the factory floor. Cumulatively, it may be stated that the majority (73.7%) of research subjects were exposed to some form of ototoxic hazardous substance or physical noise at the study locality. Table 21, below summarizes the exposure status of participants.

Table 21: Workers exposure to chemicals, noise and unexposed

Workers Response	Yes	%	No	%	Frequency	%
Workers exposure to chemicals	151	50.8	146	48.2		
Worker exposure to noise >or = to 85dBA	105	35.4	192	64.6		
Workers exposed to chemicals and noise					122	40.7
Workers exposed to chemicals only					29	9.7
Workers exposed to noise only					70	23.3
Workers unexposed to noise & chemicals					76	25.3

6.8 Hearing threshold by each frequency and each ear

The first objective of the study aimed to determine whether combined interaction of noise and chemical exposure affect workers hearing. Mean hearing thresholds for each ear are shown in Figures 14 and 15 by exposure. For the frequency range 0,5kHz to 1kHz the hearing loss is between mild to moderate hearing loss. For the frequency 2kHz to 8kHz there is a slight hearing loss amongst workers.

Figure 14: Mean hearing threshold by frequency in right ear

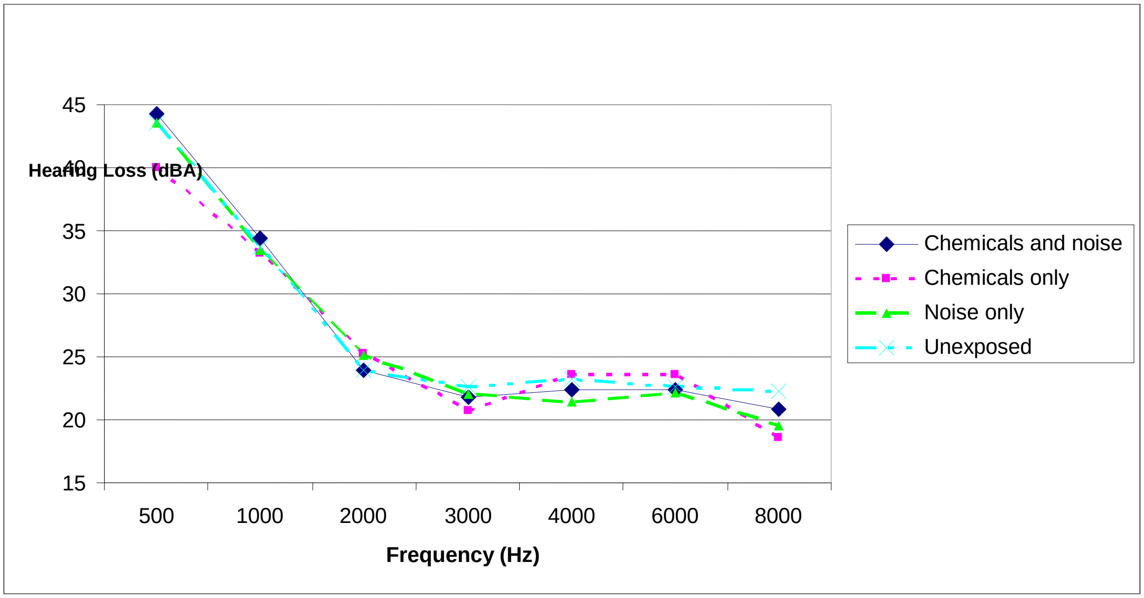
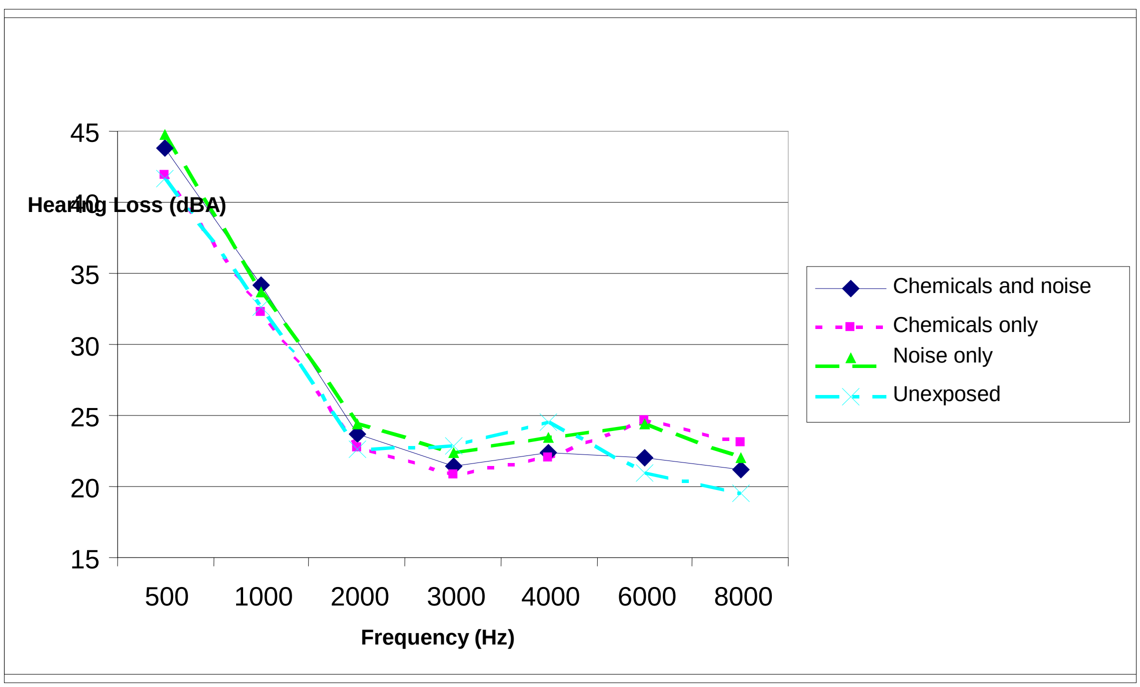


Figure 15: Mean hearing threshold by frequency in left ear



6.9 Linear models of hearing loss at each frequency and each ear

The multiple generalized linear modeling showed a positive association between age and hearing thresholds at most frequencies. Older workers showed early signs of hearing loss across all frequencies. There was an absence of association between exposure levels and hearing thresholds.

Pure tone audiometry only covers the speech spectrum: 0,5kHz, 1kHz, 2kHz, 3kHz, 4kHz, 6kHz and 8kHz considered to be the gold standard in the evaluation of hearing (Campo, 2009).The lack of baseline audiometric testing of workers in areas where the noise exposure rating exceeded the permissible limit of 85dB(A) prevents comparing baseline audiograms to audiograms taken during the study. The comparison would have determined the extent of noise induced hearing loss amongst the workers. Table 22 depicts the severity of hearing loss amongst research subjects.

The severity of hearing loss amongst research subjects are depicted in the audiogram are in accordance with the study definition of noise induced hearing loss. It will be noted from the audiogram that no research subjects were exposed to hearing threshold levels within the range of 60-65, 75-80 dB. However, when comparing the severity of hearing loss to the frequency range one finds a very small percent of research subjects in the severe to profound categories as defined in the audiogram. Nonetheless, the situation for research subjects appear serious in terms of long term hearing loss risk factors when analysing the audiogram for frequency range 4kHzHz, 6kHz and 8kHz. Within this range just more than 60% of the research subjects are at risk of suffering permanent hearing loss if they continue to have co-exposure to ototoxic chemicals and noise. It must be noted, considering that the vast majority of the research subjects are in the employ of labour brokers who engage temporary staff with a high turnover over short duration, such long term detection may not be identified and protection from the Compensation for Occupational Illnesses and Diseases Act, 1993 (Act 130 of 1993) may hardly surface considering the intermittent periods of employment.

Table 22: Factors associated with hearing loss in workers at each frequency and each ear

Frequency	Partial regression coefficients					P Value
	Age	Sex (Male)	Noise and chemical exposed	Noise exposed	Chemical exposed	
Right ear						
1KHz	-0.112*	-0.212	0.955	-0.639	0.154	0.370
2KHz	0.187*	-3.045*	0.322	1.176	1.220	0.017
3KHz	0.396*	-0.804	-0.138	-2.373	0.934	<0.001
4KHz	0.541*	-1.398	0.298	-0.162	0.357	<0.001
6KHz	0.546*	-1.560	0.836	0.414	1.622	<0.001
8KHz	0.581*	-0.222	-0.248	-4.359	-0.077	<0.001
Left ear						
1KHz	0.037	-1.644	1.643	-0.321	0.824	0.487
2KHz	0.262*	-2.483	1.438	-0.110	2.245	0.002
3KHz	0.422*	-0.869	-0.467	-2.422	1.260	<0.001
4KHz	0.615*	-1.397	-0.900	-3.100	1.407	<0.001
6KHz	-0.003	2.426	1.154	3.586	4.089	0.526
8KHz	0.043	2.357	1.837	3.494	3.414	0.676

* Statistically significant at 0.05 level

6.10 Noise induced hearing loss at 4khz at equivalent and above 25 dB bilaterally

There were 50 participants who were positive for hearing loss (16.7%) at equal to or greater than 25dB at the 4kHz frequency range, which is depicted in Table 23. The 4kHz notch is an indicator of occupational noise induced hearing loss (McBride and Williams, 2001) and the Compensation for Occupational illnesses and Diseases Act, 1993 Instruction 171 requires the Compensation Commissioner to look for a dip at this notch prior to awarding compensation for noise induced hearing loss. Early indications of hearing loss appears in the 3kHz, 4kHz and 6kHz frequency range and in this range 77 (25.7%) showed early signs of hearing loss at equal to or above 25dB. Over all frequency ranges commencing from 1, 2, 3, 4, 6 and 8kHz, it was noted that 229 (76.3%) of the participants showed early signs of hearing loss.

Table 23: Noise induced hearing loss at 4kHz at equivalent and above 25 dB bilaterally

Frequency Range of Hearing Loss	Status	Frequency	Percentage
4kHz = > 25dB	absent	246	82.0
	present	50	16.7
3,4 & 6kHz = > 25dB	absent	219	73.0
	present	77	25.7
1, 2, 3, 4, 6 and 8kHz = > 25dB	absent	67	22.3
	present	229	76.3

6.11 Hearing loss association

There was absence of association between chemical exposure and the study definition of hearing loss. Table 24 shows that the percent of affected individuals was very similar in the three exposed categories, unexposed had a higher percentage of participants with hearing loss (24%) at the 4kHz notch.

Table 24: Noise induced hearing loss at 4kHz notch at equivalent and above 25 dB in the four exposure groups

Categories of Exposure Groups		Noise induced hearing loss at 4kHz >=25 dB bilaterally		
		Absent	Present	Total
Chemicals and noise	Count	103	18	121
	% within Exposure	85.1%	14.9%	100.0%
Chemicals only	Count	24	4	28
	% within Exposure	85.7%	14.3%	100.0%
Noise only	Count	60	10	70
	% within Exposure	85.7%	14.3%	100.0%
Unexposed	Count	57	18	75
	% within Exposure	76.0%	24.0%	100.0%
Total	Count	244	50	294
	% within Exposure	83.0%	17.0%	100.0%

6.12Noise induced hearing loss at 3, 4 or 6kHz at equivalent or above 25 dB

There was also absence of association between chemical exposure and the study definition of hearing loss (p=0.621). Table 25 shows that a similar percentage of the exposed groups had hearing loss, while 32% of the non-exposed had hearing loss.

Table 25: Noise induced hearing loss at 3, 4 or 6kHz at equivalent and above 25 dB

Categories of Exposure Groups		Occupational hearing loss		Total
		Absent	Present	
Chemicals and noise	Count	92	29	121
	% within Exposure	76.0%	24.0%	100.0%
Chemicals only	Count	21	7	28
	% within Exposure	75.0%	25.0%	100.0%
Noise only	Count	53	17	70
	% within Exposure	75.7%	24.3%	100.0%
Unexposed	Count	51	24	75
	% within Exposure	68.0%	32.0%	100.0%
Total	Count	217	77	294
	% within Exposure	73.8%	26.2%	100.0%

6.13 Noise induced hearing loss from 1kHz to 8kHz at equivalent and above 25 dB bilaterally in the four exposure groups

There was absence of association between exposure and the study definition of hearing loss (p=0.502). Table 26 shows that the group with the greatest percentage of hearing loss was the noise-only exposed group (83%) while the chemical and noise exposed group had the lowest risk of hearing loss.

Table 26: Noise induced hearing loss from 1khz to 8kHz at equivalent and above 25 dB bilaterally in the four exposure groups

Categories of Exposure Groups		NIHL 1kHz to 8kHz		Total
		Absent	Present	
Chemicals and noise	Count	32	89	121
	% within Exposure	26.4%	73.6%	100.0%
Chemicals only	Count	7	21	28
	% within Exposure	25.0%	75.0%	100.0%
Noise only	Count	12	58	70
	% within Exposure	17.1%	82.9%	100.0%
Unexposed	Count	16	59	75
	% within Exposure	21.3%	78.7%	100.0%
Total	Count	67	227	294
	% within Exposure	22.8%	77.2%	100.0%

6.14 Factors affecting hearing loss

Tables 27 to 38 shows the frequencies of each of the Noisechem Questionnaire variables/potential confounders by exposure group. This section of the analysis seeks to assess whether the research subjects had any exposure to other risk factors affecting hearing prior to engaging employment service with labour brokers.

6.14.1 Smoking and alcohol intake by workers

Smoking and alcohol use were significantly associated with exposure (p=0.002 and 0.001 respectively). Unexposed people were most likely to smoke, and those exposed to chemicals only were least likely to smoke. Table 27 depicts the percentage of research subjects who smoke and use alcohol. It will be noted that a significant 32.8% of the participants reported to engage in smoking whereas more than a third 39.8% confirmed alcohol use.

Table 27: Smoking and alcohol intake by workers

		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Do you smoke	Yes	44	36.1%	3	10.3%	17	24.3%	34	44.7%	0.002
	No	78	63.9%	26	89.7%	53	75.7%	42	55.3%	
How many a day do you smoke	1-10	40	87.0%	2	50.0%	15	88.2%	27	79.4%	-
	11-20	6	13.0%	2	50.0%	2	11.8%	6	17.6%	
	21-30	0	.0%	0	.0%	0	.0%	1	2.9%	
For how many years have you been smoking	1-5	21	46.7%	0	.0%	8	47.1%	13	38.2%	-
	6-10	12	26.7%	1	33.3%	3	17.6%	9	26.5%	
	11-15	9	20.0%	0	.0%	3	17.6%	6	17.6%	
	16-20	0	.0%	1	33.3%	1	5.9%	3	8.8%	
	21-25	2	4.4%	0	.0%	0	.0%	2	5.9%	
	26-30	1	2.2%	0	.0%	2	11.8%	0	.0%	
	>=31	0	.0%	1	33.3%	0	.0%	1	2.9%	
Do you drink alcohol	yes	55	45.5%	7	25.0%	17	24.3%	40	52.6%	0.001
	no	66	54.5%	21	75.0%	53	75.7%	36	47.4%	
How often in a week do you drink	Once a week	46	82.1%	6	75.0%	15	88.2%	25	62.5%	
	2 times a week	8	14.3%	2	25.0%	0	.0%	11	27.5%	
	3 times a week	2	3.6%	0	.0%	1	5.9%	2	5.0%	
	4 times a week	0	.0%	0	.0%	1	5.9%	1	2.5%	
	> 5 times a week	0	.0%	0	.0%	0	.0%	1	2.5%	

6.14.2 Employment history of workers

Research participants previous employment exposure to noise and chemical showed that a very small percentage have employment histories of such exposures. These were primarily in the military, police and marine corps (Table 28).

Table 28: Employment history of workers

		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Did you work previously in the	Military	2	1.6%	1	3.4%	0	.0%	3	3.9%	
	Airforce	0	.0%	0	.0%	0	.0%	0	.0%	
	Navy	0	.0%	2	6.9%	0	.0%	0	.0%	
	Police Force	2	1.6%	0	.0%	1	1.4%	2	2.6%	
	None of the services	118	96.7%	26	89.7%	68	98.6%	71	93.4%	
For how many years	0-5	3	100.0%	3	100.0%	1	50.0%	4	80.0%	
	6-10	0	.0%	0	.0%	0	.0%	0	.0%	
	11-15	0	.0%	0	.0%	0	.0%	1	20.0%	
	16-20	0	.0%	0	.0%	0	.0%	0	.0%	
	=>21	0	.0%	0	.0%	1	50.0%	0	.0%	
Was your hearing affected by the service	Yes	0	.0%	0	.0%	0	.0%	0	.0%	
	No	3	100.0%	2	66.7%	1	100.0%	5	100.0%	
	Unknown	0	.0%	1	33.3%	0	.0%	0	.0%	

6.14.3 Hearing protection usage by workers

Use of hearing protection were not associated with exposure. Given that the work areas for research subjects are mainly in noise zones and the use of hearing protective equipment is compulsory when engineering and administrative controls are exhausted, the study points out that 83.8% of the research subjects were not wearing hearing protective equipment as shown in Table 29. Only 2% of the research subjects reported using some form of hearing protective equipment. Research subjects were required to provide their own hearing protective device at their personal cost. Therefore, it is understandable why the vast majority of research subjects did not use hearing protective devices thus exposing themselves to potential future hearing impairment or loss.

Table 29: Hearing protection usage by workers

		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Do you use hearing protection	Always	3	2.5%	1	3.4%	1	1.4%	3	3.9%	0.682
	Often	2	1.6%	1	3.4%	1	1.4%	1	1.3%	
	Seldom	20	16.4%	3	10.3%	4	5.7%	10	13.2%	
	Never	97	79.5%	24	82.8%	64	91.4%	62	81.6%	

6.14.4 Mode of transportation used by workers

Workers using a mini bus and motor vehicle were substantially associated with hearing loss not exposure. Those with noise and chemical and noise exposure were most likely to travel on a taxi. The chemical exposed and unexposed were most likely to travel by motor vehicle. From Table 30 it will be noted that as many as 74.2% of research subjects used mini bus taxis as a mode of transport to and from the workplace which generally play loud music. The extent to which such a mode of transport can be a confounding variable in predisposing research subjects to hearing loss or impairment can be significant.

Table 30: Mode of transportation used by workers

Mode of Transport		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Bus	yes	4	3.3%	1	3.4%	1	1.4%	4	5.3%	0.648
	no	118	96.7%	28	96.6%	69	98.6%	72	94.7%	
Mini Bus Taxi	Yes	99	81.1%	19	65.5%	59	84.3%	45	59.2%	0.001
	No	23	18.9%	10	34.5%	11	15.7%	31	40.8%	
Motor Vehicle	Yes	14	11.5%	8	27.6%	5	7.1%	18	23.7%	0.006
	No	108	88.5%	21	72.4%	65	92.9%	58	76.3%	
Motor Cycle	Yes	0	.0%	1	3.4%	0	.0%	1	1.3%	0.164
	No	122	100.0%	28	96.6%	70	100.0%	75	98.7%	
Other transport used	Yes	10	8.2%	3	10.3%	6	8.6%	13	17.1%	0.224
	No	112	91.8%	26	89.7%	64	91.4%	63	82.9%	

6.14.5 Power tools usage by workers

Exposure of research subjects to power tools rated the second highest, with a fifth (20.7%) being exposed to sound originating from power tools, which is depicted in Table 31. Given that majority of the research subjects are classified as labour broker contract workers, a great possibility exists that they engage in some other forms of income generating activity to supplement their contract wages which involves the use of power tools. Interestingly, in the work place the earlier finding suggests that half (50%) of the research subjects reported exposure to some type of volatile organic chemicals. However, when compared to outside the workplace, a significant 18.7% reported similar forms of exposure.

Table 31: Power tools usage by workers

Periods of usage of power tools		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Do you use power tools	Yes	31	25.4%	4	13.8%	8	11.4%	19	25.0%	0.073
	No	91	74.6%	25	86.2%	62	88.6%	57	75.0%	
How many times a month	1-5	12	38.7%	3	75.0%	2	25.0%	10	52.6%	
	6-10	5	16.1%	0	.0%	0	.0%	0	.0%	
	11-15	0	.0%	0	.0%	0	.0%	2	10.5%	
	16-20	1	3.2%	0	.0%	0	.0%	0	.0%	
	=>21	13	41.9%	1	25.0%	6	75.0%	7	36.8%	
For how many years	1-5	18	58.1%	2	50.0%	6	75.0%	13	68.4%	
	6-10	2	6.5%	0	.0%	2	25.0%	0	.0%	
	11-15	1	3.2%	0	.0%	0	.0%	1	5.3%	
	16-20	3	9.7%	1	25.0%	0	.0%	1	5.3%	
	=>21	7	22.6%	1	25.0%	0	.0%	4	21.1%	

6.14.6 Recreational activities of workers

In terms of the extent to which participants were exposed to power tools, musical instruments, concerts and solvents as confounding variables outside of the workplace, the percentage varied for each category as shown in Tables 32.

Exposure to high level sounds originating from concert attendance rated the highest amongst research subjects making up just below a quarter (23.1%) of the study population.

Additionally, just more than ten percent (11.4%) of the research subjects reported exposure to sounds originating from some form of musical instrument which they used outside of their workplace. This finding however, needs to be corroborated by determining the length of exposure to these confounding variables outside of the workplace in order to be more conclusive on the impact of exposure to confounders and risk of hearing loss impairment.

Table 32: Recreational activities of workers

Periods of recreational activities		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Do you play a musical instrument	Yes	10	8.2%	5	17.2%	10	14.3%	9	11.8%	0.423
	No	112	91.8%	24	82.8%	60	85.7%	67	88.2%	
How many times a month	1-5	4	40.0%	4	80.0%	8	80.0%	4	44.4%	
	6-10	0	.0%	0	.0%	1	10.0%	2	22.2%	
	11-15	1	10.0%	1	20.0%	0	.0%	1	11.1%	
	16-20	2	20.0%	0	.0%	1	10.0%	1	11.1%	
	=>21	3	30.0%	0	.0%	0	.0%	1	11.1%	
For how many years	1-5	9	90.0%	2	40.0%	9	90.0%	5	55.6%	
	6-10	0	.0%	0	.0%	1	10.0%	3	33.3%	
	11-15	0	.0%	0	.0%	0	.0%	0	.0%	
	16-20	0	.0%	0	.0%	0	.0%	0	.0%	
	=>21	1	10.0%	3	60.0%	0	.0%	1	11.1%	
Do you attend concerts, discos or night clubs	Yes	28	23.0%	5	17.2%	13	18.6%	23	30.3%	0.315
	No	94	77.0%	24	82.8%	57	81.4%	53	69.7%	
How many times a month	1-5	28	96.6%	5	100.0%	11	84.6%	23	100.0%	
	6-10	1	3.4%	0	.0%	1	7.7%	0	.0%	
	11-15	0	.0%	0	.0%	0	.0%	0	.0%	
	16-20	0	.0%	0	.0%	0	.0%	0	.0%	
	=>21	0	.0%	0	.0%	1	7.7%	0	.0%	
For how many years	1-5	23	79.3%	3	60.0%	9	69.2%	14	60.9%	
	6-10	4	13.8%	2	40.0%	2	15.4%	6	26.1%	
	11-15	0	.0%	0	.0%	1	7.7%	0	.0%	
	16-20	1	3.4%	0	.0%	0	.0%	2	8.7%	
	=>21	1	3.4%	0	.0%	1	7.7%	1	4.3%	

6.14.7 Chemical (solvent) usage by workers

Table 33 indicates that cumulatively 56 (18.7%) of the research subjects were exposed to chemicals outside the workplace. When these findings are considered cumulatively, its suggests that given the prevalence of high levels of noise and volatile organic chemicals in the workplace, coupled to the confounding variables outside of the workplace for a significant duration of time, the probability that the research subjects are at higher risks of suffering from hearing loss becomes more apparent.

Table 33: Chemical (solvent) usage by workers

Periods of exposure to solvents		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Are you exposed to solvents	Yes	28	23.0%	3	10.3%	12	17.1%	13	17.1%	0.392
	No	94	77.0%	26	89.7%	58	82.9%	63	82.9%	
How many times a month	1-5	16	57.1%	2	66.7%	11	91.7%	6	42.9%	
	6-10	2	7.1%	0	.0%	0	.0%	2	14.3%	
	11-15	0	.0%	1	33.3%	0	.0%	0	.0%	
	16-20	1	3.6%	0	.0%	0	.0%	0	.0%	
	=>21	9	32.1%	0	.0%	1	8.3%	6	42.9%	
For how many years	1-5	20	71.4%	1	33.3%	10	83.3%	11	78.6%	
	6-10	0	.0%	0	.0%	1	8.3%	2	14.3%	
	11-15	3	10.7%	0	.0%	1	8.3%	0	.0%	
	16-20	1	3.6%	2	66.7%	0	.0%	0	.0%	
	=>21	4	14.3%	0	.0%	0	.0%	1	7.1%	

6.14.8 Chronic disease history of workers

Table 34 indicates that cumulatively workers with high blood pressure were 15 (5%) and 10 (3.3%) were on medication for this condition, for cholesterol 7 (2.3%) had high cholesterol and 6 (2%) were on medication, for asthma 11 (3.7%) suffered from asthma and 6 (2%) took medication for this condition, for eczema 16 (5.4%) suffered from eczema and 7 (2.3%) were on medication for this condition and for allergies 40 (13.4%) suffered from allergies and 12 (4%) were on medication for this condition. These conditions were marginally non significant.

Table 34: Chronic disease history of workers

Chronic Disease Type		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
High blood pressure	Unknown	7	5.7%	0	.0%	1	1.4%	1	1.3%	0.054
	Yes	3	2.5%	2	6.9%	2	2.9%	8	10.5%	
	No	112	91.8%	27	93.1%	67	95.7%	67	88.2%	
Do you now or have in the past taken medication for this	Yes	2	1.7%	1	3.4%	1	1.4%	6	7.9%	
	No	112	93.3%	28	96.6%	69	98.6%	69	90.8%	
	Unknown	6	5.0%	0	.0%	0	.0%	1	1.3%	
High Cholesterol	Yes	3	2.5%	1	3.6%	1	1.4%	2	2.6%	0.808
	No	116	95.1%	27	96.4%	68	97.1%	74	97.4%	
	Unknown	3	2.5%	0	.0%	1	1.4%	0	.0%	
Do you now or have in the past taken medication for this	Yes	2	1.7%	1	3.4%	1	1.4%	2	2.6%	
	No	117	97.5%	28	96.6%	68	97.1%	74	97.4%	
	Unknown	1	.8%	0	.0%	1	1.4%	0	.0%	
Asthma	Yes	3	2.5%	3	10.3%	1	1.4%	4	5.3%	0.130
	No	119	97.5%	26	89.7%	69	98.6%	72	94.7%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	1	.8%	2	6.9%	1	1.4%	2	2.7%	
	No	118	99.2%	27	93.1%	69	98.6%	73	97.3%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
Eczema	Yes	9	7.4%	2	6.9%	2	2.9%	3	3.9%	0.511
	No	112	92.6%	27	93.1%	68	97.1%	73	96.1%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	4	3.3%	0	.0%	1	1.4%	2	2.6%	
	No	117	96.7%	28	100.0%	69	98.6%	74	97.4%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
Allergies	Yes	19	15.7%	3	10.3%	10	14.3%	8	10.5%	0.104
	No	102	84.3%	25	86.2%	60	85.7%	68	89.5%	
	Unknown	0	.0%	1	3.4%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	5	4.1%	1	3.4%	3	4.3%	3	4.0%	
	No	116	95.9%	27	93.1%	66	94.3%	72	96.0%	
	Unknown	0	.0%	1	3.4%	1	1.4%	0	.0%	

6.14.9 Chronic disease history of workers continued

Table 35 indicates that cumulatively workers suffering from migraine were 77 (25.75%) and 51 (17.1%) were on medication, for tuberculosis 13 (4.34%) were suffering from this disease and were also on medication, for kidney related problems 14 (4.68%) were suffering from kidney problems and 6 (2%) were on medication, for diabetes 7 (2.34%) were suffering from diabetes and 6 (2%) were on medication, for the condition white finger 7 (2.34%) were affected by this condition, however no medication was taken for this condition. Migraines were significantly higher in the chemical and noise (10%) and noise only (7%) exposure groups.

Table 35: Chronic disease history of workers continued

Chronic Disease Type		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Migraine	Yes	30	24.6%	11	37.9%	21	30.0%	15	20.0%	0.235
	No	92	75.4%	18	62.1%	49	70.0%	60	80.0%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	27	22.3%	8	27.6%	10	14.3%	6	7.9%	
	No	94	77.7%	21	72.4%	60	85.7%	70	92.1%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
TB	Yes	8	6.6%	0	.0%	4	5.7%	1	1.3%	0.132
	No	111	91.0%	28	100.0%	66	94.3%	74	98.7%	
	Unknown	3	2.5%	0	.0%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	8	6.7%	0	.0%	4	5.7%	1	1.3%	
	No	109	90.8%	28	100.0%	66	94.3%	75	98.7%	
	Unknown	3	2.5%	0	.0%	0	.0%	0	.0%	
Kidney problems	Yes	5	4.1%	1	3.6%	4	5.7%	4	5.3%	0.936
	No	116	95.1%	27	96.4%	66	94.3%	71	94.7%	
	Unknown	1	.8%	0	.0%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	2	1.7%	1	3.6%	2	2.9%	1	1.3%	
	No	116	97.5%	27	96.4%	68	97.1%	75	98.7%	
	Unknown	1	.8%	0	.0%	0	.0%	0	.0%	
Diabetes	Yes	3	2.5%	2	7.4%	1	1.4%	1	1.4%	0.676
	No	117	96.7%	25	92.6%	68	97.1%	72	97.3%	
	Unknown	1	.8%	0	.0%	1	1.4%	1	1.4%	
Do you now or have in the past taken medication for this	Yes	3	2.5%	2	7.1%	0	.0%	1	1.3%	
	No	116	96.7%	26	92.9%	69	98.6%	74	97.4%	
	Unknown	1	.8%	0	.0%	1	1.4%	1	1.3%	
WhiteFinger	Yes	2	1.6%	1	3.6%	2	2.9%	2	2.7%	0.906
	No	120	98.4%	27	96.4%	68	97.1%	73	97.3%	
Do you now or have in the past taken medication for this	Yes	0	.0%	0	.0%	0	.0%	0	.0%	
	No	120	100.0%	28	100.0%	70	100.0%	75	100.0%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	

6.14.10 Chronic disease history of workers continued

Table 36 indicates that cumulatively workers suffering from mumps were 15 (5%) and 11 (3.67%) were on medication for this condition, for measles 16

(5.35%) were suffering from this disease and 13 (4%) were on medication for measles, for meningitis no worker reported suffering from this condition were not on any form of medications for this disease and for the condition jaundice a marginal 3 (1%) were suffering from this condition and 2 (0,67%) were on medication for this condition. A history of mumps and measles were significantly higher in the chemically exposed (p=0.001).

Table 36: Chronic disease history of workers continued

Chronic Medication Type		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Mumps	Yes	2	1.6%	5	17.9%	1	1.4%	7	9.2%	0.001
	No	120	98.4%	23	82.1%	69	98.6%	69	90.8%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	1	.8%	2	7.1%	1	1.4%	7	9.2%	
	No	119	99.2%	26	92.9%	69	98.6%	69	90.8%	
Measles	Yes	1	.8%	4	14.3%	1	1.4%	10	13.2%	0.001
	No	121	99.2%	24	85.7%	69	98.6%	66	86.8%	
Do you now or have in the past taken medication for this	Yes	0	.0%	2	7.1%	1	1.4%	10	13.2%	
	No	120	100.0%	26	92.9%	69	98.6%	66	86.8%	
Meningitis	Yes	0	.0%	0	.0%	0	.0%	0	.0%	
	No	122	100.0%	28	100.0%	70	100.0%	76	100.0%	
Do you now or have in the past taken medication for this	Yes	0	.0%	0	.0%	0	.0%	0	.0%	
	No	120	100.0%	28	100.0%	70	100.0%	76	100.0%	
Jaundice	Yes	0	.0%	0	.0%	2	2.9%	1	1.3%	0.267
	No	121	100.0%	28	100.0%	68	97.1%	74	98.7%	
Do you now or have in the past taken medication for this	Yes	0	.0%	0	.0%	1	1.4%	1	1.3%	
	No	120	100.0%	28	100.0%	68	97.1%	73	97.3%	
	Unknown	0	.0%	0	.0%	1	1.4%	1	1.3%	

6.14.11 Historical head injuries and poisioning suffered by workers

No definitive conclusion could be made from the findings regarding other health problems such as a history of head injury, colour vision problems and a history of acute poisoning amongst research subjects can be a confounding variable in hearing loss. Colour vision problems were marginally non significantly higher in the chemical and noise exposed participants (p=0.067). What is significant from Table 37 is that 18.5% of research subjects reported having a history of head injury and 16% suffered from color vision problems, and a small number (2%) suffered from acute poisoning. Skull fractures may spare the middle ear but damage either the cochlea or eighth nerve, producing sensorineural hearing loss (May, 2000).

Research subjects history of experiencing a state of unconsciousness are depicted in Table 37. A total of 7% of the research subjects reported having a history of experiencing a state of unconsciousness. The finding suggests that a history of experiencing unconscious states coupled with workplace noise and chemical exposure can predispose research subjects to hearing loss impairment

Table 37: Historical head injuries and poisioning suffered by workers

Medical Condition		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Acute Poisoning	Yes	1	.8%	1	3.6%	1	1.4%	1	1.3%	0.736
	No	119	99.2%	27	96.4%	69	98.6%	75	98.7%	
Colour vision problems	Yes	26	21.5%	5	18.5%	9	12.9%	6	7.9%	0.067
	No	95	78.5%	22	81.5%	61	87.1%	70	92.1%	
Head injury	Yes	19	15.6%	7	25.0%	13	18.6%	16	21.1%	0.615
	No	103	84.4%	21	75.0%	57	81.4%	60	78.9%	
If yes, where you unconscious	Yes	7	36.8%	4	50.0%	5	41.7%	4	25.0%	0.641
	No	12	63.2%	4	50.0%	7	58.3%	12	75.0%	
Unconscious for how many hours	1-5	4	57.1%	3	75.0%	4	80.0%	2	50.0%	
	6-10	2	28.6%	0	.0%	1	20.0%	1	25.0%	
	11-15	0	.0%	0	.0%	0	.0%	0	.0%	
	16-20	0	.0%	0	.0%	0	.0%	0	.0%	
	=>21	1	14.3%	1	25.0%	0	.0%	1	25.0%	

6.14.12 Balance problems and medication consumption by workers

Balance problems were not associated with exposure and hearing impairments as depicted in Table 38. The study reveals that a marginal 5 (1.67%) of the research subjects have a history of difficulties maintaining their balance. With such a precondition, coupled with exposure to sound and chemicals in the workplaces the probability of predisposing these workers to further hearing impairment cannot be overlooked.

Table 38: Balance problems and medication consumption by workers

Periods of medication consumption and status of ears		Exposure								P value
		Chemicals and noise		Chemicals only		Noise only		Unexposed		
		Count	%	Count	%	Count	%	Count	%	
Any balance problems	Yes	0	.0%	1	3.6%	2	2.9%	2	2.6%	0.299
	No	122	100.0%	27	96.4%	68	97.1%	74	97.4%	
If yes, how long did the attacks last in hours	1-5	0	.0%	0	.0%	2	100.0%	2	100.0%	
	6-10	0	.0%	0	.0%	0	.0%	0	.0%	
	11-15	0	.0%	0	.0%	0	.0%	0	.0%	
	16-20	0	.0%	0	.0%	0	.0%	0	.0%	
	=>21	0	.0%	0	.0%	0	.0%	0	.0%	
Do you now or have in the past taken medication for this	Yes	0	.0%	0	.0%	2	100.0%	2	100.0%	
	No	0	.0%	0	.0%	0	.0%	0	.0%	
	Unknown	0	.0%	0	.0%	0	.0%	0	.0%	
Do you regularly take painkillers	Yes	52	43.0%	11	37.9%	37	54.4%	29	38.2%	0.210
	No	69	57.0%	18	62.1%	31	45.6%	47	61.8%	
If yes, how many per day	1-5	49	100.0%	11	100.0%	31	100.0%	29	100.0%	
	6-10	0	.0%	0	.0%	0	.0%	0	.0%	
	11-15	0	.0%	0	.0%	0	.0%	0	.0%	
	16-20	0	.0%	0	.0%	0	.0%	0	.0%	
	=>21	0	.0%	0	.0%	0	.0%	0	.0%	
For how many years	1-5	42	89.4%	8	80.0%	27	87.1%	24	82.8%	
	6-10	4	8.5%	1	10.0%	1	3.2%	4	13.8%	
	11-15	0	.0%	0	.0%	1	3.2%	1	3.4%	
	16-20	0	.0%	0	.0%	2	6.5%	0	.0%	
	=>21	1	2.1%	1	10.0%	0	.0%	0	.0%	
Are these painkillers on prescriptions	Yes	13	25.5%	1	8.3%	10	32.3%	10	37.0%	0.281
	No	38	74.5%	11	91.7%	21	67.7%	17	63.0%	
Presence of ear wax	No	103	84.4%	28	96.6%	55	78.6%	63	82.9%	0.174
	Yes	19	15.6%	1	3.4%	15	21.4%	13	17.1%	
Inflammation	No	121	99.2%	29	100.0%	70	100.0%	75	98.7%	0.758
	Yes	1	.8%	0	.0%	0	.0%	1	1.3%	

6.15 Logistic regression model and the study definition of noise induced hearing loss

Other risk factors identified which were significantly or marginally non significantly associated with the study definition of noise induced hearing loss were: age ($p<0.001$), taking the bus to work ($p=0.010$), high blood pressure (p=0.006), white finger (p=0.004), jaundice (p=0.064), colour vision problems (p=0.028), regularly taking painkillers was protective (p=0.060).

These were the variables that were entered in block 1 of the model and after a backwards selection process based on likelihood ratios, age, taking the bus and having white finger were significantly associated with the study definition of noise induced hearing loss after adjustment for the other confounders. The interaction between chemical and noise exposure showed a slight trend towards being a risk factor for hearing loss (OR 1.7) but the p value was insignificant. Chemical and noise exposure on their own were also not significantly associated with hearing loss. Table 39, below shows the logistic regression model with the variables age, transport (bus), white finger.

Table 39: Logistic regression model with the variables age, transport (bus), white finger

Covariates Risk Factors	β	Sig.	OR	95.0% C.I.for OR	
				Lower	Upper
Age	.100	.000	1.106	1.068	1.145
Bus	1.380	.066	3.973	.914	17.266
White Finger	2.034	.026	7.644	1.279	45.679
Chemical and noise exposure	.539	.512	1.714	.343	8.575
Exposed to chemicals	-.891	.185	.410	.110	1.533
Exposed to noise	-.139	.780	.870	.328	2.310
Constant	-4.921	.000	.007		

β - Beta coefficient for each independent variable, Sig - Significant P Value, OR – Odds Ratio, 95% CI - Confidence Interval

6.15.1 Odds ratio of hearing loss

Logistic regression was used to evaluate the association between hearing loss and risk factors such as exposure to chemicals and noise independently and co-exposure. Covariates such as age, taking the bus to work, high blood pressure, white finger, jaundice, colour vision problems and regularly taking painkillers were used in the regression models. After a backwards selection process using the likelihood ratio test, age, taking the bus and having white finger were found to be significant covariates and were included in the final model.

Co-exposure to chemicals and noise showed a slight trend towards being a risk factor for hearing loss with an odds ratio of 1.7 (95% CI = 0.34 - 8.57, p = 0.512). No significant association with hearing loss was evident for workers exposed to chemical only with odds ratio of 0.41 (95% CI = 0.11 – 1.53, p = 0.19) and noise only with odds ratio of 0.87 (95% CI = 0.32 – 2.31, p = 0.78), is shown in Table 39.

6.16 Adequacy of current legislation on hearing loss acquired through chemical exposure

Existing occupational health and safety legislation applicable to the rubber manufacturing industry was evaluated. The legislation that is applicable is the Occupational Health and Safety Act, 1993 (Act 85 of 1993) inclusive of regulations. Table 40 and 41 below outlines the existing provisions and shortcoming thereof for the Hazardous Chemical Substances Regulations and Noise Induced Hearing Loss Regulations:

Table 40: Current legislation on hearing loss acquire through chemical exposure

Occupational Health and Safety Act, 1993		
Regulation	**Hazardous Chemical Substances Regulations**	**Provisions for chemical induced hearing loss**
5	**Assessment of Potential Exposure** An immediate assessment is required for workplaces using hazardous chemical substances where workers could be potentially exposed.	Provisions are silent on ototoxic properties of hazardous chemical substances.
6	**Air Monitoring** Where there is a risk of hazardous chemical substances being inhaled, it becomes incumbent on the employer to put a measurement programme for the airborne concentrations of hazardous chemical substances.	Measurement programme does not consider ototoxic properties of the hazardous chemical substances
7	**Medical Surveillance** Workers exposed to hazardous chemical substances that are listed in Table 3 of the Hazardous Chemical Substance regulations and have a listed Biological Exposure Index in the regulation are required to be under medical surveillance.	No provisions are made for audiometric testing of workers who are exposed to ototoxic chemicals.

Table 41: Current legislation on hearing loss acquire through chemical exposure continued

Occupational Health and Safety Act, 1993 Continued		
Regulation	**Noise Induced Hearing Loss Regulations**	
6	**Assessment of potential noise exposure** All workplaces where it is considered that workers may be exposed to noise at or exceeding 85dBA should be assessed.	No provisions are made for ototoxic chemical assessment.
7	**Noise Monitoring** When the noise assessment indicates the noise exposure is at or above 85dBA, noise measurement programme is required for noise exposure at the workplace.	No provisions are made for ototoxic chemical monitoring.
8	**Medical Surveillance** Medical surveillance is required for workers exposed to noise at or above 85dBA.	No provisions are made for medical surveillance of workers exposed to ototoxic chemicals.
9	**Noise Zone** Workplaces where exposure to noise is at or above 85dBA are required to be zoned as a noise zone.	No provisions are made for ototoxic chemical that may be present in the workplace.

6.17 Effectiveness of existing quality and safety management systems

The research organization held certification for the Occupational Health and Safety Assessment Series (OHSAS) 18001:2007, ISO (the International Organization for Standardization) 14001:2004 and ISO 9001:2008. The certification was confined to the principal employer exclusive of all labour brokers and labour broker workers.

6.17.1 Policy Statement

The research organization had an organizational policy statement addressing the environmental and quality management intention of the organization. However, health and safety was omitted from the policy. The study organization's policy delimited the scope of the policy to apply only to the principal employer thus excluding all labour brokers on site. Each labour broker was considered to be a service provider to the principal employer was excluded from the policy statement. Table 42 below indicates the integration of the environmental, quality and safety policy statements clauses.

Table 42: Integrated policy statement

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.2	Occupational Health and Safety policy	4.2	Environmental policy	5.3	Quality policy

6.17.2 HIRA, environmental aspects customer focus

The hazard identification and risk assessment was outsourced to an Approved Inspection Authority (AIA) which conducted the risk assessment and provided a report of the findings. The recommendations made in the report were not implemented. Legal compliance was partially attained by the employer.

Environmental aspects of the research location were identified and mitigation measures were installed to reduce the environmental impacts. Scrubbers and bag filters were in place to reduce air emissions. Storm water and oil spillages were directed to three tier sumps thus preventing oil entering into the storm water outlet. Adherence to these requirements were mainly undertaken to conform to the municipal trade permit. Waste was segregated into plastics, rubber, cardboards, metals, and wood.

The research organization adhered to customer requirements and placed greater emphasis on international customers than on local customers for financial reasons. Table 43, shows the HIRA, environmental aspects and customer focus of the research organization.

Table 43: HIRA, environmental aspects and customer focus

Clause	**OHSAS 18001:2007**	**Clause**	**ISO 14001:2004**	**Clause**	**ISO 9001:2008**
4.3.1	Hazard identification, risk assessment and determining controls	4.3.1	Environmental aspect	5.2	Customer focus

6.17.3 Legal and other requirements

Legal registers were kept by the research location for occupational health and safety and environmental legislation. Legal specialist was engaged by the research location to maintain these registers. Pressure vessels which included the John Thomson Boiler and air compressor were inspected, examined and tested under pressure as prescribed by the Occupational Health and Safety Act, 1993. Health and safety representatives were appointed from the principal employer’s staff compliment. Health and safety committee included only these representatives. Provisions of Section 37 (2) of the Occupational Health and Safety Act 1993 was used to exclude the labour brokers at the research location. Table 44, below shows the legal clauses and product requirement in OHSAS 18001:2007, ISO 14001:2004 and ISO 9001:2008.

Table 44: Legal and other requirements

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.3.2	Legal and other requirements	4.3.2	Legal and other requirements	5.2 7.2.1	Customer focus Determination of requirement related to the product

6.17.4 Objectives and targets

The research organization set objectives to reduce the number of incidents, increase the number of near miss reports and carried out occupational hygiene surveys as prescribed by legislation. Environmental aspects and impacts objectives were set and included scheduled stack emission and waste effluent testing. Quality objectives focused on the testing of raw materials on arrival, monitoring the production process by drawing samples and testing the product at each stage was comprehensively undertaken by the research location to ensure continuous improvement. Quality objective improved customer satisfaction which increased sales nationally and internationally. Table 45 shows the objectives and targets clauses in OHSAS 18001:2007, ISO 14001:2004 and ISO 9001: 2008.

Table 45: Objectives and targets

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.3.3	Objectives	4.3.3	Objectives and targets	5.4.1	Quality objectives

6.17.5 Organizational structure and responsibilities

Management at the research organization made provisions for human resources, specialized skills, organizational infrastructure and financial resources for quality, environment and safety. There was a dedicated quality and environmental manager whilst safety was outsourced to an external service provider. Organizational structure was illustrated on an organizational chart clearly outlining roles, responsibilities and protocols adhering to OHSAS 18001:2007, ISO 14001:2004 and ISO 9001: 2008. Table 46, shows the required organizational structure and responsibilities for each standard.

Table 46: Organizational structure and responsibilities

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.4.1	Resources, roles, responsibility, accountability and authority	4.4.1	Resources, roles, responsibility and authority	5 6	Management responsibility Resource management

6.17.6 Training, awareness and competence

Training awareness sessions were carried explaining the importance of the quality, safety and environmental management systems in the manufacturing process. Both management and employees responsibilities were described to gain commitment and alignment to the organizations quality, environmental and safety policies. Compliance to regulatory requirements was included in the training programme for forklift operators licence and first aid certificate. Training, awareness and competence requirements stipulated in Table 47 were conformed to.

Table 47: Training awareness and competence clause

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.4.2	Competence training and awareness	4.4.2	Competence training and awareness	6.2.2	Competence, awareness and training

6.17.7 Consultation and communication

The research organization had a documented procedure for internal and external consultation and communication with interested and affected parties. At the factory floor level consultation and communication took place with the representatives from each labour broker individually. Consultation and communication was limited to the principal employer's personnel. Table 48 shows the requirement for consultation and communication in OHSAS 18001:2007, ISO 14001:2004 and ISO 9001:2008 below which were satisfied to a certain extent.

Table 48: Consultation and communication

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.4.3	Consultation and communication	4.4.3	Communication	7.2.3	Customer communication

6.17.8 Control of documents

Quality, safety and environmental procedures for controlling all documents pertaining to the three management systems were in place. The location of documents and when they were last reviewed were recorded in the procedures. Provisions were made to keep all current versions available and the removal of obsolete documents from the system or appropriately stamped obsolete. Controlled documents were available at terminals on the factory floor with read only access. Table 49, below points out the control of documents in OHSAS 18001:2007, ISO 14001:2004 and ISO 9001:2008.

Table 49: Control of documents

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.4.5	Control of documents	4.4.5	Control of documents	4.2.3	Control of documents

6.17.9 Operation control

The research organization's management identified operational control measures for activities that presented potential risk to safety, environment and quality are depicted in Table 50. Labour brokers and contractors carrying out operations for the research organization were bound by their respective contracts to follow the prescribed operational controls in order to maintain the safety, quality and environmental objectives and targets of the research organization. Procedures and instructions were in place to ensure the consistent quality of the final products throughout the manufacturing process.

Table 50: operational control

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.4.6	Operation control: • Purchased goods, equipment and services • Contractors and visitors to the workplace	4.4.6	Operation control: Establishing procedures for identified environmental aspects and communicating the requirements to suppliers, including contractors	7 7.1 7.2 7.3 7.4 7.5	Product realization Planning of product realization Customer related process Design and development Purchasing Production and service provision

6.17.10 Emergency preparedness and control of non conforming product

Procedures were in place to deal with potential emergency situations and potential accidents that could impact on the safety, environment and quality organization relevant clauses are depicted in Table 51. The research organization periodically reviewed emergency preparedness and response procedures after incidents and emergency situations. Emergency services close to the research organization conducted inspections at the research location to determine the appropriate method for responding to an accident and emergency situation. Fire-fighting equipment were checked for availability and suitability.

Table 51: Emergency preparedness

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.4.7	Emergency preparedness and response	4.4.7	Emergency preparedness and response	8.3	Control of nonconforming product

6.17.11 Management review

Minutes of the management review meeting were deemed to be confidential by management from the research location consequently were not available for examination. The relevant clauses are shown in Table 52, below.

Table 52: Management review

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.6	Management review	4.6	Management review	5.6	Management review

6.18 Summary of chapter

The co-exposure to chemicals and noise showed a slight trend towards being a risk factor for hearing loss with an odds ratio of 1.7 (95% CI = 0.34 - 8.57, $p = 0.512$). No significant association with hearing loss was evident for workers exposed to chemical only with odds ratio of 0.41 (95% CI = 0.11 – 1.53, $p = 0.19$) and noise only with odds ratio of 0.87 (95% CI = 0.32 – 2.31, $p = 0.78$). The principal employer only employed 10.4% of the study population whilst the vast majority 89.6% was employed by three separate labour brokers who were individually responsible for their own occupational health and safety. The integrated quality, environment and safety management systems were in place at the research location. Current legislation on hearing loss caused by ototoxic chemicals was inadequate in preventing and protecting workers in the rubber industry.

CHAPTER SEVEN

DISCUSSION OF RESEARCH RESULTS

7.1 Introduction

The study investigated the combined exposure to noise and chemicals on hearing in a selected rubber industry in Durban. Workers participating in the study provided informed consent and completed an adapted NoiseChem Questionnaire. Four Environmental Health Diploma graduates who were bilingual in English and Zulu administered the NoiseChem Questionnaire. The human resource management practice of the research organization was included in the NoiseChem Questionnaire. The organizations' existing quality, environment, health and safety management were directly observed during the investigation. The adequacy of current legislation on hearing loss was reviewed and deficiencies in respect of provisions for chemical induced hearing loss were identified. The cross-sectional field study results are discussed below.

7.2 Demographic Profile of Research Subjects

Majority of the research subjects were African males. Indians, Whites and Coloureds made up the remainder of the research subjects. Females were in the minority. Given that the research locality and the sensitivity surrounding the study, the under representation of the different race and gender groups is not perceived as a limitation when formulating conclusions from the findings. Caucasian males have poorer auditory thresholds and higher prevalence of noise induced hearing loss while African American females have the lowest prevalence of hearing loss (Driscoll and Royster, 1984). Race and susceptibility to noise could be attributed to the protective role played by the presence of melanine in the inner ear (Barrenas and Lindgren, 1991).

The justification for such an argument, is that the concept of labour brokering based on profiteering at the expense of worker well being transcends race and gender variables. It is founded on the basis of a willing worker wanting to enter into a specified contractual agreement with the broker. Hence it is alluded that the findings holds validity for workers irrespective of race and gender provided that they are exposed to the same occupational health hazard as tested for in this study. However, what the study accedes to is the significant diversity of physical characteristics based on age, weight and height that may have a bearing on the extent to which exposure to noise and ototoxic substance will have on hearing loss impairment amongst the research subjects. These variables although not tested for extensively in this study incorporated research subjects from a diverse ranges of age, weight and height categories which were analysed cumulatively which enhances the strength and quality of analysis.

The under-representation of women in the study is in keeping with the general trends in the labour market as very few of them are known to enter occupations demanding direct factory floor participation although certain occupational categories such as the clothing and textile sector may attract more females compared to males. Another reason for such a trend may lend itself to the observations made by Horton and Langhinnerich, (2002) who assert that women prefer more part-time work as it enables them to balance their career and family life. Hence, this trend suggests that an overwhelmingly large percentage of research subjects were not assured of legal protection in terms of occupational health safety benefits, neither did they enjoy any long term work benefits.

The fact that an overwhelming large percentage of research subjects were being sourced by the principal employer in the study through labour brokers is not atypical in the South African labour market landscape. Supply of labour in South Africa with high levels of unemployment makes job seekers willing to accept any form of employment as an alternative to unemployment. This finding confirms the assertion made by Standing, (1997) who states that South African companies are turning towards greater use of flexiworkers, through casual labour, contract labour, sub-contracting to smaller organizations, home workers and other 'out workers', and agency workers. The issue of labour broking in South Africa is a highly politically contested one. Ndunge, (2009) explains that this practice has created discontent amongst the major role players in South Africa which includes organized labour and the chamber of business. In light of the legal context that the broker is the real employer means workers are powerless to enforce the rights enshrined in the Constitution of the Republic of South Africa and the different Labour Legislations. Crush *et al*., (2001) who quote Rees argue that South African employers using sub-contracting to cheapen costs and increase flexibility often disallow unions and avoid protective regulation and legislation. It is in this context that this study confirms the nature and extent of labour brokering in the South African manufacturing sector and the implications for compromise of occupational and health safety legislations.

7.3 Distribution of Research Subjects by Employer and Labour Broker

The principal (permanent) employer in the study employed a marginal number of workers in all the strategically important positions to oversee the organisations day to day operations. The vast majority of workers were employed via Labour Brokers which substantially reduced labour costs, increased flexibility on the part of the principal employer and avoidance of trade unions. This finding is no different to the works of Riet, (2010), Ndunge, (2009), Benjamin, (2009), Crush *et al.*, (2001), Kenny and Bezuidenhout, (1999), Klerck (1994), Horton and Langhinnerich (2002) and Mwilima (2009) to cite a few, who provide a deep insight in the literature section of this study on the rationale for engaging workers through labour brokers in industry.

In the South African context, given the overwhelmingly high unemployment rates amongst all race groups, it comes as little surprise when the Labour Minister Mdladlana in the year 2009 described labour broking as a form of human trafficking as the practice involves selling the labour of workers to the highest bidder with little or no protection from occupational health hazards. However, such a statement must be viewed in a balanced way. Supply of labour in South Africa with high levels of unemployment makes job seekers willing to accept any form of employment as an alternative to unemployment. Hence one may argue from the perspective of the unemployed that risking ones health and safety inorder to survive is like being torn between the proverbial “devil and the deep sea”. It may be argued, that the question of labour brokering in the context of massive unemployment in South Africa raises an important social issue as on the one hand the state is expected to create conditions for the employment of its citizens and on the other extreme is challenged with the task of regulating a sector in which citizens volunteer themselves consciously out of basic necessity. A contentious issue such as this indeed raises the question of public choice in respect of which is the lesser of the evil: labour brokering or the risk of starvation due to unemployment.

Supply of labour in South Africa with high levels of unemployment makes job seekers willing to accept any form of employment as an alternative to unemployment. This finding confirms the assertion made by Standing, (1997) who states that South African companies are turning towards greater use of flexiworkers, through casual labour, contract labour, sub-contracting to smaller organizations, home workers and other ‘out workers’, and agency workers. The issue of labour broking in South Africa is a highly politically contested one. Ndunge, (2009) explains that this has created discontent amongst the major role players in South Africa which includes organized labour and the chamber of business. In light of the legal context that the broker is the real employer means workers are powerless to enforce the rights enshrined in the Constitution of the Republic of South Africa and the different Labour Legislations. Crush *et al*., (2001) who quote Rees argue that South African employers using sub-contracting to cheapen costs and increase flexibility often disallow unions and avoid protective regulation and legislation. It is in this context that this study confirms the nature and extent of labour brokering in the South African manufacturing sector and the implications for compromise of occupational and health safety legislations.

Benjamin, (2008) indicates that the Occupational Health and Safety Act, 1993 (Act 85 of 1993), is applicable to all workplaces irrespective of its level of formality. Furthermore, this Act is directed to larger employers who have formalized occupational health and safety management systems. Workers employed through labour brokers present a challenge to occupational health and safety in that workers who are required to work longer hours and under more dangerous conditions consequently suffer higher rates of injury in this type of employment (Benjamin, 2008; and Kenny and Bezuidenhout, 1999). The finding further attests to the fact that companies using labour brokers ensure a core pool of well paid staff which practice ensure its systems function and upon which casual workers are grafted to sustain productivity. Workers are employed on the basis of remaining healthy and earliest sign of illness their contracts are terminated. Hence, it is imperative to ensure that such a core group of staff are healthy, well trained and retrained with expertise to ensure the core business of these companies.

7.4 Workers ototoxic chemical exposures in the workplace

The ototoxic chemicals that were targeted were volatile organic chemicals (VOCs). Exposure assessments were conducted by placing monitoring devices on workers in their breathing zone. It was not possible to measure each worker's actual exposures to the VOCs therefore decisions were taken by the researcher to identify the highest exposed workers based on their duration of exposure, work activity and usage of VOCs. This approach is referred to as the worst-case sampling approach where workers are subjectively selected by the researcher who identifies the highest exposed worker non-randomly (Spear, 2005). This approach requires fewer samples to be taken. A limitation of worst case sampling is that it requires the occupational hygienist to recognize the worst-case conditions, which may include professional judgment about the specific task and specific work practices unique to an individual worker. The researcher is a registered occupational hygienist consequently was able to make these decisions. The American Industrial Hygiene Association recommends that six to ten samples are needed to perform a baseline exposure profile (Mulhausen and Damiano, 1998). In this study six samples were taken which was within the recommended range.

The investigations identified four ototoxicants namely p-Xylene, n-Hexane, Ethylbenzene and Toluene (Morata and Little, 2002) and Campo *et.al.,* (2009) as major sources of ototoxins in the workplace. Although one cannot make a strong generalization from these separate tests undertaken on research subjects due to restrictions placed by the research locality on the number of chemical samples that could be taken. It is significant to note that the presence of ototoxins in the work environment. Nonetheless, based on this finding, one may conclude that despite the prevalence of such ototoxins, in terms of the Occupational Health and Safety Act, 1993 (Act 85 of 1003) it may appear at face value that the research locality is in conformity with the South African occupational health and safety norms with the exception of n-Hexane in the case of Workers A and B only. However, this finding is not conclusive considering that the tests undertaken were not permitted to be extensive enough to make a deeper analysis on the nature and extent of VOC prevalence in the workplace. Nonetheless, based on this finding and the prevalence of such ototoxins, in terms of the Occupational health and Safety Act, 1993 (Act 85 of 1003) it may appears that the research locality is in conformity with the South African occupational health and safety norms with the exception of n-Hexane in the case of Workers A and B only.

The methodology used to obtain the chemical samples conformed to the legal requirements of the Occupational Health and Safety Act, 1993. It is known that this methodology is mainly used for instituting corrective action in the workplace. This methodology served has a tool to estimate the health risk to exposed workers in the selected rubber industry (Boleij *et al*., 1995). The results indicated that chemical exposures were within the prescribed limits of the Occupational Health and Safety Act, 1993. Although one cannot make strong generalization from these separate tests undertaken on research subjects due to restrictions placed by the research locality on the number of chemical samples that could be taken. It is significant to note the existence of ototoxins in the work environment.

It is important to note that in this study toluene and ethylbenzene were present which are internationally known to predispose workers to hearing impairment. In this respect, Morata, (2003) argues that recent animal experiments confirmed that chemicals such as toluene and ethyl benzene amongst other VOCs listed in Table 19 interacts synergistically with noise resulting in damage to the auditory system. Exposures to these chemicals in sufficiently high concentrations may affect hearing in the absence of noise. Such chemicals inhaled or absorbed through the skin are known to enter the blood stream and affects the cochlear structures and the central auditory system (Odkvist *et. al.,* 1982, Morata *et.al.,* 2002 and Teixeira *et.al.,* 2002).

7.4.1 Exposure to ototoxic risks at the research locality

Notwithstanding the fact that hard public choices needs to be made on the labour brokering sector and occupational health and safety standards in light of the high levels of unemployment, the study points out that a significant number of research subjects were exposed to ototoxic chemicals and physical noise which substantially increased the risk of hearing impairment. Almost all research subjects originating from labour brokers in the research locality risked hearing impairment. On the contrary those workers employed by the principal employer in key management and administrative positions to ensure production stability were least at risk of suffering hearing impairment from all potential sources within the research locality. This finding confirms the Presidential Economic Joint Working Groups, (2009) assertion that low income workers, the unemployed and vulnerable groups are at a greater risk from this form of labour practice. This finding also confirms that of Kenny and Bezuidenhout, (1999) who assert that labour brokering and other forms of casualisation are used by industry to evade health and safety legislation, which not only inflates production costs but also endangers workers health.

7.4.2 Extent of volatile organic chemicals exposure on research subjects

The presence of volatile organic chemicals (VOC's) at the research locality predisposed research participants ototoxic chemical exposure. Ototoxic chemicals present in volatile organic chemicals included n-hexane, toluene, ethyl benzene and xylene. The occupational exposure limit for n-hexane, substantially exceeded the legal permissible limit with the potential of endangering the research subjects auditory system. This finding confirms that of Morata, (2003) who affirms that recent experiments on animals has proven that chemicals such as toluene and ethyl benzene interacts synergistically with noise resulting in damage to the auditory system. Similarly studies by Odkvist *et. al.,* (1982) and Teixeira *et.al.*, (2002) confirm that such chemicals either inhaled or absorbed through the skin are known to enter the blood stream affecting the cochlear structures and the central auditory system. In addition, exposures to these chemicals in sufficiently high concentrations may have adverse effects on hearing capability even in the absence of noise.

7.5 Workers noise exposure in the workplace

The results point to an infringement of these provisions which compromises workers' hearing. Berger *et al.,* (2003) confirms that noise surveys establish the potential of work environments producing permanent noise induced hearing loss. The risk of hearing loss is accelerated when prescribed control measures are not in place and workers are exposed to ototoxic chemicals.

7.5.1 Noise exposure monitoring and risk of hearing impairment

Significant numbers of research subjects were exposed to noise levels in excess of the noise rating limit of 85dBA. Noise exposure monitoring indicated that certain areas in the research locality exceeded the noise rating limit of 85 dBA, as legislated by the Occupational Health and Safety Act of 1993. In such instances, the Act prescribes the need to have a Hearing Conservation programme in place to mitigate the negative effects of noise on the auditory system. It is evident from the study that such compliance was absent. In addition, no medical surveillance programme was in place to monitor the hierarchy of noise control as a preventative measure in managing hearing loss impairment. This finding corroborates with that of Gelfand (2001), Lustig *et al.,* (2003), Ackley *et al* (2007) and Berger *et al* (2003) who assert that even those that are exposed to noise levels ranging between 71-90 dBA are at risk of severe hearing loss and those above 90 dBA are exposed to profound hearing loss.

7.5.2 Workers hearing threshold (Audiometry) Audiograms and severity of hearing loss

Workers hearing were evaluated by pure tone audiometry, which covered the speech spectrum. Majority of the research subjects hearing levels were within the normal range. Baseline audiometric test were not conducted on workers, on the account that the principal employer and labour brokers disputed responsibility. Absence of this data prevents comparative trend analysis which would have indicated deterioration or stability of workers hearing. Nonetheless, the risk factors for research subjects appear serious in terms of long term hearing loss when the audiogram for frequency range 4000Hz, 6000Hz and 8000Hz was analysed. Within this range just more than 60% of the research subjects were at risk of suffering permanent hearing loss if they continued to have exposure to noise at such a frequency range. It must be noted once again that considering that a vast majority of the research subjects were in the employ of labour brokers who engage temporary workers resulting in a high turnover over a short duration of time, long term detection of its impact maybe escaped. Similarly, protection in terms of the Compensation for Occupational Illnesses and Diseases Act (1993) through the employer maybe averted, resulting in workers taking self responsibility for remedying their hearing condition later in life when such presents itself.

7.5.3 Hearing protective devices

Hearing protective devices is considered the last alternative administrative measure in engineering and related work environments. Notwithstanding its ranking, the majority of workers in the study were not provided with hearing protective devices, which exposed workers directly to noise hazards. In the study, only 2% of the research subjects reported using protective hearing devices although certain areas in the research locality exceeded the noise rating limit of 85dBA

7.6 Confounding factors that predisposes research subjects to hearing loss

The study noted that a small proportion of research subjects indulged in smoking and alcohol use which in the literature is known to predispose one to hearing loss with prolonged usage combined with exposure to ototoxic chemicals. Similarly, research subjects who used mini bus taxis as mode of transport which exposed them to a broad range of noise levels and in certain instances in excess of the noise rating limits of 85dBA where further predisposed to hearing loss. In so far as recreational exposure to ototoxic chemicals and physical noise for prolonged period of time through concert attendance, usage of power tools and solvents and to a lesser extent playing musical instruments was concerned, a significant number of research subjects reported such exposure. When such levels of exposure are combined to those prevalent in the research locality, it mostly likely poses a potential risk to hearing loss impairment. In addition, a significant proportion of the research subjects reported to suffer from migraines and allergy related health conditions for which they depended on chronic medication. Head injuries and colour vision problems and minor states of unconsciousness and balance difficulties were also prevalent amongst a small proportion of the research subjects.

The prevalence of prescribed and self administered medication for pain on a long term basis are known to be ototoxic resulting in hearing impairment in the future was noted amongst research subjects as confounding variables. When these findings are considered cumulatively, it suggests that given the prevalence of high volume of sound and VOCs in the workplace, coupled with the fact a significant percent of the research subjects are exposed to confounding variables of different sorts outside of the workplace, the probability that research subjects are at higher risks of suffering from hearing loss impairments over time becomes even more pronounced. Pain relieving medications that are known to have an aspirin base called salicylates has come to be known as one of the foremost ototoxic agents resulting in hearing loss impairments. Lustig *et al.,* (2003) in the literature study allude to high doses of acetylsalicylic acid causing sensorineural hearing loss, tinnitus, and vertigo.

7.6.1 Smoking and alcohol intake by workers

Alcohol preferentially blunts the lower frequencies thresholds including 1kHz which is an important frequency to discriminate vowels (Upile *et al.,* 2007). Research subjects who smoke and consume alcohol are more likely to be predisposed to hearing loss as a result of exposure to noise and chemicals in the workplace. In so far as smoking is concerned there is an increasing body of studies that have reported positive association between smoking and hearing loss (Itoh *et al.,* 2001, Nakanishi *et al.,* 2000; and Noorhassim *et al*.,1998. Other studies among noise exposed workers observed more adverse effects on hearing in smokers than in non-smokers (Barone *et al*.,1987; Virokannas *et al*., 1995; Starck *et al.,* 1999. Cigarette burning is known to release organic solvents such as benzene, styrene, xylene and lead, mercury and carbon monoxide (Darral *et al.,* 1998).

7.6.2 Mode of transportation used by workers

When one considers the compactness of mini bus taxis and the high levels of noise generated through music the long term effect of exposure to this mode of transport being a confounding variable cannot be dismissed. In the South African context, the mini bus taxi is a politically contested public transport sector which constantly evades regulation, and music sound levels are often defined as a nuisance variable as compared to an actual noise induced hearing loss variable. Bingham *et al.,* (2001) indicate that sound levels generated through music emitted from ‘boom boxes’ in taxis measures in excess of 110dBA which is well in excess of the prescribed limits of 85dBA in terms of the Occupational Health and Safety Act, 1993 (Act 85 of 1993).

7.6.3 The healthy worker effect

The strategy used to overcome the healthy worker effect was the use of internal comparison group which consisted of workers who were not exposed to noise and were not exposed to ototoxic chemicals. This strategy was justifiable in that workers came from the same environment and tended to have similar experiences. Consequently the presence of the healthy worker effect was effectively controlled.

7.7 Odds Ratio hearing loss (Combined exposure to chemicals and noise on hearing)

The present study evaluated the potential of developing hearing loss in rubber workers exposed to ototoxic chemicals and noise. A substantial portion of research subjects were exposed to both ototoxic chemicals and noise. Multiple regression analysis revealed that there was a slight trend towards co-exposure to chemicals and noise being a risk factor for hearing loss with an odds ratio of 1.7 (95% CI = 0.34 - 8.57, p = 0.51). No significant association with hearing loss was evident for workers exposed to chemical only with odds ratio of 0.41 (95% CI = 0.11 – 1.53, p = 0.19) and noise only with odds ratio of 0.87 (95% CI = 0.32 – 2.31, p = 0.78). The results in this study was similar to that of Jacobsen *et al*., (1993) where the relative risk for the noise and chemicals (solvent) group was 1.8 (95% CI = 1.6 – 2.1, p = 0.001), the relative risk for chemicals (solvent) only group was 1.4 (95% CI = 1.1 – 1.9, p = 0.001) and the noise only group was 1.9 (95% CI = 1.7 – 2.1, p = 0.001). However, the odds ratio in the Jacobsen *et al*., (1993) study for noise only and chemicals only was substantially higher than the current study.

Sliwinska-Kowalska *et al.,* (2004) study on dock yard workers indicated that workers were 3.34 (95% CI = 2.06 – 5.43, p = 0.001) more likely to suffer hearing loss from noise only exposure and 4.88 (95% CI = 3.09 – 7.68, p = 0.001) more likely to suffer hearing loss from combined exposure to noise and solvents and. Kim *et al.,* (2005) study in the aviation industry pointed towards odds ratio of 4.28 (95% CI = 1.71 – 10.75, p = 0.001) for noise only, 2.57 (95% CI = 0.64 – 10.31, p = 001) and 8.12 (95% CI = 2.03 – 32.53, p = 0.001) more likely to suffer hearing loss from combined exposure to noise and chemicals. The low odds ratio in this study when compared to the other two studies may be attributed to workers not being employed for long periods and healthy fit workers are continuously employed and at the earliest sign of illness the workers employment contract is terminated.

7.8 Adequacy of current legislation on hearing loss acquired

Benjamin (2008:21) indicates that the Occupational Health and Safety Act, 1993 (Act 85 of 1993), is applicable to all workplaces irrespective of its level of formality. Furthermore, this Act is directed to larger employers who have formalized occupational health and safety management systems. Workers employed through labour brokers present a challenge to occupational health and safety in that workers who are required to work longer hours and under more dangerous conditions consequently suffer higher rates of injury in this type of employment (Benjamin, 2008; and Kenny and Bezuidenhout, 1999). The finding further attests to the fact that companies using labour brokers ensure a core pool of well paid staff who ensure its systems function and upon which casual workers are grafted to sustain productivity. Hence, it is imperative to ensure that such a core group of staff are healthy, well trained and retrained with expertise to ensure the core business of these companies.

The backbone of the Occupational Health and Safety Act, 1993 is Section 8, Duties of Employer which requires the employer to assess the risks at the workplace and take the necessary precautionary measures if deemed necessary. This is a discretionary requirement and the employer can argue that a risk does not exist therefore no precautionary measures are required. When hearing loss does occur it may be at an advanced stage and may be attributed to noise only although ototoxic chemicals may be in the ambient environment. The specific provisions that pertain to Hazardous Chemicals Substances Regulations (HCSR) were promulgated on the 25th August 1995 and the specific regulations that pertaining to Noise Induced Hearing Loss Regulations (NIHL) were promulgated on the 7th March 2003, which makes both sets of regulations out-of-date with current scientific and technological progress in the field of audiology, occupational health and hygiene.

Current legislation does not call for employers to give particular attention to any effects on workers' health and safety due to interactions between noise and work-related ototoxic chemicals. NIHL makes provisions for assessment to be carried out of potential noise exposure and adverse health effects that the excessive noise may have on workers. Interaction of ototoxic chemicals and noise in the work environment are not considered in the noise assessment. The employer is required to establish and maintain a system of medical surveillance for all workers exposed to noise at or above 85dBA, however, combined exposure to noise and ototoxic chemicals adversely effects workers hearing below the prescribed exposure limit for noise. The conservation of workers hearing is thus compromised when joint exposure to ototoxic chemicals and noise occurs consequently do not receive the protection afforded to workers by the Occupational Health and Safety Act, 1993 and Regulations. Records are required for previous work-related noise exposure prior to a worker's current employment and previous ototoxic chemical exposures to workers are disregarded.

7.9 Safety, Quality and Environmental Management

The safety management system in place did not advocate absolute safety but strived to control and continually improve the level of risk. The implementation of the systems ensures that deviations from the norm are sufficiently infrequent. The main objective of the safety management systems was to use available resources to reasonably prevent accidents and be prepared when accidents occurred. Occupational diseases prevention does not receive the same attention as occupational accidents. Chemical induced hearing loss will be considered an occupational disease.

The safety, quality and environmental management systems that were implemented embodied the “plan-do-check-act” management model and conformed to the continual improvement principle. All three systems overlapped in elements and in clauses as shown in Annexure 11. The purpose and fundamental requirements are common to all three systems. The safety, environmental and quality management systems are linked directly to the organization’s business processes which enabled the organization to trade in the international market. Workers well being were incidental to the manufacturing process.

7.10 Summary

Workers were co-exposed to chemical and noise at a rubber manufacturing factory and were almost two times more likely to suffer occupational induced hearing loss. There was a limited number of ototoxic chemical sampled mainly on the account of restrictions placed by the research location. The safety, quality and environmental management systems were in place at the research location which the principal employer conformed to. Workers employed with the labour brokers were excluded. The human resource management practice of the research location involved three different labour brokers which accounted for almost 90% of the work force. The remainder 10% was employed by the principal employer. Current legislation in South Africa provides for hearing loss acquired from physical noise and does not make adequate provisions for chemical acquired hearing loss.

CHAPTER EIGHT

CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

In the previous chapter the results of the findings was analysed and interpreted. This chapter summarises the main findings, make final conclusions based on the analysis and interpretation of data and suggest the way forward on how to improve on occupational health and safety within the rubber industry in respect of ototoxic chemical induced hearing loss. Although the study was confined to the rubber industry, the findings are of general importance to almost all chemical manufacturing sectors in South Africa. Notwithstanding the parameters and the limitations of this study, it provides valuable insight as an exploratory research upon which the effects of occupational exposure to ototoxic chemicals and noise on the auditory system has being recognized and recommendations are made to address the potential occupational risk.

Schacht and Hawkins (2006) in the literature study alert to the presence of ototoxic chemical substances in the work place affecting the structure and function of the inner ear and the signal transmission pathways to the central nervous system. Although this study was not conclusive on the interaction of noise and chemical beyond the legislated legal limits as factors in predisposing research subjects to hearing loss impairment, as an exploratory study, it provides credible insights into understanding the effects of certain ototoxic chemicals on the auditory system and their interactions with noise Morata *et al*., (1997).

8.2 Summation Of Study

8.2.1 Literature study and conceptual framework

The research was founded on international studies on the hearing loss impairment in a work environment acquired through ototoxic chemicals. The literature focused on four broad but important concepts which forms the basis upon which the study is constructed, the bio-medical chemical and physical context of hearing loss induced through ototoxic chemical exposures, the human resources practices, global standards and the inadequacies of South African legislation in addressing chemical induced hearing loss. The literature study drew on the most current research findings and conclusions which informed the empirical aspect of the study.

8.2.2 Methodology

The study was an exploratory one aimed at determining whether co-exposure exposure to chemicals and physical noise advances hearing loss amongst workers in the selected rubber industry. It targeted a selected group of 300 workers (purposive sample) originating from labour brokers within a manufacturing sector in the Metropolitan Area of Durban. An evaluation of the noise levels was conducted on the various processing areas of the manufacturing plant. Pure tone audiometry was conducted on the selected group. An adapted NoiseChem questionnaire was administered which included the health history, work history, chemical and noise exposure, physical features, lifestyle, ototoxic exposures not related to current or past exposures and demographic data amongst all respondents in the study (Morata and Little, 2002).

The collected data was analysed using the statistical software SPSS version 15.0 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics such as mean, standard deviation and range were used to summarize quantitative data, while frequency tabulations and percentages were used to report categorical data. Bivariate and multivariate associations between categorical exposures or confounders vs. the outcomes were assessed. Means were compared between the two groups using independent t-tests. Finally, generalized linear regression models were used to estimate relationships between exposures to noise and chemicals and the hearing thresholds after controlling for confounding variables.

8.3 Way forward

8.3.1 Co-exposure of ototoxic chemicals and noise

The present study evaluated the potential of developing hearing loss in rubber workers exposed to ototoxic chemicals and noise. The study points to a significant increase in the odds of developing hearing loss. Co-exposure to chemicals and noise showed a slight trend towards being a risk factor for hearing loss with an odds ratio of 1.7 (95% CI = 0.34 - 8.57, p = 0.51) but the p value was not significant. No significant association with hearing loss was evident for workers exposed to chemical only with odds ratio of 0.41 (95% CI = 0.11 – 1.53, p = 0.19) and noise only with odds ratio of 0.87 (95% CI = 0.32 – 2.31, p = 0.78). The results in this study was similar to that of Jacobsen *et al*., (1993) where the relative risk to hearing loss for the noise and chemicals (solvent) group was two times more likely to occur. Sliwinska-Kowalska *et al.,* (2004) study on dock yard workers indicated that workers were five times more likely to suffer hearing loss from combined exposure to noise and solvents. Kim *et al.,* (2005) study in the aviation industry pointed towards an eight times more likely to suffer hearing loss from combined exposure to noise and chemicals. The low odds ratio in this study when compared to the other two studies may be attributed to labour broking policy of the research locality and the healthy worker effect where only the young and healthy remain employed and at the earliest sign of illness the workers employment contract is terminated.

8.3.2 Gaps in legislation

The study highlights gaps in legislation which perhaps may have been overlooked in the absence of emerging research in this field. Current legislation tabled under the Occupational Health and Safety Act of 1993, in respect of Noise Induced Hearing Loss Regulations only addresses hearing impairment emanating from a physical noise source. These regulations do not require the employer to monitor workers hearing when exposed to ototoxic chemicals when exposed to equivalent noise levels that are below the prescribed limit of 85dBA. Regular medical surveillance should be required for workers co-exposed to noise and ototoxic chemicals notwithstanding the noise exposure level and workers health outcomes should be recorded in order to detect early changes at individual and collective levels. The main purpose of medical surveillance is to have a system which identifies early signs and symptoms of hearing impairment. Provisions for hearing protective equipment should be made for workers when exposed to noise exposure levels from 80dBA when they are exposed to noise and ototoxic chemicals mainly as a preventative measure. Education and training programmes need to explain the potential health effects of ototoxic chemicals in there hearing conservation programmes.

In respect of a specific recommendation to reduce levels of hearing loss impairment in the work place a need exists for audiometric monitoring to be deemed necessary if there is potential risk of occupational exposure to ototoxic chemicals which may affect the hearing of exposed workers. Moreover annual audiometric tests should be conducted on workers whose ototoxic chemical exposures (without regard to respiratory protection worn) are at 50% of the most stringent criteria for occupational exposure limits, either based on the American Occupational Safety Health Administration Permissible Exposure Limits (OSHA PEL) or the American Conference of Governmental Industrial Hygienist (ACGIH)- Threshold Limit Value Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices (2012), notwithstanding the noise exposure level (U.S. Army Fact Sheet 51-002-0903,).

Ototoxic chemicals may occur through dermal uptake, for which occupational exposure limits are based on respiratory intake of ototoxic chemicals. Consequently, the occupational exposure limits will not offer protection to workers. Biological exposure monitoring is required to control the total body burden. The occupational exposure limits are based on endpoints other than ototoxicity.

The Hazardous Chemical Substance Regulations, tabled under the Occupational Health and Safety Act, 1993 published in 1995 needs to be updated in keeping with emerging occupational exposure limits at an international level. Hoet and Lison, (2008) proposed a ‘noise notation’ which is similar to the skin notation for dermal absorption at work places. The ‘noise notation’ could be added to the occupational exposure limits of chemical substances for which there is significant concern about potential ototoxic effect, when experiential data suggest that ototoxicity is the main health effect or that ototoxic effect occur at a level close to the occupational exposure limit.

8.3.3 Alignment of occupational health and safety policy to international standards

The Department of Labour which is the custodian of occupational health and safety policy for all workplaces in South Africa with the exception of mines, shipping and aviation safety should consider formulating a policy similar to the 2003 European Parliament Directive EC 10 which states, under "Obligations of Employers" that when carrying out risk assessments, employers should "…give particular attention to: any effects on workers' health and safety resulting from interactions between noise and work-related ototoxic substances and noise and vibration. The directive made provisions for two lower action levels and one exposure limit level. The lower exposure action level is 80dBA Leq8h (time weighted average (TWA) of the noise exposure levels for a nominal 8-hour working day). Workers are permitted to have hearing test and to information about hearing conservation and the risk of hearing loss. Hearing protection must be provided to workers on demand. The upper exposure action level is 85dBA Leq8h at which reasonable measures to reduce noise exposure and hearing conservation programmes including compulsory use of hearing protection must be implemented. The exposure limit is 87dBA Leq8h measured inside the hearing protectors. The directive indicates that this level is considered to be the ceiling level. In the South African context it would be advisable to retain the 85dBA exposure level to avoid confusion amongst employers other provisions of the directive could be incorporated into the Occupational Health and Safety Act, 1993 to align the Act to international norms. Johnson and Morata, (2010) declare that Finland, Denmark, Sweden and Norway have implemented the European Directive EC 10 however, they have retained their old threshold limit value of 85dBA Leq8h.

8.3.4 Increasing awareness on occupational health and safety rights

The Department of Labour and the Trade Union movement in South Africa are well placed to promote awareness on the right to occupational health and safety in the workplace amongst workers. Even though workers are engaged through labour brokers, on predetermined contracts that often violates their occupational health and safety wellbeing, the Constitution of the country is supreme providing security to all of its citizens. These rights could be printed in brochures or leaflets which are handed to unemployed workers when applying for their Unemployment Insurance Fund or when calling at unions upon dismissal or retrenchments to take note of when engaging with prospective employers. They should be provided adequate information and training on measures taken by the employer to ensure a healthy and safe environment especially when this condition is not met or compromised.

8.3.5 Ongoing monitoring and evaluation of the Occupational Health and Safety Act

The Department of Labour should recognise the Occupational Health and Safety (OHS) management system as an integral part of its organisations business. It needs to achieve Occupational Health and Safety performance targets within the department, allocate resources, set Occupational Health and Safety objectives and targets, involve labour movements and facilitate work place forums participation, review policy periodically and provide training to its policy implementing staff on changing contexts and emerging new trends in policy. Planning phase to address objectives and targets which typically will be to reduce and eliminate occupational accidents and occupational diseases in the workplace. Routine monitoring and periodic audit will help provide a critical assessment of all elements of the Occupational Health and Safety management system at the national, provincial and regional levels. It needs to formulate a systematic approach to identifying hazards, quantifying risks and implementing appropriate control measures as a proactive measure. The Occupational Health and Safety Assessment Series (OHSAS) 18001:2007 should be made mandatory for all organizations. This will get organizations to formalize there safety management system.

8.3.6 Future research

The nature and scope of this study is exploratory in nature considering the fact that the issue of outsourcing of human resources and compromise of occupational health and safety standards is only recently drawing the attention of policy makers. Outsourcing of human resources in the South African context referring to labour brokering is an emerging trend in the country and a direct response to the implementation of global neo-liberal macro economic policy based on flexible labour with the aim of amassing profits. It is a highly contested area especially within labour rights movements, the state and the private sector. In light of this local research in this field, it is now only beginning to emerge and were it has, the findings are very scant to attract appreciable attention. This is especially in light of the fact that access to research sites is often restricted and permeated by ambivalence on the part of research subjects especially workers for fear of victimisation and intimidation from employers resulting in low levels of participation, interest and action, post research. In addition one finds that labour brokers tend to serve as gatekeepers restricting access to research sites and employers evade social inquiry into the nature of this sector. Given this restriction, the study partially explored the extent of compromise in the implementation of the Occupational and Health Safety Act in respect of hearing impairment amongst workers in the rubber industry.

8.4 Conclusion

This study has provided evidence that the combine exposure of chemicals and noise increases the risk of hearing impairment amongst workers engaged by labour brokers for employment. Both the literature study and the empirical data attest to this. Scientific evidence on its own is not going to change current practices. It needs to be accompanied by the raised public awareness and that of politicians and policy makers in terms of occupational health and safety implications. Substantial amount of work is still necessary to turn the scientific evidence into public language and to describe in simple terms why the change in policy is critical.

On a positive note South Africa has a sound Occupational Health and Safety policy in place and is a signatory to international labour declarations that calls for decent and humane work environments. However, despite commitment to such policies may be lauded, the study highlights gaps in its implementation which can only be remedied through agreements with the state, organised labour movements and the private sector on its implementation, monitoring and evaluation. The problem is striking a balance between contested and conflicting interests within this trinity of stakeholders. While this may be a long drawn process, the study calls for greater awareness amongst vulnerable workers on their Constitutional rights when working in hazardous environment. It calls for diligent monitoring and evaluation of such environments by the Department of Labour which needs to feed into ongoing future research.

Such research needs to be comprehensive incorporating different sectors and spread across local, provincial and national levels. It needs to engage with policy, practice, emerging trends and patterns in human resource management and impacts on the social, psychological and physical well being of workers engaged in different sectors. Being on top of international trends through ongoing research and comparative analysis can only help to improve on ethical work practices in keeping with international norms and standards. It must be noted that globalisation is an unavoidable phenomenon and the world has shrunk, permeating, breaking down and diluting national boundaries. Given this state of affairs, an adaptive response to international norms and standards in the practice of Occupational Health and Safety even though South Africa is a developing country can only enhance its preparedness to ensure a healthy work force and avoid the negative impact it may have in the long term on its health care system. Private sector profits at the expense of the health of its citizens are both irreversible and unsustainable for a developing nation which has huge and chronic levels of backlog in promoting its national human resource potential.

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ANNEXURE 1

NOISE EXPOSURE SURVEY PROCEDURE

NOISE MEASUREMENT CONDUCTED IN ACCORDANCE WITH SANS 10083:2012 CLAUSE 8

PURPOSE: The purpose of the noise measurement is to establish the current noise levels in the ambient environment.

DESCRIPTION OF THE MEASUREMENT ENVIRONMENT: Giving the materials used for the construction of the building if any, including wall floor and ceilings/roof finishes.

A DIMENSIONED DRAWING OR SKETCH THAT INDICATES MEASURING POINTS AND NOISE ZONE BOUNDARIES: Depicting the workplace layout and equipment.

THE 8h RATING LEVEL: For each noise zone and for specific areas or locations such as operators' positions. Select three positions that are well distributed over the area under investigation, using the following microphone heights and take measurement at each point:

a) 1.5m above the floor or ground in which the persons are standing.
b) 0.9m above the middle of the seat plane.

DESCRIPTION OF NOISE SOURCE: The noise is from a single point or multiple points.

DESCRIPTION OF THE OPERATING CONDITIONS OF THE NOISE SOURCE(S): Include non operational sources and machinery, of which the estimated effect should be given when in operation during measurements.

DESCRIPTION OF THE MEASUREMENT EQUIPMENT INCLUDING SERIAL NUMBERS: Integrating sound level meter configuration that complies with accuracy requirements for type 2 instrument.

THE CALIBRATION DATES OF THE MEASURING EQUIPMENT: Sound calibrator that complies with the requirements for a type 2 calibrator.

DATE(S) OF THE TEST

NAME OF THE TEST OFFICER

THE ADDRESS OF THE SITE

ANNEXURE TWO
PURE TONE AUDIOMETRY PROCEDURE

SCREENING AUDIOMETRIC TEST CONDUCTED IN ACCORDANCE WITH SANS 10083:2012 CLAUSE 14

Particulars Of The Test Subject That Is:

(i) Name
(ii) Identity Number
(iii) Work Identification
(iv) Age

Trade Name and Type of Business of the Employer

The Nature of the Work Including A Description of the Work Procedure and Area

The Date and Place of the Test

Details of the baseline audiometry determined at the commencement of employment, in terms of the relevant legislation.

Measurement of Hearing Threshold measured at least at the following frequencies:
500Hz, 1kHz, 2kHz, 3kHz, 4kHz, 6kHz and 8kHz.

Establish clinical information – presence of ear wax, inflammation etc.

Test Environment: Audiometric investigation to be conducted in a booth or room that conforms to SANS 10182.

Measuring Equipment for Screening Audiometry: Use a audiometer that complies with at least the requirements for a type 4 audiometer with a frequency range of 8kHz for which a value of hearing level of at least 70dB.

Details of the calibration certificate for both the audiometer and booth.

The Name of The Test Officer.

AUDIOMETRIC DATA FORM: REAL-TIME MONITORING FOR HEARING THRESHOLDS

Facility Name and Location: ___________________ **Date Monitoring Conduct:** ____________________

Monitoring Conducted By: ____

Audiometer (Type/Manufacturer/Model): ____

Monitor Calibration: ____

Identification of Personnel	**Age (yr)**	**Hearing Threshold (dB) Per Ear (R and L) at Specific Frequency (Hz)**																	
		250 Hz		**500 Hz**		**1000 Hz**		**2000 Hz**		**3000 Hz**		**4000 Hz**		**6000 Hz**		**8000 Hz**			
		R	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**		

Comments:

ANNEXURE THREE

NOISECHEM QUESTIONNAIRE

DATE:

____

SECTION A: PERSONNAL

Please leave blank any questions you do not understand or do not know the answer to. A research assistant will go through your questionnaire with you.

NAME & SURNAME:____

STAFF NUMBER:____

	01	02	03	04
Employer	**Principal employer**	**Labour broker A**	**Labour broker B**	**Labour broker C**

JOB TITLE, WORK AREA & NATURE OF WORK:

____

____

____

____

1.	Age		Years
2.	Weight		Kg
3.	Height		m

		01	02
4.	Sex	Male	Female

		01	02	03	04
5.	Eye Colour	Blue	Green	Brown	Other
		01	02	03	05
6.	Hair Colour	Blonde	Reddish	Black	Other

		01	02	03	04	05
7.	Race	African	Coloured	Indian	White	Other

		01	02
8.	Left or Right Handed	Left	Right

		01	02
9.	Do you smoke?	Yes	No

		01	02	03	04	05
9.A	If Yes: How many a day?	1-10	11-20	21-30	31-40	> = 41

		01	02	03	04	05	06	07
9.B	For how many years?	1-5	6-10	11-15	16-20	21-25	26-30	> = 31

		01	02
10.	Do you drink alcohol?	Yes	No

		01	02	03	04	05	06
10.A	If Yes: how often in a week	1 X week	2 X week	3 X week	4 X week	5 X week	> 5 X

							week

		01	02	03	04	05
11.	Did you work previously in the:	Military	Air Force	Navy	Police Force	None of the Services

		01	02	03	04	05
11.A	For how many years?	0 to 5	6 to 10	11 to 15	16 to 20	= > 21

		01	02	03
12.	Was your hearing affected by the service?	Yes	No	Unknown

		01	02	03	04
13.	Do you use hearing protection?	Always	Often	Seldom	Never

		01	02
14.	Do you participate in hunting, target shooting?	Yes	No

		01	02	03	04	05
14.A	If Yes, How many times a month?	1 to 5	6 to10	11 to 15	16 to 20	= > 21

		01	02	03	04	05
14.B	For how many years?	1 to 5	6 to 10	11 to 15	16 to 20	= > 21

		01	02	03	04	05
15.	What mode of transport do you use?	Bus	Mini Bus Taxi	Motor Vehicle	Motorcycle	Other

		01	02
16.	Do you use power tools?	Yes	No

		01	02	03	04	05
16.A	If Yes, How many times a month?	1 to 5	6 to10	11 to 15	16 to 20	= > 21

		01	02	03	04	05
16.B	For how many years?	1 to 5	6 to 10	11 to 15	16 to 20	= > 21

		01	02
17.	Do you play a musical instrument?	Yes	No

		01	02	03	04	05
17.A	If Yes, How many times a month?	1 to 5	6 to10	11 to 15	16 to 20	= > 21

		01	02	03	04	05
17.B	For how many years?	1 to 5	6 to 10	11 to 15	16 to 20	= > 21

		01	02
18.	Do you attend concerts, discos or night clubs?	Yes	No

		01	02	03	04	05
18.A	If Yes, How many times a month?	1 to 5	6 to10	11 to 15	16 to 20	= > 21

		01	02	03	04	05
18.B	18. B. For how many years?	1 to 5	6 to 10	11 to 15	16 to 20	= > 21

		01	02
19.	Are you exposed to solvents? (e.g. painting, printing, car repairs)	Yes	No

		01	02	03	04	05
19.A	If Yes, How many times a month?	1 to 5	6 to10	11 to 15	16 to 20	= > 21

		01	02	03	04	05
19.B	For how many years?	1 to 5	6 to 10	11 to 15	16 to 20	= > 21

SECTION B: MEDICAL

Please indicate whether you have or have ever had in the past any of the following, by circling the appropriate block:

		01	02	03
20.	High Blood Pressure (Hypertension)	Yes	No	Unknown
20.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
21.	High Cholesterol	Yes	No	Unknown
21.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
22.	Asthma	Yes	No	Unknown
22.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
23.	Eczema	Yes	No	Unknown
23.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
24.	Allergies	Yes	No	Unknown
24.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
25.	Migraine (Headaches)	Yes	No	Unknown
25.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
26.	Tuberculosis	Yes	No	Unknown
26.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
27.	Kidney problems	Yes	No	Unknown
27.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
28.	Diabetes	Yes	No	Unknown
28.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
29.	White finger (condition due to cold stress and	Yes	No	Unknown

	vibration)			
29.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
30.	Mumps	Yes	No	Unknown
30.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
31.	Measles	Yes	No	Unknown
31.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
32.	Meningitis	Yes	No	Unknown
32.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
33.	Jaundice	Yes	No	Unknown
33.A.	Do you now or have in the past taken medication for this?	Yes	No	Unknown
34.	Acute poisoning	Yes	No	Unknown
34.A.	If Yes, What type of poisoning?			
35.	Colour vision problems?	Yes	No	Unknown

		01	**02**
36..	Head Injury	Yes	No

		01	**02**
36.A	If Yes, Where you unconscious?	Yes	No

		01	**02**	**03**	**04**	**05**
36.B	For how many hours?	1 to 5	6 to 10	11 to 15	16 to 20	= > 21

		01	**02**
37.	Any balance problems?	Yes	No

		01	**02**	**03**	**04**	**05**
38.A	If Yes, how long do the attacks last in hours?	1 to 5	6 to 10	11 to 15	16 to 20	= > 21

		01	02	03
38.B	Do you now or have in the past taken medication for this?	Yes	No	Unknown

		01	02	03
39.	Are you on any other long term medication?	Yes	No	Unknown
39.A	If Yes, Which medication?			

		01	02
40.	Do you regularly take painkillers?	Yes	No

		01	02	03	04	05
40.A	If Yes, How many per day?	1 to 5	6 to10	11 to 15	16 to 20	= > 21

		01	02	03	04	05
40.B	For how many years?	1 to 5	6 to10	11 to 15	16 to 20	= > 21

		01	02
40.C	Are these painkillers on prescriptions?	Yes	No

SECTION C: AUDIOMETRIC TEST

		01	02	03
41.	Otoscopic Examination	Presence of ear wax	Inflammation	Other

		01	02	03	04	05	06	07
		500Hz	1kHz	2kHz	3kHz	4kHz	6kHz	8kHz
42.A	Right Ear							
42.B	Left Ear							

Name of Tester	
Signature of Tester	

THANK YOU.

ANNEXURE FOUR

PROCEDURE FOR CHEMICAL SAMPLING AT THE WORKPLACE

NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH (NIOSH) MANUAL OF ANALYTICAL METHODS: 1501 HYDROCARBONS, AROMATIC

PURPOSE

Determine the chemical vapours in workplace air to which workers are exposed too.

CHEMICALS TO BE SAMPLED: Toluene, Xylene and Styrene

SAMPLING:

- Air sampling equipment consist of a pump connected to a collection device called a sorbent tube. Sampling flow rate for the pump will be set at 0.2ℓ/min.
- The sampling medium to be used for capturing the workplace chemicals are solid sorbent tube (coconut shell charcoal, 100mg/50mg).
- Air sampling pump capable of sampling at the required flow rate with the sampling medium in line is set up. Thereafter, the pump is placed in a holster and attached to the worker the sampling medium which is connected to the pump by means of tubing is attached to the worker's collar by means of a clip. The sampling medium is placed at the collar to capture chemicals in the breathing zone of the worker. The pump will be switched on and the commencement time and end time will be recorded. Samples will be taken for 2-4 hours.
- Upon capturing the chemicals on the sampling medium it would then be sealed, packaged and couriered to an approved laboratory for chemical analysis as per Analytical Method 1501.
- The laboratory will then provide the results for the samples taken.

ANNEXURE 5 AUDIOMETER CALIBRATION CERTIFICATE

Stanyer Electroserve cc.

SALES, SERVICE AND REPAIRS TO MEDICAL AND ACOUSTIC INSTRUMENTATION
Ck. 94/05783/23

P.O. Box 273,
Gillitts, 3603,
Tel: 031-7090710
Fax: 031-7028778

No. 2 Gilro Park
34 Gillitts Road
Pinetown
3610

Certificate of Air-Conduction Calibration

Company Name & Address
D.U.T
Durban
K.Z.N

Certificate no. 8101/A1

110,0	Pre- Calibration Microphone
110,0	Post Calibration Microphone

Frequency in Hertz	Limits in Hertz	Actual Frequency	SPL Tolerance at 70 dB	Actual SPL Left	Actual SPL Right
250	242-258		94-100		
500	485-515	499	80,5-86,5	83,1	83,3
1000	970-1030	999	74,5-80,5	77,5	77,2
2000	1940-2060	1999	76-82	79,0	79,3
3000	2910-3090	2998	78,5-84,5	82,1	82,3
4000	3880-4120	3998	79-85	83,1	83,3
6000	5820-6180	5995	81-91	86,5	86,1
8000	7760-8240	7995	80,5-90,5	85,2	85,4

ATT AT 4000 HZ	90	85	80	75	70	65	60	55	50	45	40	35	30
	103,0	98,1	93,2	88,2	83,3	78,3	73,3	66,2	63,2	58,2	53,2	48,2	43,1

Calibration Equipment used ___

Quest 1800		HP2030020
Quest 1/3 Octave Filter	OB 300	HV1070028
Quest Octave Filter		
B & K Artificial Ear		
Quest ½ "Microphone	CRL224	900028
ACO ½ "Pressure Microphone	4153	11621
Artificial Mastoid	4930	842289
Testmate	175	01016872
Quest Sound Calibrator	CA 22	J1070023

Certificate number: 2008-602/603/604

Calibration Equipment used ✓

Quest 1800		HP1070017
Quest Sound Calibrator	CA-12B	U2030044
Quest Octave Filter	OB 100	HW6120027
L & D Artificial Ear	AEC 101	0189
B & K ½ "Microphone	4936	2064317
L & D ½ "Pressure Microphone	2559	3214

Certificate number 2008-595/596/597

The air conduction calibration of the above instrument has been checked in accordance with the SANS 10154-2:2004 and has found to be in agreement with the recommended limits. The Certification of the calibration is valid for a period of one year (subject to the expectations given in SANS 10154-2: 2004) While every endeavor is made to ensure this certificate is accurate, Stanyer Electroserve cc or its employees shall in no way be liable for any errors, whether in fact or opinion.

	Audiometer	Left Earphone	Right Earphone
Make	Tremetrics	Telephonic	Telephonic
Model	RA300	TDH 39P	TDH 39P
Serial no.	072619	C079850	C079854

Calibration Date: 10-11-2008 Calibration Due: 09-11-2009

Calibrated by Mr. G.D. Stanyer / Mr. P.T. Stanyer Signature: [redacted]

Certified in Noise Measurement and Calibration

Member: Mr. G.D. Stanyer

ANNEXURE 6 : CALIBRATION CERTIFICATE FOR CASELLA PUMPS

CASELLA CEL

Certificate of Conformity and Calibration

Instrument Type Apex Standard I.S. Personal Air Sampler
Serial Number 4481290

Applicable standards:-

EN1232 - Workplace Atmospheres: Pumps for Personal Sampling of Chemical Agents
MDHS14/3 - General Methods for Sampling and Gravimetric Analysis of Respirable and Inhalable Dust
NIOSH 0600 - Particulates Not Otherwise Regulated, Respirable

Test Conditions:-

Temperature	18.5	°C
Humidity	33	%RH
Pressure	1009	mBar

Test Engineer:- John Parker

Date of Issue:- October 28, 2008

Equipment Used

Air Flow Calibrator:
Type: BGI TriCal   Serial Number: Eq No 10551

Declaration of conformity

This test certificate confirms that the instrument specified above has been successfully tested to comply with the manufacturer's published specifications.

Tests are performed using equipment traceable to national standards in accordance with Casella's ISO 9001:2000 quality procedures. This product is certified as being compliant to the requirements of the CE Directive.

Test and Calibration Results :-

General tests

Item	Measured value	Lower Limit	Upper Limit	Status
Pump temperature (°C)	19.5	15.5	21.5	Pass
Battery voltage (V)	5.28	4.4	5.8	Pass
General hardware	N/A	N/A	N/A	Pass
Infrared communication	N/A	N/A	N/A	Pass

General tests   All Tests Pass

Flow rate accuracy

Set flow point (litres/min)	Measured flow rate (litres/min)	Error (%)	Error Limits (%)		Status
			Min	Max	
1.50	1.44	-4.17%	-5%	5%	Pass
2.00	1.94	-3.09%	-5%	5%	Pass
2.50	2.47	-1.21%	-5%	5%	Pass
3.00	2.99	-0.33%	-5%	5%	Pass
3.30	3.29	-0.30%	-5%	5%	Pass

Flow rate accuracy   All Tests Pass

Flow control accuracy

Set flow point (litres/min)	Inlet pressure loading (cm H_2O)	Measured flow rate (litres/min)	Error (%)	Error Limits (%)		Status
				Min	Max	
2.00	10	1.96	Ref.	Ref.	Ref	Ref.
2.00	40	1.92	-2.08%	-4%	4%	Pass

Flow control accuracy   All Tests Pass

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Page 1 of 1

CASELLA CEL

Certificate of Conformity and Calibration

Instrument Type Apex Standard I.S. Personal Air Sampler
Serial Number 4481291

Applicable standards:-

EN1232 - Workplace Atmospheres: Pumps for Personal Sampling of Chemical Agents
MDHS14/3 - General Methods for Sampling and Gravimetric Analysis of Respirable and Inhalable Dust
NIOSH 0600 - Particulates Not Otherwise Regulated, Respirable

Test Conditions:-

Temperature	19	°C
Humidity	32	%RH
Pressure	1009	mBar

Test Engineer:- John Parker

Date of Issue:- October 28, 2008

Equipment Used

Air Flow Calibrator:
Type: BGI TriCal **Serial Number:** Eq No 10851

Declaration of conformity

This test certificate confirms that the instrument specified above has been successfully tested to comply with the manufacturer's published specifications.

Tests are performed using equipment traceable to national standards in accordance with Casella's ISO 9001:2000 quality procedures. This product is certified as being compliant to the requirements of the CE Directive.

Test and Calibration Results :-

General tests

Item	*Measured value*	*Lower Limit*	*Upper Limit*	*Status*
Pump temperature (°C)	19.5	16	22	Pass
Battery voltage (V)	5.28	4.4	5.8	Pass
General hardware	N/A	N/A	N/A	Pass
Infrared communication	N/A	N/A	N/A	Pass

General tests **All Tests Pass**

Flow rate accuracy

Set flow point (litres/min)	*Measured flow rate (litres/min)*	*Error (%)*	*Error Limits (%)*		*Status*
			Min	*Max*	
1.50	1.52	1.32%	-5%	5%	Pass
2.00	1.99	-0.50%	-5%	5%	Pass
2.50	2.48	-0.81%	-5%	5%	Pass
3.00	2.98	-0.67%	-5%	5%	Pass
3.30	3.29	-0.30%	-5%	5%	Pass

Flow rate accuracy **All Tests Pass**

Flow control accuracy

Set flow point (litres/min)	Inlet pressure loading (cm H_2O)	*Measured flow rate (litres/min)*	*Error (%)*	*Error Limits (%)*		*Status*
				Min	*Max*	
2.00	10	2.00	Ref.	Ref.	Ref.	Ref.
2.00	40	1.96	-2.04%	-4%	4%	Pass

Flow control accuracy **All Tests Pass**

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Web: www.casella-es.com

CASELLA CEL

Certificate of Conformity and Calibration

Instrument Type Apex Standard I.S. Personal Air Sampler
Serial Number 4481292

Applicable standards:-

EN1232 - Workplace Atmospheres: Pumps for Personal Sampling of Chemical Agents
MDHS14/3 - General Methods for Sampling and Gravimetric Analysis of Respirable and Inhalable Dust
NIOSH 0600 - Particulates Not Otherwise Regulated, Respirable

Test Conditions:-

Temperature	19.5	°C
Humidity	32	%RH
Pressure	1009	mBar

Test Engineer:- John Parker

Date of Issue:- October 28, 2008

Equipment Used

Air Flow Calibrator:
Type: BGI TriCal   Serial Number: Eq No 10851

Declaration of conformity

This test certificate confirms that the instrument specified above has been successfully tested to comply with the manufacturer's published specifications.

Tests are performed using equipment traceable to national standards in accordance with Casella's ISO 9001:2000 quality procedures. This product is certified as being compliant to the requirements of the CE Directive.

Test and Calibration Results :-

General tests

Item	Measured value	Lower Limit	Upper Limit	Status
Pump temperature (°C)	19.5	16.5	22.5	Pass
Battery voltage (V)	5.3	4.4	5.8	Pass
General hardware	N/A	N/A	N/A	Pass
Infrared communication	N/A	N/A	N/A	Pass

General tests All Tests Pass

Flow rate accuracy

Set flow point (litres/min)	Measured flow rate (litres/min)	Error (%)	Error Limits (%)		Status
			Min	Max	
1.50	1.51	0.66%	-5%	5%	Pass
2.00	1.98	-1.01%	-5%	5%	Pass
2.50	2.48	-0.81%	-5%	5%	Pass
3.00	2.99	-0.33%	-5%	5%	Pass
3.30	3.29	-0.30%	-5%	5%	Pass

Flow rate accuracy All Tests Pass

Flow control accuracy

Set flow point (litres/min)	Inlet pressure loading (cm H_2O)	Measured flow rate (litres/min)	Error (%)	Error Limits (%)		Status
				Min	Max	
2.00	10	1.98	Ref.	Ref.	Ref.	Ref.
2.00	40	1.94	-2.06%	-4%	4%	Pass

Flow control accuracy All Tests Pass

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CASELLA CEL

Certificate of Conformity and Calibration

Instrument Type Apex Standard I.S. Personal Air Sampler
Serial Number 4481293

Applicable standards:-

EN1232 - Workplace Atmospheres: Pumps for Personal Sampling of Chemical Agents
MDHS14/3 - General Methods for Sampling and Gravimetric Analysis of Respirable and Inhalable Dust
NIOSH 0600 - Particulates Not Otherwise Regulated, Respirable

Test Conditions:-

Temperature	19.5	°C
Humidity	32	%RH
Pressure	1009	mBar

Test Engineer:- John Parker

Date of Issue:- October 28, 2008

Equipment Used

Air Flow Calibrator:
Type: BGI TriCal **Serial Number:** Eq No 10851

Declaration of conformity

This test certificate confirms that the instrument specified above has been successfully tested to comply with the manufacturer's published specifications.

Tests are performed using equipment traceable to national standards in accordance with Casella's ISO 9001:2000 quality procedures. This product is certified as being compliant to the requirements of the CE Directive.

Test and Calibration Results :-

General tests

Item	*Measured value*	*Lower Limit*	*Upper Limit*	*Status*
Pump temperature (°C)	21	16.5	22.5	Pass
Battery voltage (V)	5.25	4.4	5.8	Pass
General hardware	N/A	N/A	N/A	Pass
Infrared communication	N/A	N/A	N/A	Pass

General tests **All Tests Pass**

Flow rate accuracy

Set flow point (litres/min)	*Measured flow rate (litres/min)*	*Error (%)*	*Error Limits (%)*		*Status*
			Min	*Max*	
1.50	1.55	3.23%	-5%	5%	Pass
2.00	2.00	0.00%	-5%	5%	Pass
2.50	2.51	0.40%	-5%	5%	Pass
3.00	3.00	0.00%	-5%	5%	Pass
3.30	3.29	-0.30%	-5%	5%	Pass

Flow rate accuracy **All Tests Pass**

Flow control accuracy

Set flow point (litres/min)	Inlet pressure loading (cm H_2O)	*Measured flow rate (litres/min)*	*Error (%)*	*Error Limits (%)*		*Status*
				Min	*Max*	
2.00	10	2.00	Ref.	Ref.	Ref.	Ref.
2.00	40	1.97	-1.52%	-4%	4%	Pass

Flow control accuracy **All Tests Pass**

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CASELLA CEL

Certificate of Conformity and Calibration

Instrument Type Apex Standard I.S. Personal Air Sampler
Serial Number 4481294

Applicable standards:-

EN1232 - Workplace Atmospheres: Pumps for Personal Sampling of Chemical Agents
MDHS14/3 - General Methods for Sampling and Gravimetric Analysis of Respirable and Inhalable Dust
NIOSH 0600 - Particulates Not Otherwise Regulated, Respirable

Test Conditions:-

Temperature	20	°C
Humidity	32	%RH
Pressure	1009	mBar

Test Engineer:- John Parker

Date of Issue:- October 28, 2008

Equipment Used

Air Flow Calibrator:
Type: BGI TriCal **Serial Number:** Eq No 10851

Declaration of conformity

This test certificate confirms that the instrument specified above has been successfully tested to comply with the manufacturer's published specifications.

Tests are performed using equipment traceable to national standards in accordance with Casella's ISO 9001:2000 quality procedures. This product is certified as being compliant to the requirements of the CE Directive.

Test and Calibration Results :-

General tests

Item	*Measured value*	*Lower Limit*	*Upper Limit*	*Status*
Pump temperature (°C)	20.5	17	23	Pass
Battery voltage (V)	5.3	4.4	5.8	Pass
General hardware	N/A	N/A	N/A	Pass
Infrared communication	N/A	N/A	N/A	Pass

General tests **All Tests Pass**

Flow rate accuracy

Set flow point (litres/min)	*Measured flow rate (litres/min)*	*Error (%)*	*Error Limits (%)*		*Status*
			Min	*Max*	
1.50	1.51	0.66%	-5%	5%	Pass
2.00	1.97	-1.52%	-5%	5%	Pass
2.50	2.47	-1.21%	-5%	5%	Pass
3.00	2.97	-1.01%	-5%	5%	Pass
3.30	3.27	-0.92%	-5%	5%	Pass

Flow rate accuracy **All Tests Pass**

Flow control accuracy

Set flow point (litres/min)	Inlet pressure loading (cm H_2O)	*Measured flow rate (litres/min)*	*Error (%)*	*Error Limits (%)*		*Status*
				Min	*Max*	
2.00	10	1.97	Ref.	Ref.	Ref.	Ref.
2.00	40	1.96	-0.51%	-4%	4%	Pass

Flow control accuracy **All Tests Pass**

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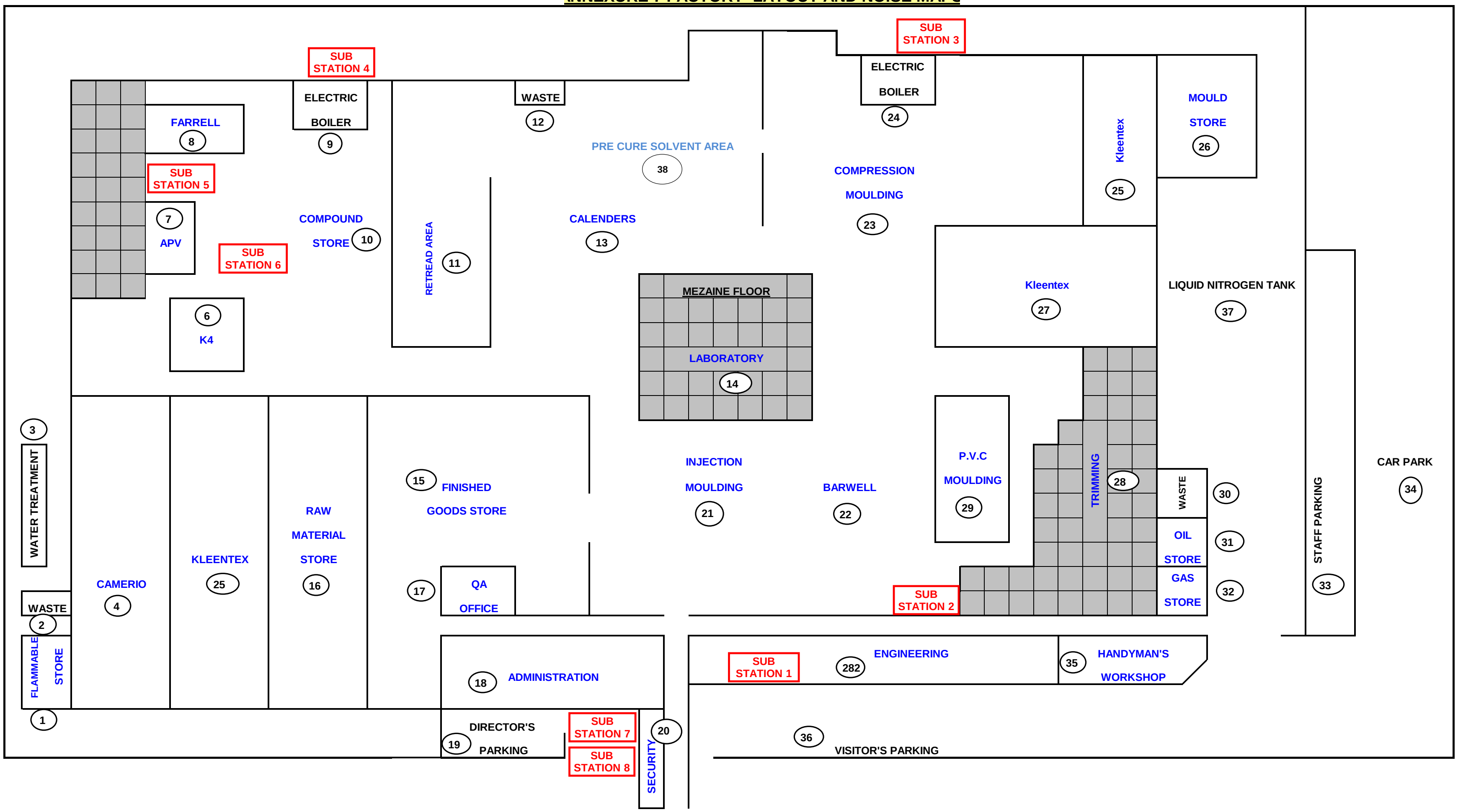
ANNEXURE 7 FACTORY LAYOUT AND NOISE MAPS

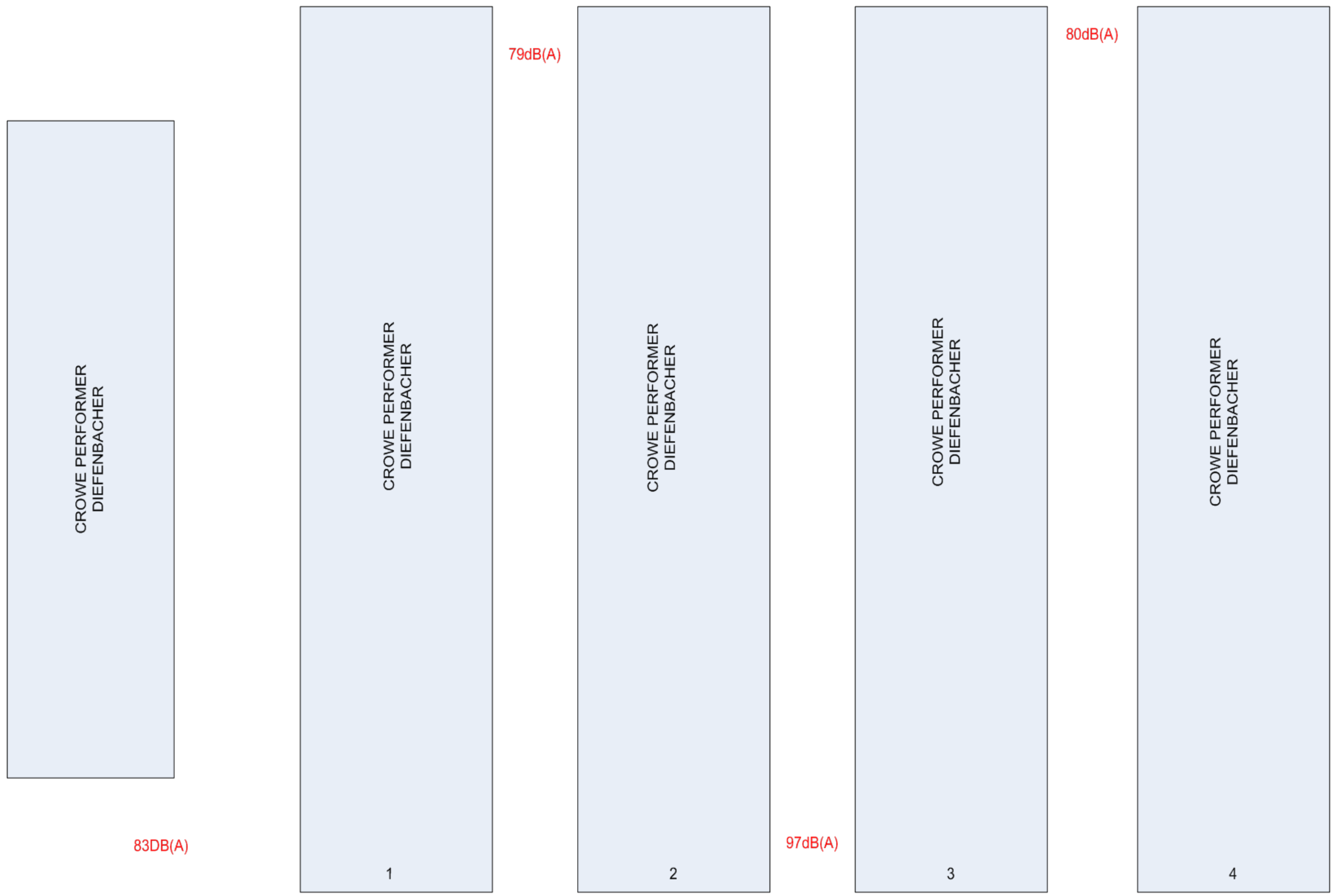


1	FLAMMABLE STORE	*11*	RETREAD AREA	*21*	INJECTION MOULDING	*31*	OIL STORE
2	WASTE AREA	*12*	WASTE AREA	*22*	BARWELL	*32*	GAS STORE
3	WATER TREATMENT	*13*	CALENDERS	*23*	COMPRESSION MOULDING	*33*	STAFF PARKING
4	CAMERIO	*14*	LABORATARY	*24*	ELECTRIC BOILER	*34*	CAR PARK
5	PVC GUMBOOTS	*15*	NISHED GOODS STOF	*25*	KLEENTEX	*35*	HANDYMAN'S WORKSHOP
6	K4	*16*	RAW MATERIAL STORE	*26*	MOULD STORE	*36*	VISITORS' PARKING
7	APV	*17*	QA OFFICE	*27*	ENGINEERING	*37*	LIQUID NITROGEN TANK
8	FARRELL	*18*	ADMINISTRATION	*28*	TRIMMING	*38*	PRE CURE SOLVENT AREA
9	ELECTRIC BOILER	*19*	DIRECTOR'S PARKIN	*29*	PVC MOULDING		
10	COMPOUND STORE	*20*	SECURITY	*30*	WASTE AREA		

NOISE MAPS: INJECTION MOULDING

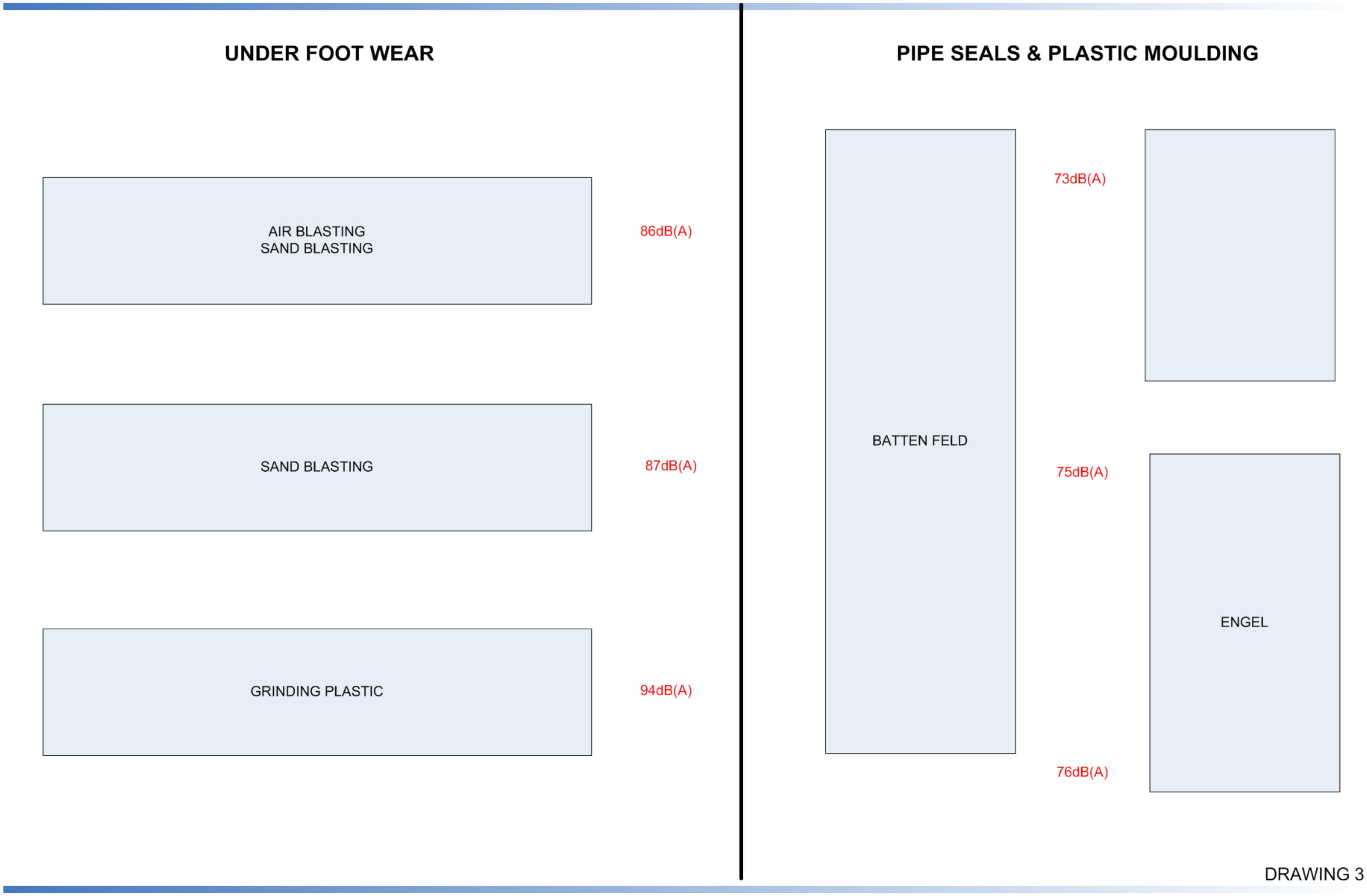
DRAWING 1

NOISE MAPS: BARWEL DEPARTMENT

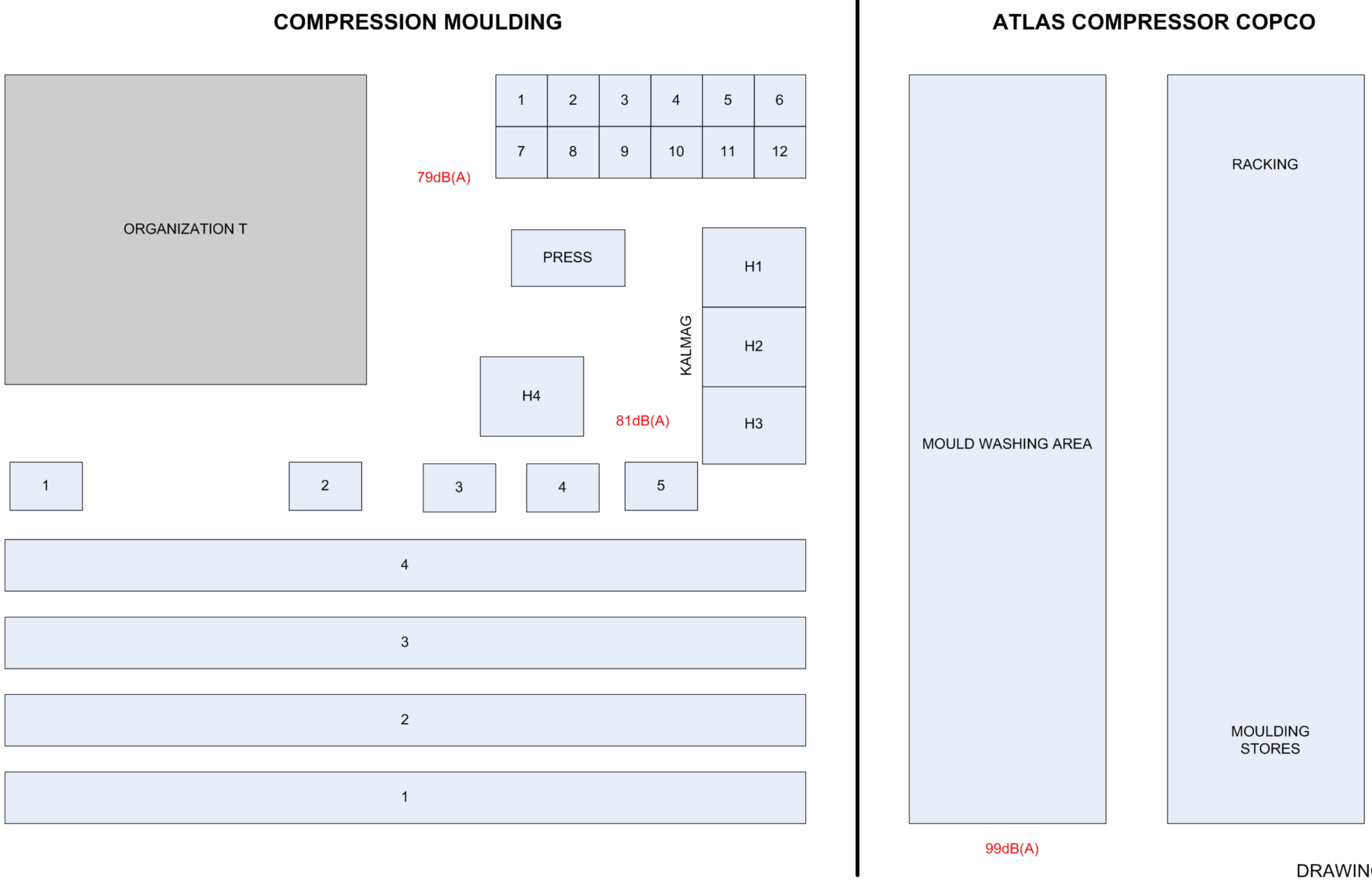


DRAWING 2

ORGANIZATION W : NOISE MAPS

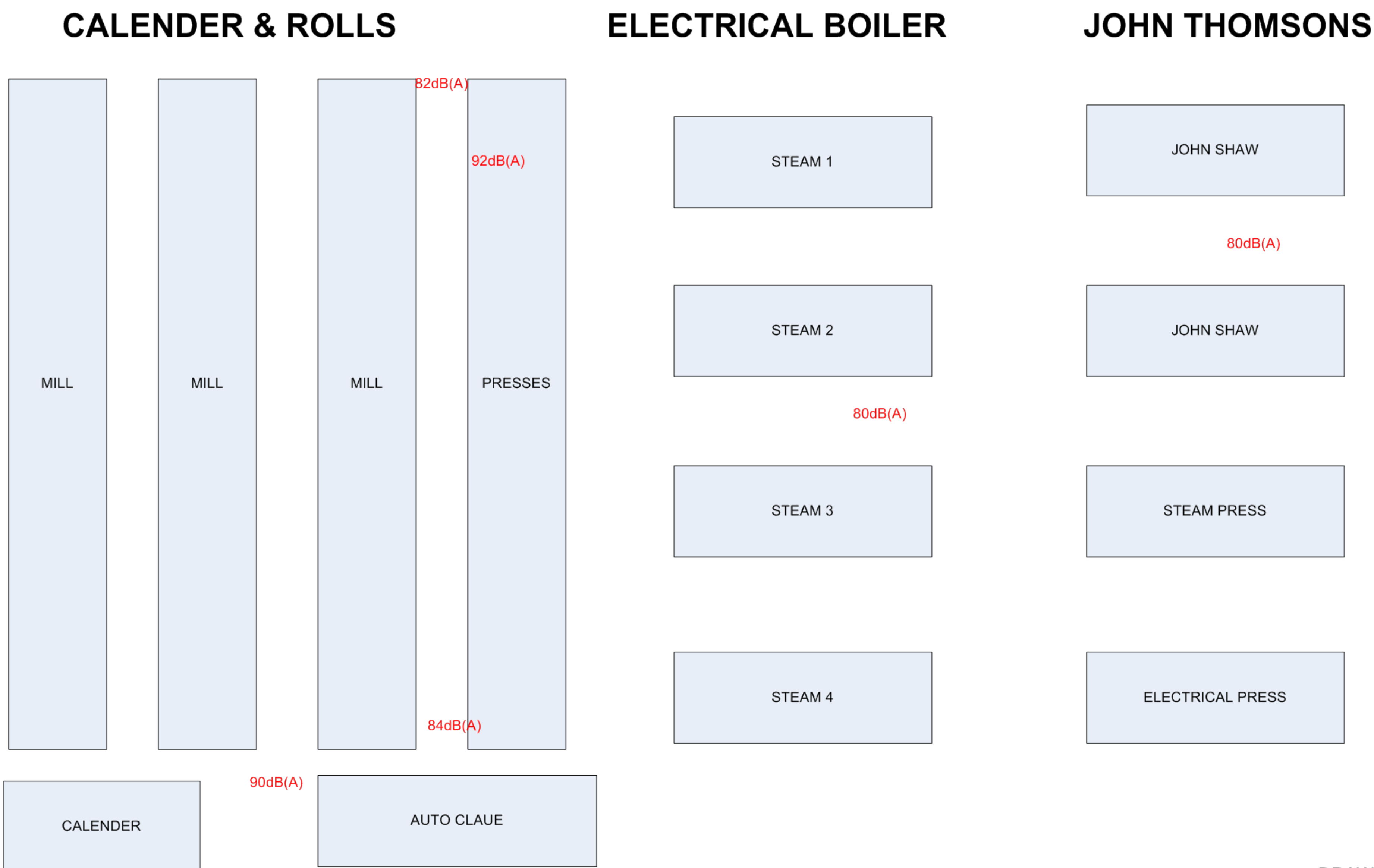


ORGANIZATION W : NOISE MAPS



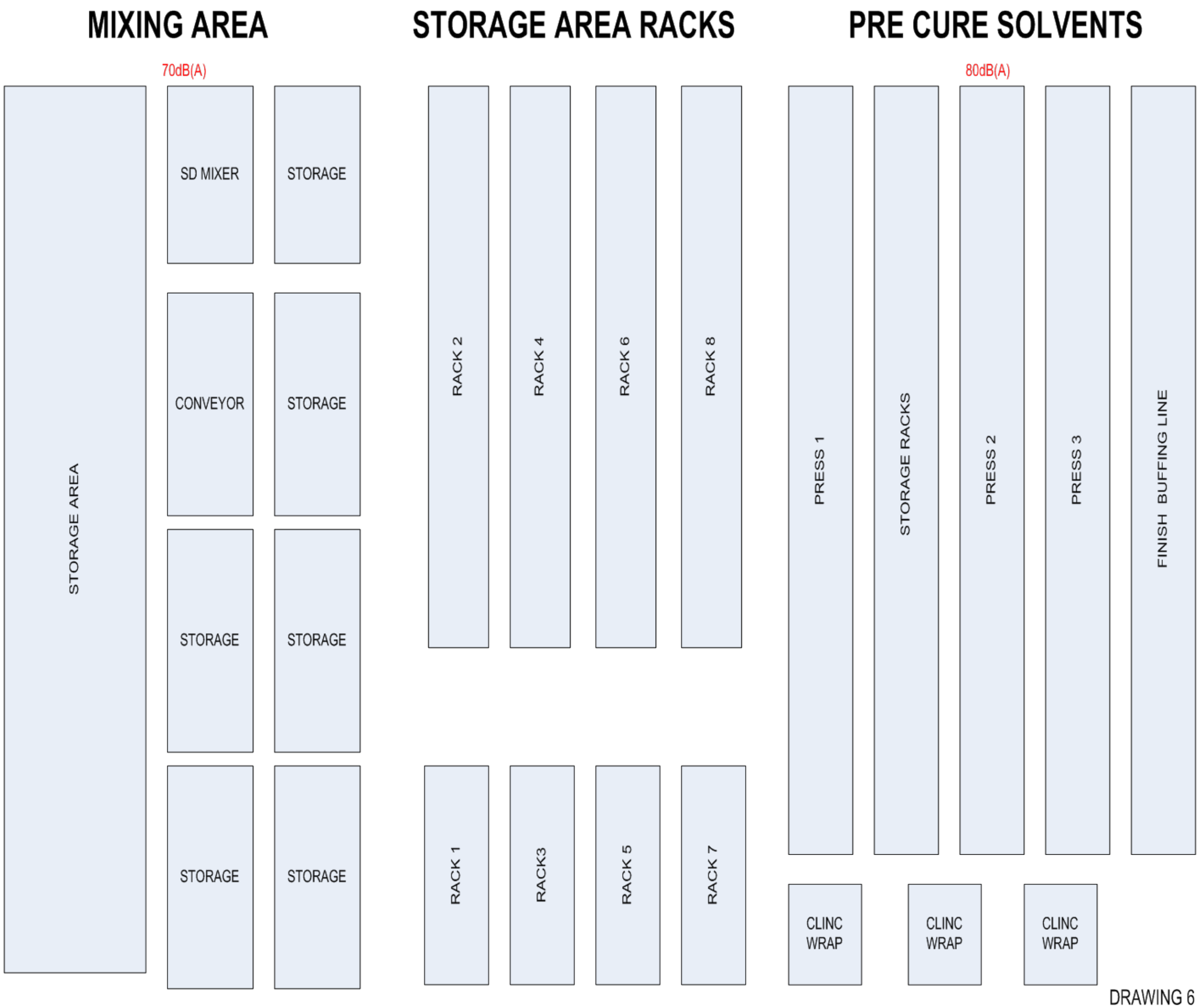
DRAWING 1

ORGANIZATION W : NOISE MAPS

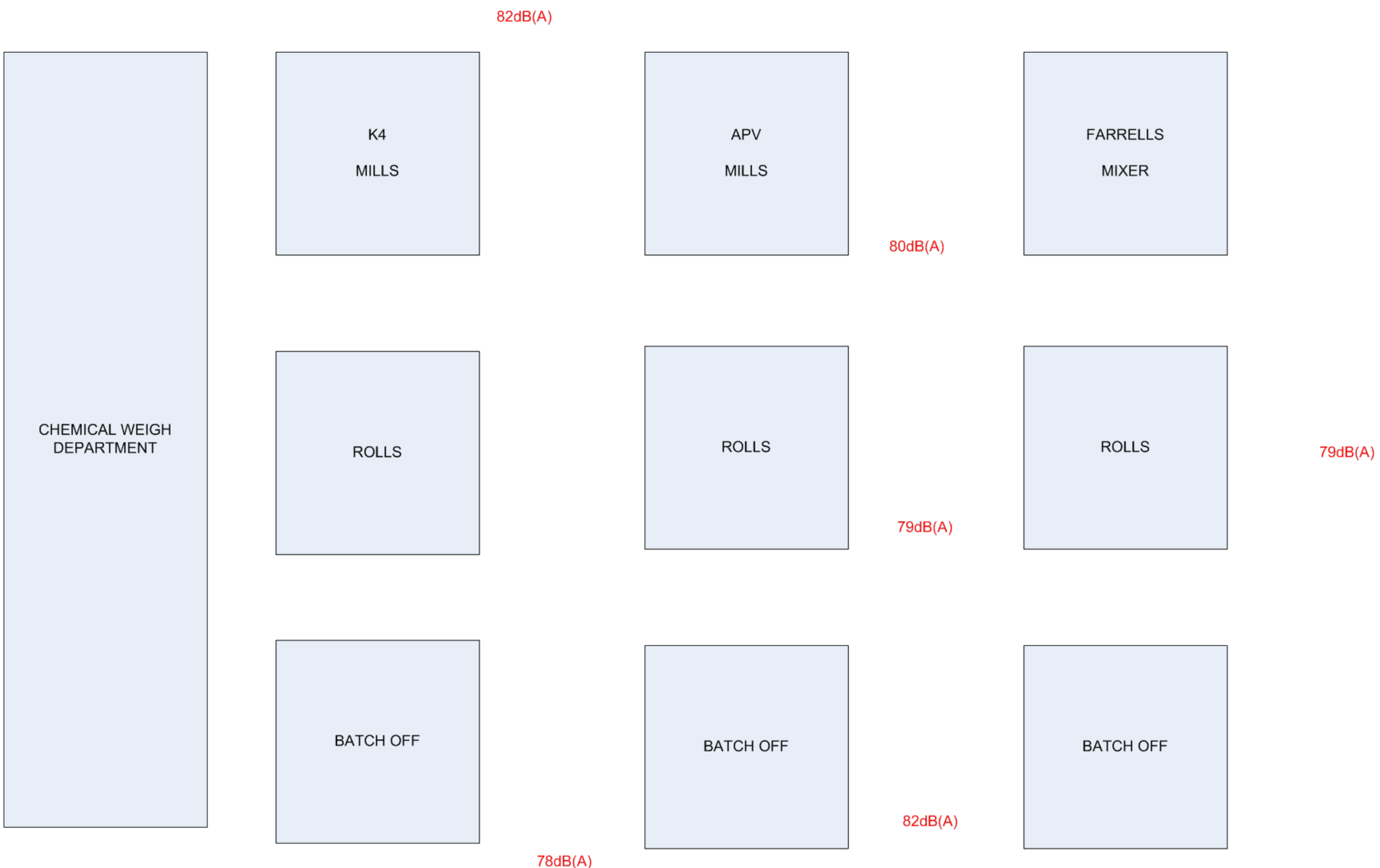


DRAWING 5

ORGANIZATION W : NOISE MAPS



ORGANIZATION W: NOISE MAPS K4 CALENDARS

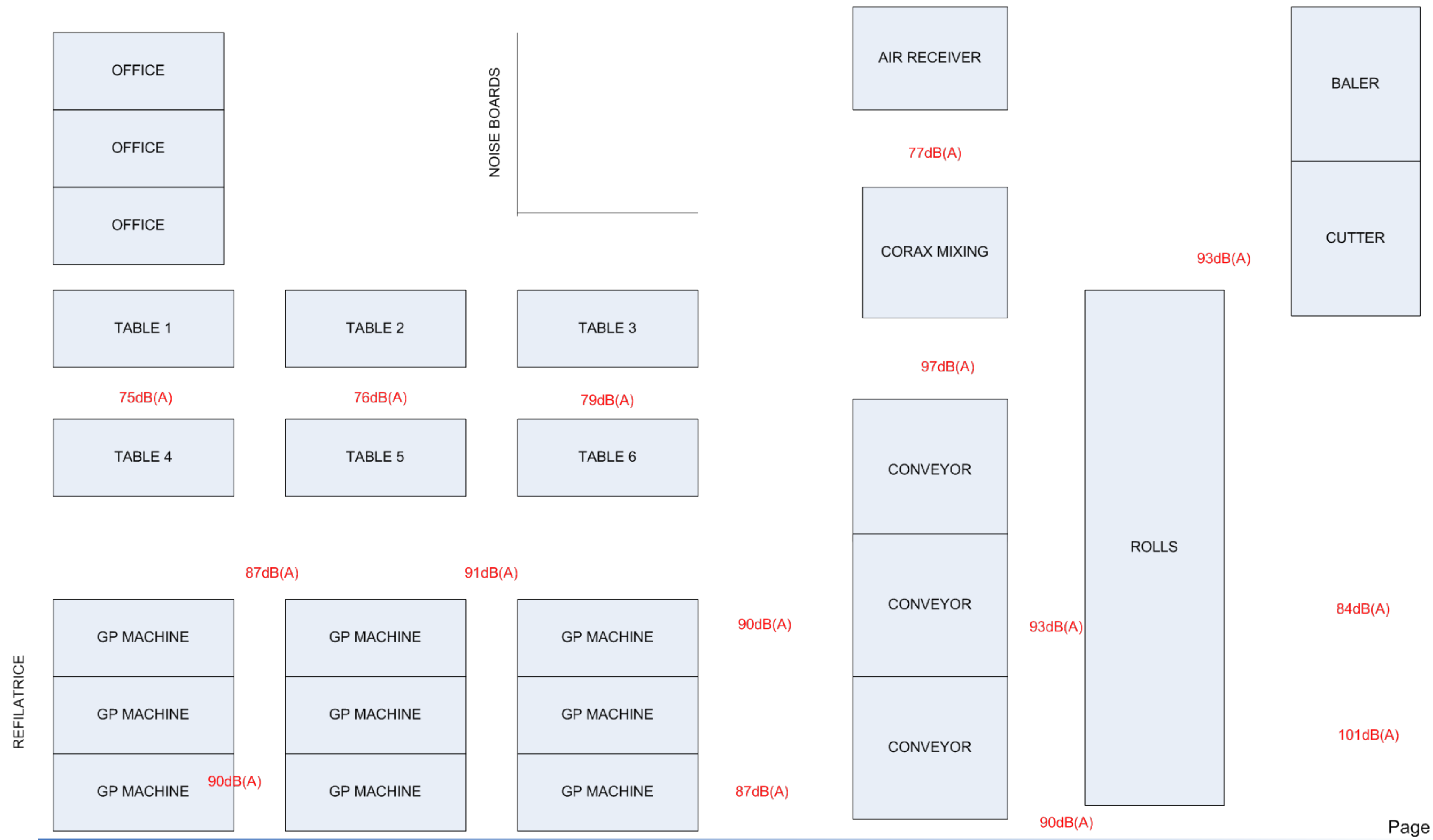


DRAWING 7

ORGANIZATION W: NOISE MAPS

TRIMMING DEPARTMENT

SECOND FLOOR



Page 8

ANNEXURE 8

LETTER OF REQUEST TO CONDUCT RESEARCH

P.O. BOX 1334 DURBAN 4000 SOUTH AFRICA

TEL: 031-3732034 Fax: 031-3732038 DIRECT FAX 086 674 0551

ivann@dut.ac.za

FACULTY OF MANAGEMENT SCIENCES

DEPARTMENT OF QUALITY AND PRODUCTION MANAGEMENT

1st December 2008

RUBBER FACTORY

REQUEST FOR PERMISSION TO CONDUCT RESEARCH AT RUBBER FACTORY

With reference to our meeting on Monday the 1st December 2008 on the above subject.

I am currently studying for the Doctorate in Technology: Quality Management with the Durban University of Technology; and I am expected to conduct a research study as a requirement for the degree. May I therefore, request your permission to conduct this study at your Rubber Manufacturing Factory.

The topic for my research is: **"A study of coexposure to chemicals and**

noise in the Rubber Industry: A Case Study”. This is a quantitative, cross sectional, descriptive study as it involves the use of a structured health questionnaire, noise and chemical survey and audiometric test to workers in the factory floor and office environment. Workers in the office environment will be the group that are not exposed to chemicals and noise. More details of the thesis will follow in this letter.

Confidentiality

This research will be conducted in the strictest confidence and in terms of the ethical issues anonymity is a prerequisite before any research can be authorised. If any of these issues are transgressed the matter will be taken very seriously in terms of the study being allowed to continue or the awarding of a degree. Therefore, be assured that the results and data captured will only be known to the researcher.

Benefits to your Organisation

In terms of the Occupational health and Safety Act, 1993 it will be in your interest to know the health status of your workers and work environment. The study will be done in the strictest of confidence only you and the researcher will be aware of the results. Legislation requires employers to determine the health status of their workers and considering that this assessment will bear no cost to your organization, it will only be of value to your organization.

Broad Outcome of Study

The research to be undertaken will include workers exposed to physical noise and chemicals in the workplace and those workers who are not exposed to physical noise and chemicals, primarily workers involved in administrative activities. The relationship of chemicals and hearing loss in South Africa is unknown, consequently there is a gap of knowledge in this area. The research intends establishing if a relationship does exist and if so the researcher will suggest precautionary measures that could be taken to prevent hearing loss from this source. The rubber manufacturing industry uses chemicals which are potentially ototoxic and workers are exposed to noise.

Sample Seize

The sample seize for the research if permission is granted will be as follows:

Rubber Manufacturing Factory	**Sample Office/Admin Workers**	**Sample Factory Floor Workers**	**Total Sample Seize**
Compounding and Banbury Mixing	5	45	50
Milling	5	45	50
Extruding and Calendaring	5	45	50
Component Assembly	5	45	50
Curing and Vulcanizing	5	45	50
Inspection and Finishing	5	45	50
TOTAL SAMPLE	**30**	**270**	**300**

Audiometric Testing

The sample population will undergo audiometric testing. The instrument that will be used for audiometric test is an audiometer with a pair of head phones. Prior to conducting the audiometric test a Noisechem Questionnaire will be completed. The approximate time to test each workers hearing is 10 minutes. The questionnaire is mainly yes/no questions, essentially to eliminate any other causes of hearing loss, which will be completed at the place of work, thereby avoiding production time loss. Audiometric tests will be conducted over all three shifts and every effort will be made to expedite the entire process.

Noise Survey

Noise maps of all areas will be drawn. The sound level meter will be used to take noise measurements. Workers will not be interrupted when noise measurements are taken.

Chemical Survey

Chemicals samples will be undertaken by using Casella Pumps, tubing and charcoal tubes. The chemical will be captured on charcoal tubes which are attached to a Casella Pump (approximate weight 600g) by means of tubing. The sampling instruments will be attached to the worker by means of harness for a period of two hours. Worker will continue their normal work activities. The charcoal tubes will be sent externally for analysis.

Conclusion

The audiometric test, noise and chemical survey will take a maximum period of two weeks. There will be three assistants accompanying the researcher over this period. The assistants will be third and fourth year Environmental Health students whom have completed the National Diploma or Bachelor of Technology in Environmental Health.

The research will provide a complete noise and chemical survey of your factory. It will also provide audiometric test of selected workers. Furthermore it will contribute to the body of knowledge on chemicals and hearing loss. The researcher assures management that there will be full disclosure of the findings to the management of the Rubber Factory. Confidentiality will be maintained at all times.

Your favourable consideration of my request will be greatly appreciated.

Yours faithfully

____

IVAN NIRANJAN

RESEARCHER

STUDENT NUMBER: 18902511

ANNEXURE 9

CONSENT FORM TO PARTICIPATE IN STUDY

DURBAN UNIVERSITY of TECHNOLOGY

FACULTY OF MANAGEMENT SCIENCES
DEPARTMENT OF QUALITY AND PRODUCTION MANAGEMENT
CONSENT TO PARTICIPATE IN RESEARCH STUDY

PROJECT TITLE: Co-exposure to noise and chemicals on hearing.

I, ______________________________________, agree to participate in this study.

I understand that I will be asked questions about my work history, noisy activities, usage of chemicals, medical history and symptoms. I will also be conducting hearing test which checks my ability to hear different sounding tones.

No information that I provide for this study can be disclosed in a way which will identify me unless I give written permission.

My participation is voluntary, and I may withdraw from the study at any given time without prejudice to myself.

Any questions I have concerning this study will be directed to the project leader, Mr. Ivan Niranjan, Durban University of Technology, P. O. Box 1334, Durban, 4001, telephone 031-373 2034.

PARTICIPANTS SIGNATURE:___________________________DATE___________

ANNEXURE 10

SOUND LEVEL METER CALIBRATION CERTIFICATE

CASELLA CEL

Certificate of Conformance and Calibration

Instrument Type	**CEL- 430.**	**Pre-amplifier**	**Integral to unit.**
Serial Number	077848	Serial Number	N/A
Firmware revision	V1.03		
Performance Class	2		
Microphone Type	**CEL-252**	**Calibrator Type**	**N/A**
Serial Number	008054	Serial Number	

Applicable Sound Level meter standards:-

IEC 61672-1 2002-5 (Electroacoustics – Sound Level Meters)
IEC 60651 1979, IEC 60804:2000, ANSI S1.4: 1983, ANSI S1

Test Conditions:-

Temperature	24	°C
Humidity	42	%RH
Pressure	1014	mBar

Test Engineer:- Anthony Dye

Date of Issue:- 19-Jul-07

Declaration of conformity

This test certificate confirms that the instrument specified above fully complies with the manufactures published specifications.

Tests are performed using equipment traceable to national standards in accordance with Casella's ISO 9001:2000 quality procedures. This product is certified as being compliant to the requirements of the CE Directive.

Test Summary :-

Self generated Noise tests	All Tests Pass
Level Linearity and Overload tests	All Tests Pass
Frequency weightings A/C/Z	All Tests Pass
F and S Time weightings	All Tests Pass
Pulse Tests	All Tests Pass
Peak C weighting tests	All Tests Pass
Acoustic Tests	All Tests Pass

Casella CEL (U.K)
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E-mail: online@casella-es.com
Web: www.casella-es.com

Page 1 of 6

ANNEXURE 11

Integration of OHSAS 18001:2007, ISO 14001:2004 and ISO 9001:2008

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
-	Introduction	-	Introduction	0 0.1 0.2 0.3 0.4	Introduction General Process approach Relationship with ISO 9004 Compatibility with other management systems
1	Scope	1	Scope	1	Scope
2	Normative references	2	Normative references	2	Normative references
3	Terms and definitions	3	Terms and definitions	3	Terms and definitions
4	Occupational Health and Safety System Elements	4	Environmental management system requirements	4	Quality management system
4.1	General requirements	4.1	General requirements	4.1	General requirements
4.2	Occupational Health and Safety policy	4.2	Environmental policy	5.3	Quality policy
4.3.	Planning	4.3	Planning	5.4	Planning
4.3.1	Hazard identification, risk assessment and determining controls	4.3.1	Environmental aspect	5.2	Customer focus
4.3.2	Legal and other requirements	4.3.2	Legal and other requirements	5.2 7.2.1	Customer focus Determination of requirement related to the product
4.3.3	Objectives	4.3.3	Objectives and targets	5.4.1	Quality objectives
4.4	Implementation and operation	4.4	Implementation and operation	7	Product realization
4.4.1	Resources, roles, responsibility, accountability and authority	4.4.1	Resources, roles, responsibility and authority	5 6	Management responsibility Resource management
4.4.2	Competence, training and awareness	4.4.2	Competence, training and awareness	6.2.2	Competence, awareness and training
4.4.3	Communication, participation and consultation	4.4.3	Communication	5.5.3 7.2.3	Internal communication Customer communication
4.4.4	Documentation	4.4.4	Documentation	4.2	Documentation
4.4.5	Control of documents	4.4.5	Control of documents	4.2.3	Control of documents

Table: Correspondence of OHSAS 18001:2007, ISO 14001:2004 and ISO 9001:2008 (continued)

Clause	OHSAS 18001:2007	Clause	ISO 14001:2004	Clause	ISO 9001:2008
4.4.6	Operation control	4.4.6	Operation control	7 7.1 7.2 7.3 7.4 7.5	Product realization Planning of product realization Customer related process Design and development Purchasing Production and service provision
4.4.7	Emergency preparedness and response	4.4.7	Emergency preparedness and response	8.3	Control of nonconforming product
4.5	Checking	4.5	Checking	8	Measurement analysis and improvement
4.5.1	Performance measurement and monitoring	4.5.1	Monitoring and measurement	7.6 8.2	Control of monitoring and measuring devices Monitoring and measurement
4.5.2	Evaluation of compliance	4.5.2	Evaluation of compliance	8.2.3 8.2.4	Monitoring and measurement of processes Monitoring and measurement of product
4.5.3	Incident investigation, nonconformity, corrective action and preventive action	-	-	-	-
4.5.3.1	Incident investigation	-	-	-	-
4.5.3.2	Non-conformity and corrective and preventive action	4.5.3	Non-conformity and corrective and preventive action	8.3 8.4 8.5.2 8.5.3	Control of non-conforming product Analysis of data Corrective action Preventive action
4.5.4	Control of records	4.5.4	Control of records	4.2.4	Control of records
4.5.5	Internal audit	4.5.5	Internal audit	8.2.2	Internal audit
4.6	Management review	4.6	Management review	5.6	Management review