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PERSONAL OCCUPATIONAL EXPOSURE TO TOTAL WELDING FUME

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Public Health (Occupational Hygiene).

DECLARATION

I, Dave Pooke Seleme, declare that this report is based upon my own research studies. The work is being submitted for the degree of Master of Public Health in the field of Occupational Hygiene at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any qualification or examination at this or any other university. The Senate Plagiarism Policy is signed and attached as Appendix One.



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DP Seleme

03 November 2016

ACKNOWLEDGEMENT

This study would have not been successful without the financial assistance from my employer. I will also want to extend the word of gratitude to my supervisor, Dr. Andrew Swanepoel for guidance in the process and editing of the report. Thanksgiving also go to Mr. Lethlogonolo Mokgobo and Sakhele Gqabaza for their guidance and assistance in the statistical analysis of the data as well as Dr. Mmuso Ramantsi for informative discussion on occupational diseases.

ABSTRACT

Background: The primary route of occupational exposure to total welding fume is through inhalation. Recurrent and prolonged inhalation via occupational exposure to total welding fume at concentrations above the 5 mg/m^3 is likely to cause pulmonary and respiratory diseases, such as metal fume fever, chronic bronchitis, occupational asthma, manganese poisoning and arc welder's siderosis. The severity of the personal occupational exposure to total fume is determined by a number of factors which entail the composition of the welding electrode, welding base, the type of welding, the surface coating of the welding base, welder's positioning and the effectiveness of existing control measures.

Aim and Objectives: This study aimed to determine if employees were overexposed to total welding fumes during Manual Metal Arc (MMA) welding operations in a workshop environment of a large coal-fired power generating utility from August to September 2011, in the Free State province of SA. The specific objectives for this study were:

- To describe personal occupational exposure to total welding fume;
- To compare personal occupational exposure to total welding fume to the Occupational Exposure Limit (OEL) of 5 mg/m^3.
- To identify the most exposed occupations

Methodology: This employed a descriptive cross-sectional study design. This study was conducted in a workshop in the Free State province of South Africa (SA), during MMA welding operations spanning August to September 2011. The personal dust samples of total welding fume were collected in strict accordance with Part 1 of International Standards Organization (ISO) 10882 of 2001 and were compared to the SA OEL of 5 mg/m^3. The personal dust samples of total welding fume were collected by a sampling train which consisted of constant battery operated sampling pump, flexible tubing, open-face cassette, 37 mm mixed cellulose acetate filter. The assembled and calibrated sampling trains were positioned inside the welding helmets of the employees within the breathing zone during data collection. Data was analysed by means of gravimetric weighing followed by determination of personal occupational exposure concentrations by standard calculations.

Results: Fifty samples of personal occupational exposure to total welding fume were collected. Two samples exceeded the occupational exposure limit of 5 mg/m^3. The sum of the personal occupational exposure concentrations to total welding fume was 95.91 mg/m^3.

The arithmetic mean was 1.918 mg/m^3 and median 1.595 mg/m^3. The highest (maximum) measured personal occupational exposure concentration was 7.12 mg/m^3 whilst the lowest (minimum) was 0.46 mg/m^3. The geometric mean was 1.631 mg/m^3, geometric standard deviation 1.742 mg/m^3 while the standard deviation was 1.278 mg/m^3. The percentage exceedance of the occupational exposure limit was 4%.

Conclusion: This study indicated that students were the most exposed employees followed by welders, utility personnel and boilermakers. This was due to students performing extensive welding, and the resultant incorrect students positioning during welding.

Recommendations: Existing engineering control measures, which included blower fans and local extraction ventilation system (LEV) must be sustained and maintained in good working order in order to reduce personal occupational exposure to total welding fume. Furthermore a mobile local extraction ventilation system must be provided. The issued disposable particulate mask with a protection factor of FFP2 must be substituted with a ventilated disposable particulate mask with the same protection factor (FFP2) but that is lined up with activated carbon layer. The disposable particulate mask with a protection factor of FFP2 means that it will offer inhalation protection against the total welding fume exposure concentrations up to 10 times the occupational exposure limit if properly used as opposed to FFP1 which offers inhalation protection up to 5 times the occupational exposure limit. The disposable particulate mask with a protection factor of FFP3 offers a better protection than the one with FFP1 and FFP2 as it protects up to 20 times the occupational exposure limit. The proper usage, care and maintenance of the disposable particulate mask are important elements in achieving the maximum inhalation protection. The activated carbon layer will assist in the capturing of the gaseous components of the welding pollutants which will prevent the inhalation of such gaseous components by exposed employees.

TABLE OF CONTENTS

1. CHAPTER 1: INTRODUCTION, LITERATURE REVIEW, AIMS & OBJECTIVES 13

1.1. Background Information 13

1.2. Introduction 14

1.3. Statement of the Problem 15

1.4. Justification for the study 16

1.5. Literature Review 17

1.6. Study Objectives 22

2. CHAPTER 2: MATERIALS AND METHODS 23

2.1. Study Design 24

2.2. Study Setting 24

2.3. Study Population 24

2.4. Study Sample 25

2.5. Measurement and Data Sources 26

2.6. Data Processing Methods and Analysis Plans 32

2.7. Ethical Considerations 34

3. CHAPTER 3: RESULTS 35

4. CHAPTER 4: DISCUSSIONS 42

5. CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS 47

6. REFERENCES 50

7. SIGNED SENATE PLAGIARISM POLICY 54

8. LIST OF TABLES

7.1.	Table 1: Demographic Description of the Study Population	22
7.2.	Table 2: List of Equipment	27
7.3.	Table 3: Statistical Representation of the Central Tendency of the Data	38
7.4.	Table 4: Statistical Representation of the Distribution of the Data	39
7.5.	Table 5: Lognormal Parametric Statistical Representation of the Data	40

9. LIST OF FIGURES

8.1. Figure 1: Picture of the Assembled 3-tier Cassette 28

8.2. Figure 2: Picture of the Calibration of the Sampling Trains 29

8.3. Figure 3: Picture of the Sampling Train Positioning Within the Breathing Zone 30

8.4. Figure 4: Picture of the Gravimetric Weighing of Filters 33

8.5. Figure 5: Sequential Representation of Data 36

8.6. Figure 6: Logprobability Plot & Least-Squares Best Fit Line 37

8.7. Figure 7: Idealized Lognormal Distribution Curve 40

8.8. Figure 8: Graphic Representation of the Most Exposed Occupations 41

10. LIST OF ANNEXURES

10.1. Annexure A: Summary of MMA Technique & Welding Fumes Induced Occupational Diseases 55

10.2. Annexure B: Copy of Electronic Bubble Flow Meter Calibration Certificate 57

10.3. Annexure C: Hazardous Chemical Substances Sampling Sheet 58

10.4. Annexure D: Copy of Professional Registration Certificate 59

10.5. Annexure E: Copy of the Mettler Calibration Certificate 60

10.6. Annexure F: Copy of Ethics Clearance Form 61

10.7. Annexure G: Copy of the Letter Requesting Permission 62

10.8. Annexure H: Consent to Participate in the Research Study 64

DEFINITIONS

A

Approved Inspection Authority is any person / entity who with the aid of specialized knowledge or equipment can make special findings regarding the health and safety of persons, the health or risk to health of any work / substance and confirm if exposure has been exceeded or not. Such person shall be approved by the Chief Inspector of the South African Department of Labour (1).

C

Cyclone is a device which is used in the sampling of the respirable particulate. It separates the coarse or non-respirable dust from respirable dust, thus collecting it in a grit pot (2).

F

Fumes are defined as solid particles generated by condensation from the gaseous state, generally after volatisation from molten metals. The particle size of the fumes is less than 1 micron. This means that the total welding fumes, once inhaled, can penetrate the alveolar space (gaseous exchange of the lung) (3).

G

Gravimetric weighing technique is an analysis whereby the filter discs are weighed before and after the sampling. The mass is derived from the subtraction of the weight of the filter discs before sampling from the weight of the filter discs after sampling. This technique is used mainly to determine the concentrations of particulate airborne contaminants.

H

Hazardous Chemical Substances means any toxic, harmful, corrosive, irritant or asphyxiant substances or a mixture of such substances for which:-

- An OEL is prescribed;
- An OEL is not prescribed, but which creates a hazard to health (4).

O

Open-face sampling technique is a technique whereby total inhalable airborne contaminants / concentrations are collected on a filter paper in a three-tier cassette without the use of the cyclone.

R

Respirable particulate refers to the fraction of airborne particulate that penetrates to the gas exchange of the region of the lung (alveoli). The size of the respirable particulate is between 0.1 – 7 micron (3 & 4).

S

South African Institute of Occupational Hygienists (SAIOH) refers to a professional regulatory body of all Occupational Hygienists in South Africa.

T

TLV / OEL of 5 mg/m^3 is defined as time weighted average of the maximum airborne concentrations of total welding fume to which nearly all employees may be repeatedly exposed for a normal 8-hour work shift (or a 40-hour work week) without adverse health effects (4 & 5).

Total inhalable particulate refers to the fraction of airborne particulate that enters the nose and mouth during breathing, and is therefore available for deposition in the respiratory tract. The particle size of total inhalable particulate is between 0.1 – 20 micron (2).

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW, AIMS & OBJECTIVES

This chapter defines the main pollutant under study and its associated health effects. The national and international occupational exposure limits are presented. Various methods of assessing personal occupational exposure to total welding fume are explained and compared. The brief overview of the test environment is provided. The published literature on total welding fume exposure is reviewed and the chapter ends with the aims and objectives of the study described in this report.

1.1. Background Information

Welding is defined as a technique that is used to join metal components by the application of heat. There are approximately 100 welding & allied welding techniques, but the four most widely used manual arc welding techniques are: Gas Metal Arc Welding (GMAW), Flux-cored Arc Welding (FCAW), Shielded Metal Arc Welding (SMAW) and Tungsten Arc Welding (GTAW) (6 – 8).

SMAW is the most frequently used and popular welding technique globally and nationally (8). The most preferred industrial terminologies for SMAW are stick welding and manual metal arc welding (MMA). This study focuses on the manual metal arc only. The MMA technique uses a consumable electrode coated in flux to lay the weld. This involves the melting of an electrode by an electric current to form a molten puddle in the base metal. Because of the generated heat, the base metal also becomes molten at the joining surfaces, which bond upon cooling (6 – 8). See Annexure A.

Total welding fume is defined as the entire fume captured on the sampling filter disc and comprises of all possible constituents. The personal occupational exposure to total welding fume is determined mainly by the following factors:

- The type of welding;
- The composition of the welding electrode;
- The welding base (mild / stainless steel);
- The surface coating of the welding base;

- Effectiveness of the existing control measures; and
- The welder's positioning (2 & 9);

Employees performing welding activities are exposed to total welding fume through inhalation. The total welding fume, due to its particle size of less than 1 micron, deposits in the alveoli space, the gaseous exchange of the lung, thereby inducing ill-health.

1.2. INTRODUCTION

Recurrent and prolonged inhalation of total welding fume at concentrations above the 5 mg/m^3 is likely to cause pulmonary and respiratory diseases, such as metal fume fever, chronic bronchitis, occupational asthma, manganese poisoning, lung cancer, arc welder's siderosis (3, 10 – 13) (See Annexure A). 5 mg/m^3 is the threshold limit value (TLV) that was established by the American Conference of Governmental Industrial Hygienists (ACGIH) (5), adopted by the United States Department of Labour (referred to as Occupational Health & Safety Administration) (14) and South African Department of Mineral Resources (15).

TLVs are referred to as occupational exposure limits (OELs) in South Africa (5, 16 and 17). In South African industries, personal exposure to total welding fume is regulated in terms of Hazardous Chemical Substances Regulations, 1995. The Hazardous Chemical Substances Regulations, 1995 are incorporated into the Occupational Health and Safety Act, 1993 (Act 85 of 1993). However, the Hazardous Chemical Substances Regulations, 1995 does not specify the occupational exposure limit for the total welding fume. Personal occupational exposure to total welding fume in South African industries is evaluated against the standard of 5 mg/m^3.

Personal occupational exposure to total welding fume at concentrations below the 5 mg/m^3 does not imply that the exposed employees are safe. It also does not imply that the exposed employees are free from a risk of developing pulmonary & respiratory diseases. Employees respond differently to exposure due to individual susceptibility, historical exposure and individual predisposition as a result of underlying medical conditions.

Welding operations do not emit welding fumes only, but a variety of other stressors / hazards, which are classified into physical, chemical and ergonomic. The physical stressors emitted during welding operations include, noise, electric magnetic fields, ultraviolet radiation and electric shock. The chemical stressors include welding fumes, gases, metal surface coatings or surface contaminants. Ergonomic stressors include awkward body postures, manual handling and bending (9).

This study focuses only on the personal occupational exposure to total welding fume during Manual Metal Arc (MMA). Physical stressors, ergonomic stressors and chemical stressors (gases & other components of total welding fume) are subjects of future researches as this study focuses on total welding fume and **are therefore excluded from this study.**

1.3. Statement of the problem

Employees performing welding operations are at a risk of developing pulmonary and respiratory diseases. South Africa has a widespread occupational lung / respiratory disease problem and to date, there is limited scientific literature indicating the contribution of welding fumes to the South African occupational disease burden. There is a large workforce performing welding in South Africa from welders at the streets to welders in industries hence the importance of this study in South Africa.

Once welders become ill resulting from occupational exposure to welding fumes, they will be booked off work. This has significant cost implications for employers due to loss of productivity, criminal or civil litigation, high compensation premiums and medical expenses. Should the exposed welder passes away, as a result of occupational exposure to welding fumes, this will prove costly to his family in terms of loss of income, society & nation at large in terms of loss of skills. Therefore, it is of utmost importance to quantify employees' occupational exposure to total welding fume followed by establishment and implementation of the state-of-the art engineering control measures and good work practices to reduce exposure.

1.4. Justification for the study

It is evident that employees performing welding operations are at a risk of developing respiratory diseases. The degree of the risk is determined by the type of welding, composition of the welding rod, welding base (mild / stainless steel), surface coating of the welding base, airborne concentrations of the welding fumes, duration and frequency of welding, welders' positioning and distance, breathing rate, individual predisposition as a result of underlying medical conditions as well as the effectiveness of the existing control measures.

Internationally, there are limited empirical studies on occupational exposure to total welding fume whereby the total welding fumes concentrations have been quantified across the range of work environments. However, there is extensive literature and scientific papers on the health effects associated with exposure to total welding fume and its constituents.

In South Africa, if one excludes confidential occupational hygiene surveys on occupational exposure to total welding fume, there is no scientific study on occupational exposure to total welding fume and on its health effects. The occupational hygiene survey reports are not available to members of public. This practice disadvantages welders from small scale production and repair work (panel beaters / motor vehicle repair industries) as they cannot afford the services of the Approved Inspection Authorities. Most of these welders perform welding without the benefit of any form of protective devices, not even the welding helmet. This leaves them exposed to welding fumes. Their level of knowledge on occupational exposure to total welding fume further aggravates their exposure.

This study seeks to provide evidence about personal occupational exposure to total welding fume during MMA welding operations. It also serves as a starting point for future studies on personal occupational exposure to total welding fume and its constituents nationally and internationally. This study will add to employers' knowledge on personal occupational exposure to total welding fume and encourage them to consider prevention and control strategies to prevent respiratory diseases among welding employees.

1.5. Literature Review

In Finland, it is estimated that approximately 13 000 employees work as full-time welders, while the corresponding number in the USA is greater than 400 000 (18). In 2008, over 390 000 welders were reported in the USA while over 1 million full-time welders were working worldwide (19).

The occupational exposure to total welding fume poses a global challenge to employers. It has been estimated that approximately 30 to 40 % of all welders have experienced metal fume fever at some time (18). In the United States of America (USA), private sectors suffered a loss of production time due to 80 employees who had a number of days away from work in 2000 due to metal fume fever and 100 in 2004 due to bronchitis (20).

The welders performing welding operations in Iran were exposed to welding fumes at concentrations above TLV of 5 mg/m^3. The study further confirmed that welders have a higher prevalence of respiratory symptoms (11). A study to describe the cases of occupational asthma due to stainless steel welding fumes at the Finnish Institute of Occupational Health during 1994 – 2003, discovered that dyspnoea was the most frequently reported work-related respiratory symptoms. After a follow-up assessment seven welders were recommended for compensation for occupational disease (21). However, the conclusion on personal exposure conditions was drawn from patient interviews only, without the aid of measurement results of total welding fume concentrations.

The study performed in an automotive industry in Malaysia from five assemblers performing welding on the assembly line on a daily basis for the 8-hour shift indicated measurements below both Occupational Health and Safety Association and American Conference of Governmental Industrial Hygiene limits. The study identified Cobalt, Carbon Monoxide Gas and Carbon Dioxide Gas as the main constituents of the welding fume through atomic absorption spectrometry (22). The atomic absorption spectrometry is the analytical technique recommended by the National Institute of the Occupational Safety and Health (NIOSH) for the elementary analysis of the total welding fume (23).

Epidemiological studies conducted between 1927 and 1986 of employees exposed to welding fumes provided adequate evidence that these employees were at an increased risk of contracting respiratory diseases (24). Some studies have suggested that an increased

risk of lung cancer was associated with welding on stainless steel components (13 & 21). Most of these studies concluded an association of occupational exposure to welding fumes and respiratory diseases, based on toxicological evidence whereby rats and rabbits were exposed to welding fume and its constituents at high concentrations in a chamber. The rats and rabbits developed respiratory diseases such as occupational asthma, lung cancer, siderosis, bronchitis and metal fume fever (24).

The basis of the conclusion of these studies was also premised on the assumption that welders who had welding as their primary and only occupation, without any historical work exposure, developed respiratory diseases (21 & 24). Although this could be true, it is not advisable to draw a conclusion on the association of occupational exposure and development of the ill-health with the absence of specific exposure information. The critical assessment of the workplace and airborne quantification monitoring reports are important parameters to inform the conclusion of whether there is an association or not, because employees could be exposing themselves to other hazardous chemical substances outside their work environment.

Welders with exposure longer than 9 years, showed a significant reduction in lung function performance (spirometry) (25). This is indicative of a pattern of obstructive airways diseases. A study conducted to describe the nature and extent of work-related respiratory diseases, discovered that South Africa has a widespread occupational lung disease problem and provided a platform for targeted prevention strategies (26).

Extensive literature has demonstrated that stainless steel welding fumes induce more lung injury and inflammation, and are retained in the lungs longer than mild steel welding fume. This is substantiated by the fact that welding on stainless steel base produces chromium (15 – 30%) and nickel (5 – 10%), which are carcinogenic (cancer-causing agents) as compared to iron (80 – 95%), emitted mostly during welding on mild steel components, which is inert (21 & 24). These are not the only constituents from welding fume as discussed above, others include manganese, copper, aluminium, magnesium, zinc, cadmium, depending on the type of welding and the component being welded (9).

At the current movement the occupational exposure limit of 5 mg/m^3 for total welding fume had been established under the South African Mine Health and Safety Act, 1996 only. ACGIH through continued research removed the TLV for total welding fume from their

ACGIH TLV booklet, 2010. OHSA and South African Hazardous Chemical Substances, 1995 had never established the occupational exposure limit for the total welding fume. The South African Mine Health and Safety Act, 1996 adopted the occupational exposure limit of 5 mg/m^3 from the ACGIH more than 30 years ago and had never reviewed it. The basis for removal of the occupational exposure limit of 5 mg/m^3 for total welding fume had been due to the fact that the composition of the welding fume varies greatly as discussed above.

The South African's Hazardous Chemical Substances Regulations, 1995, OHSA Workplace Exposure Limits, and ACGIH TLVs have assigned different occupational exposure limits to different welding fumes constituents due to their different toxicity levels. The ACGIH TLV booklet expresses occupational exposure limit for chromium as 0.5 mg/m^3, nickel as1.5 mg/m^3, iron 5 as mg/m^3, Aluminium as 1mg/m^3, copper as 0.2 mg/m^3, magnesium oxide as 10 mg/m^3 and manganese as 0.2 mg/m^3 (4,5 & 14).

OHSA and ACGIH review their hazardous chemical substances occupational exposure limits / threshold limit values / standards on annual basis through research in a quest to further lower the occupational exposure limits. The South African Department of Labour has currently set up the technical steering committee to review the South African hazardous chemical substances occupational exposure limits which were adopted more than 30 years ago from OHSA and ACGIH. This highlights the importance of over and above the sampling of personal dust of total welding fume it is equally importance to perform elementary analysis to determine the presence of different welding fume constituents. The South African Hazardous Chemical Substances Regulations, OHSA Workplace Exposure Limits and ACGIH TLV booklet state that where there are additive effects, the exposure shall be assessed and should not exceed 1.

Some studies have suggested that welding fume may cause various respiratory diseases. Such studies revealed that different welding constituents cause different respiratory diseases as follows iron causes siderosis, manganese causes chronic manganese poisoning (parkinson's disease), silica causes silicosis, fluorides causes occupational lung disease, zinc oxide causes metal fume fever, copper causes metal fume fever, cadmium causes acute chemical inhalation lung injury (27).

Although NIOSH publications has appreciated previous studies on the health effects of welding, it noted lack of data to determine whether welders are exposed to those or other

fume components at levels that would trigger the effects and understanding how exposures at given levels may lead to serious long term effects (28).

The study of 200 welding apprentices in which airway reactivity and acute respiratory responses were measured during the day classes in a welding shop discovered that average exposure levels were below the permissible exposure limits (29). The study further highlighted that controls for welding exposures such as ventilation and respiratory protective equipment were implemented. The implementation of these control measures may have reduced welding apprentices' exposure to a larger extent.

The technical assistance of branch of NIOSH performed health hazard evaluation at Morton Metalcraft, North Caroline following concerns regarding potential health effects to due exposure to welding fumes. The health hazard evaluation revealed that employees were exposed to various constituents of welding fumes at concentrations below their respective occupational exposure limits. The most prominent collected metal was iron with the highest personal concentrations of 4 mg/m^3 which was below the recommended NIOSH exposure limit of 5 mg/m^3. The gravimetric weighing was performed in accordance with NIOSH 0500 while elementary analysis was performed in accordance with NIOSH 7300 (30).

A study conducted between 2008 and 2011 by Weldox Study Group in a plant where flux-cored arc welding was conducted sampled 12 welders. The personal sampling of the total welding fume was performed inside the welding helmets during one shift. Urine and blood samples were taken after the shift to ensure the determination of chromium and nickel in both the air and blood samples. The study revealed that the personal exposure concentrations to total welding fume, chromium, nickel and manganese were reduced in 2011 from 2008. Manganese fume was reduced from 399 ug/m^3 to 6.8 ug/m^3, chromium from 187 ug/m^3 to 6.3 ug/m^3 and nickel from 76 ug/m^3 to 2.8 ug/m^3 (31)

Urinary metal concentrations were reduced as follows: chromium from 14.8 ug/l to 4.5 ug/l and nickel from 7.9 ug/l to 3.1 ug/l. The biological manganese concentration was reduced from 12.8 ug/l to 8.9 ug/l. The study attributed this reduction to improved exhaust ventilation system and the use of welding helmets with purified air supply (31).

A study conducted in Saudi Arabia indicated that welders in four of the six factories, performing MMA welding operations, were exposed to total welding fume at concentrations

above Saudi Standards, Metrology & Quality Organization (SASO)'s limit of 5 mg/m^3 (32). The SASO has set an OEL for total inhalable particulate as 15 mg/m^3 and respirable particulate as 5 mg/m^3. However, this study must be read with careful considerations of the following limitations:

- The measured occupational exposure concentrations were compared against the respirable OEL of 5 mg/m^3. There is no indication of whether the cyclone was used or not.
- If cyclones were not used in the collection of airborne total welding fume concentrations (which is normally the case with the sampling of total welding fume), then the measured occupational exposure concentrations should have been compared to the OEL of 15 mg/m^3. In this case the measured occupational exposure concentrations would have not exceeded the OEL.

Although the size of the total welding fume suggests that total welding fume is respirable in nature, the occupational hygiene sampling methods still recommend the use of open-face sampling technique.

All the 320 samples of occupational exposure to total welding fume taken in a big production plant in Arak, Iran exceeded the ACGIH TLV of 5 mg/m^3, during MMA and MIG welding operations (11). The fact that all the samples, which were taken over a number of days, exceeded the TLV leaves no room for the questioning of the representation and reproducibility of the sampling results. These exposure conditions are likely to cause respiratory diseases and require urgent management attention.

In summary, extensive literature reviews indicated that recurring and prolonged exposure to total welding fume puts exposed employees at a risk of developing pulmonary and respiratory diseases. The risk of developing pulmonary and respiratory diseases is influenced by a number of factors, which include different welding techniques. There are extensive documented epidemiological studies on the pulmonary effects of welding fumes conducted in various settings but limited information on the casualty, dose-response and possible underlying mechanisms regarding the inhalation of welding fume exists (33).

1.6. Study Objectives

The aim of this study was to determine if employees were overexposed to total welding fumes during MMA welding operations in a workshop environment of a large coal-fired power generating utility from August to September 2011, in the Free State Province of SA, with the following as the specific objectives:

- To describe personal occupational exposure to total welding fume;
- To compare personal occupational exposure to total welding to the OEL of 5 mg/m^3.
- To identify the most exposed occupations.

CHAPTER 2: MATERIALS AND METHODS

This chapter gives an account of the study design and description of the study setting, population and sample. The method used for assessing personal occupational exposure to total welding fume is explained, the materials used for data collection are listed. The measurement and data sources and possible limitations are discussed. The chapter concludes with data processing methods and analysis plan where the data collection quality control and data management quality control are outlined.

These study objectives were attained by means of descriptive cross-sectional study design (34 & 35). There are a number of internationally available methods for measuring personal occupational exposure to total welding fume. These methods include the following:

- National Institute of Occupational Safety & Health (NIOSH) Analytical Method 7300;
- Part 1 of International Standard Organization (ISO) 10882 of 2001 (2 & 36);

The measurement of personal occupational exposure to total welding fume was conducted in strict accordance with Part 1 of International Standard Organization (ISO) 10882 of 2001 (2 & 36). This is an internationally accepted method for determination of total welding fume exposure concentrations and provides guidance on location of the sampling train and specifies the flow rate and sampling duration.

This method was preferred above NIOSH Analytical Method 7300 because it specifies that the sampler must be positioned inside / behind the welder's helmet (visor) / face shield and within the breathing zone (within 30 cm of their breathing zone (nose & mouth)). Whereas the other methods only specify that the sampler must be positioned within the breathing zone.

The positioning of the sampler inside the welding helmet provides more accurate exposure concentrations that the employee is exposed to. This practice provides more representative exposure concentrations as opposed to positioning the sampler outside the welding helmet. The welding helmet serves as a shielding / barrier when the sampler is placed inside / behind the welding helmet and exposure concentrations are representative of what employees are exposed to.

2.1. Study Design

This study employed a descriptive cross-sectional study design (34 & 35). The descriptive cross-sectional study design was appropriate to this study mainly because the study focused on the description and quantification of personal occupational exposure to total welding fume at a particular point in time (August – September 2011). It provides a snapshot of personal occupational exposure to total welding fume.

2.2. Study Setting

This study was conducted in a workshop of a large coal-fired power generating utility in the Free State Province of SA, during MMA welding operations. The activities which take place in this workshop include MMA welding, Metal Inert Gas (MIG) welding, argon Tungsten Inert Gas (TIG) welding, plasma cutting and oxy-acetylene gas cutting. These activities are performed on a daily basis for approximately six hours, on an intermittent basis. This workshop provided a better setting for this study than other workshops, due to daily and prolonged MMA welding operations. It represents welding operations in a workshop environment in South Africa. This allowed quantification monitoring to take place over reasonably prolonged durations.

2.3. Study Population

Data for this study was collected from staff located in the workshop. The workshop had a staff complement of 19 employees at the period of data collection. The staff complement consisted of the following occupations: supervisor (1), planner (1), welders (5), boilermakers (4), utility men (4) and students (4). There were 14 males and 3 females. All employees were professionals in their different trades and worked eight hours per day (no night shifts). The socio-demographic data of the study population was deemed unnecessary due to the fact that the study did not focus on the social behavior.

Table 1: Demographic description of the study population

Gender	Profession / Trade	Age Category	Minimum Level of Education	Maximum Level of Education
Males (14) Females (3)	boilermakers (4); welders (5), utility men (4) and students (4) All are qualified with exception of students who were preparing for a trade test.	25 – 50 years	N2	N3

The table above describes the study population in terms of the age category, and academic achievements / level of professionalism.

2.4. Study Sample

Fifty personal occupational exposure samples were collected over a number of days amongst welders, boilermakers, students and utility men, who performed only MMA welding and had consented to participating. Due to variations in the rate of total welding fume generation, air flow patterns, changes in work patterns (difference in work habits), all employees (welders, students, boilermakers and utility men) performing MMA welding were sampled. The fifty personal occupational exposure samples were considered adequate to enable statistical analysis. The supervisor and planner did not perform welding operations and were therefore excluded from the sample. The planner is mainly office-based while the supervisor spends 50 percent of the shift in the office and the other 50 percent in the workshop. The supervisor performs physical and visual supervision of various activities taking place in the workshop. The boilermakers, utility men, students and welders who performed other types of welding (not MMA welding) were also excluded from the sample,

the reason being that the study focussed on personal occupational exposure to total welding fumes during manual metal arc welding.

2.5. Measurement and Data Sources

2.5.1. Measurement / Sampling Materials

Calibrated sampling trains were used to collect samples / data from the work environment. These sampling trains consisted of the following items:

Table 2: List of equipment used

No.	Item	Quantity	Serial Numbers
1.	Tuff battery operated constant flow pumps	9	201021
			17791
			10471
			10472
			10474
			3121330
			1821626
			1421234
			3121324
2.	Gillian battery operated constant flow pumps	5	47E10229300
			47E10229100
			47E10229200
			47E1022900
			47E1022901
3.	∅37 mm filter cassettes (3-tiered cassettes)	50	N/A
4.	∅ 37 mm filter disc (Polyvinylchloride (PVC, 5.0µm pore size))	50	N/A
5.	∅ 37 mm filter support pads	50	
6.	∅ 37 mm cassette adaptors	10	
7.	Rubber / plastic tubing	10	
8.	In-house chemical sampling field sheet for data collection	50	
9.	Stop watch for recording measurement times	1	

The table above documents the name of the instruments and their serial numbers, quantities and consumables used to collect the data.

2.5.2. ASSEMBLY AND CALIBRATION OF MEASUREMENT MATERIALS

2.5.2.1. Assembly of measurement / sampling materials (trains)

The ∅ 37 mm support pad was transferred from the holder into a clean cassette base by means of tweezers. This act was followed by the placement of ∅ 37 mm polyvinylchloride filter disc on top of the support pad inside the clean cassette base. Both the second and third cassette components were manually squeezed into the cassette base followed by the placement of cassette adaptor into the cassette base and encapsulation by means of the masking tape. The cassette adaptor was placed into the cassette base. The encapsulation ensured that there was no air leakage during sampling. The assembly of the 3-tier cassette was then completed and ready for open-face sampling and is illustrated in Figure 1 below. The 3-tier cassette prevents filter from tearing during sampling as opposed to 2-tier cassette.

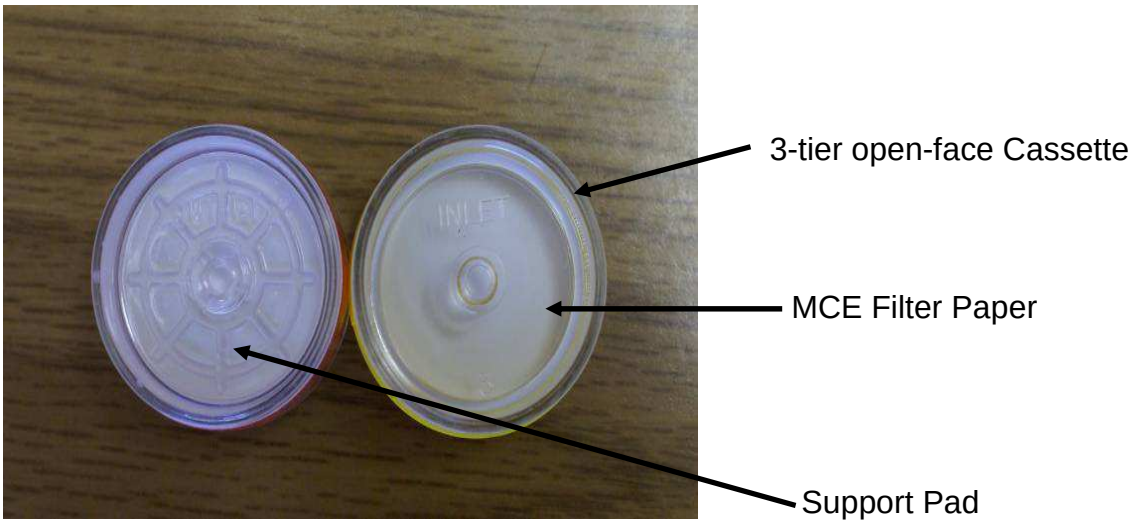


Figure 1: Assembled 3-tier filter cassette

The flexible tubing was manually connected to the sampling pump holder followed fastening it with the cable tier. The clippers were then mounted onto the flexible tubing followed by the manual connection of the flexible tubing to the 3-tier cassette by means of cassette adaptor. The assembly of the sampling train was then completed and the sampling train was ready for pre-calibration.

2.5.2.2. Calibration of measurement / sampling materials (trains):

The sampling pump flow rates setting before data collection and flow rate verification after data collection were conducted in accordance to ISO 10882 of 2001 and in the laboratory environment (2 & 36) as illustrated in Figure 2 below. The flow rate of each sampling pump was set at 1 litre / minute by means of an electronic bubble flow meter, serial no. 0804071-S before sampling (data collection). The flow rate of each sampling pump was verified after data collection by means of the same electronic bubble flow meter and remained within the allowable ± 5% deviation field. The pre and post flow rate data was transferred to the in-house chemical field sheet.

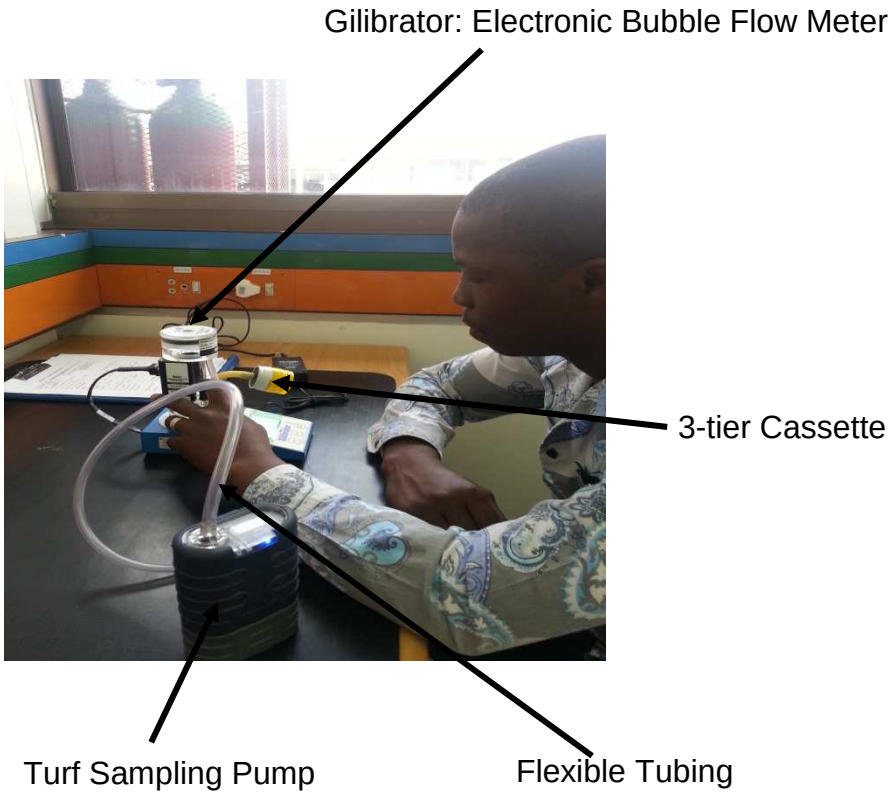


Figure 2: Calibration of the sampling trains

The electronic flow meter was calibrated on the 22nd of June 2011 to appropriate national traceable standard and the calibration certificate, certificate number: R0023-1/3 is attached in Appendix B.

2.6. Sampling Procedure:

The sampling trains were attached to the welders, boilermakers, students and utility men throughout the welding duration (6 hours), with the sampler inlet located within the breathing zone of the workers (within 30 cm of their breathing zone (nose & mouth)) and inside the welding helmet (visor) as required by ISO 10882 of 2001. The sampling training positioning is illustrated in Figure 3 below.

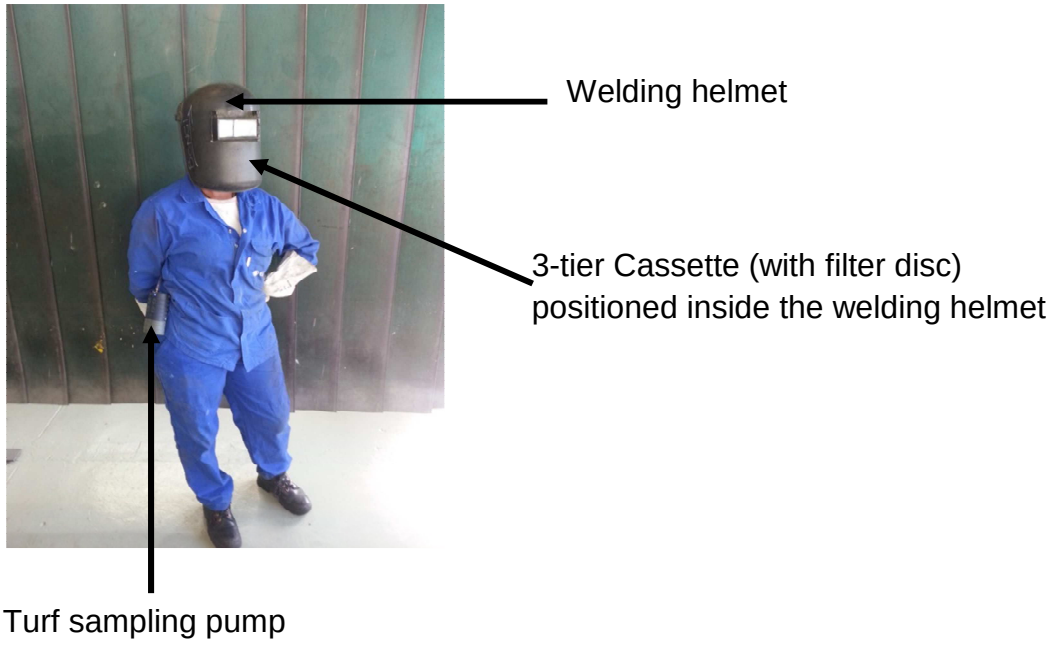


Figure 3: Sampling train positioning within the breathing zone

The in-house hazardous chemical substances field sheet was used for the recording of the measurement data (sampling pump flow rate, serial numbers, sampling starting time, sampling ending time, exposure conditions and calculations as well as the occupations of the study participants). The field sheet is attached as Annexure C.

The sampling was conducted over 6-hour duration due to welding activities occurring over 6-hour period. The remaining 2 hours were spent on housekeeping during which they were exposed to zero total welding fume. The personal occupational exposure concentrations were normalized to 8-hour by means of standard calculations using the following formula:

TWA over 8-hour = C1 X t1 + C2 Xt2 / 8

TWA over 8-hour = TWA over 6 hours X t/8

Where t is the exposure time.

This study objectives were answered as follows

- **Objective 1**

This was conducted by means of gravimetric weighing in strict accordance with Part 1 of ISO 10882 of 2001, using a calibrated Mettler AT250 electronic balance, serial number: K60384, which indicates numerical values up to the fifth decimal. The difference between pre and post masses was expressed in milligrams and recorded in the in-house chemical substances field sheet. The mass, average flow rates and sampled time were used to calculate personal occupational exposure to total welding fume.

Objective 2

The calculated 8-hour personal occupational welding fume exposure concentrations were compared directly to the OEL of 5 mg/m^3 to determine if the OEL has been exceeded or not.

Objective 3

The averaged 8-hour personal occupational welding fume exposure concentrations were compared by job categories in order to determine the most exposed occupations.

2.7. DATA PROCESSING METHODS AND ANALYSIS PLANS

All measurements were collected by a competent Occupational Hygienist certified by the South African Institute of Occupational Hygiene (SAIOH), Certificate Number: 0357. The professional registration certificate is attached as Annexure D.

2.7.1. Data Collection Quality Control:

Data collection on personal occupational exposure to total welding fume was conducted in strict accordance with Part 1 of ISO 10882 of 2001, by means of calibrated sampling trains and a standardized in-house hazardous chemical substances sampling sheet appended. The handling of personal occupational exposure samples was conducted in strict accordance with the said method. Three blank filter discs were used as control samples and treated the same way as the field filter discs.

Used field / data collection filter discs inside the 3-tier cassette were transported back to the laboratory in a sample carrying case designed in such a manner as to avoid possible contamination and vibration.

2.7.2. Data Management Quality Control:

Each of 50 filter discs was assigned a unique identifier so as to avoid confusion during sampling and analysis. Each one of the sampling pumps was identified by means of its serial number in order to ensure traceability. The unique identifier of each filter disc and the serial number of each corresponding sampling pump were captured on the standardized in-house chemical field sheet in order to avoid confusion and ensure traceability.

After sampling all the data was entered and stored in a computerized database. The data was converted to a statistical software package called Industrial Hygiene Statistics (IHSTAT), version 2008, USA, to enable data cleaning, management and analysis. The IH STAT is an internationally accepted Occupational Hygiene Statistical software package.

IHSTAT enables statistical analysis of occupational hygiene measurement data and compliance testing with occupational exposure limits. IHSTAT was developed by American

Industrial Hygiene Association and determines whether samples are normally distributed or lognormally distributed where

- Normal distribution – data that clusters around a mean / average
- Lognormal distribution – the logarithm of data is normally distributed

It also determines the percentage of samples that exceed the occupational exposure limit (37). The data was only accessible to and managed by the researcher in an attempt to exercise a high degree of confidentiality.

2.7.3. Data Analysis Quality Control:

The collected samples were analysed by means of a gravimetric weighing technique using a calibrated Mettler AT250 electronic balance, serial no. K60384. The gravimetric weighing is illustrated in Figure 4 below.

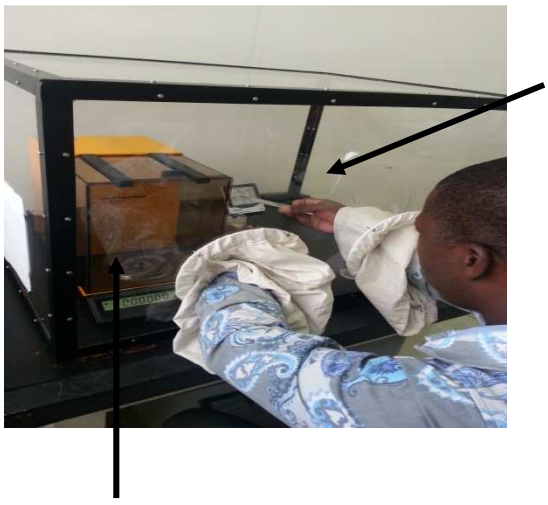


Figure 4: Gravimetric weighing of filter papers

The Mettler AT250 electronic balance was calibrated to appropriate a traceable national standard by SANAS accredited Calibration Facility, Somandla Calibration Solutions cc, and the calibration certificate is attached in Appendix E.

2.8. ETHICAL CONSIDERATIONS

Ethics approval was obtained from the University of Witwatersrand Human Research Ethical committee and the ethics clearance form is appended as Annexure F. The permission to conduct the study in a workshop and the use of the data was obtained in writing from the management and the permission letter is appended as Annexure G. The participation of the subjects in this study is voluntary. A voluntary informed written consent form was submitted to subjects for consent and signatures (See Annexure H). A high degree of confidentiality, respect, justice and anonymity was guaranteed.

CHAPTER 3: RESULTS

Personal occupational exposure concentrations of total welding fume were measured in a workshop of a large coal-fired power generating utility in the Free State Province of SA, during MMA welding operations. The personal occupational exposure concentrations to total welding fume were measured from August to September 2011. Employees who were exposed to the total welding fume concentrations included boilermakers, utility men, welders and students. The measured personal occupational exposure concentrations were compared to the Occupational Exposure Limit of 5 mg/m^3 as specified in the South African Mine Health and Safety Act, 1996 (Act 25 of 1996).

The graphic function of the IHSTAT was utilized to describe central tendency of the data and distribution of the data. The results of the personal occupational exposure concentrations of total welding fume, sequential statistical analysis, descriptive statistical analysis, central tendency and distribution thereof are presented in the following tables and figures.

The number of personal occupational exposure measurements taken and number of measurements exceeding the occupational exposure limit are sequentially represented in the figure below.

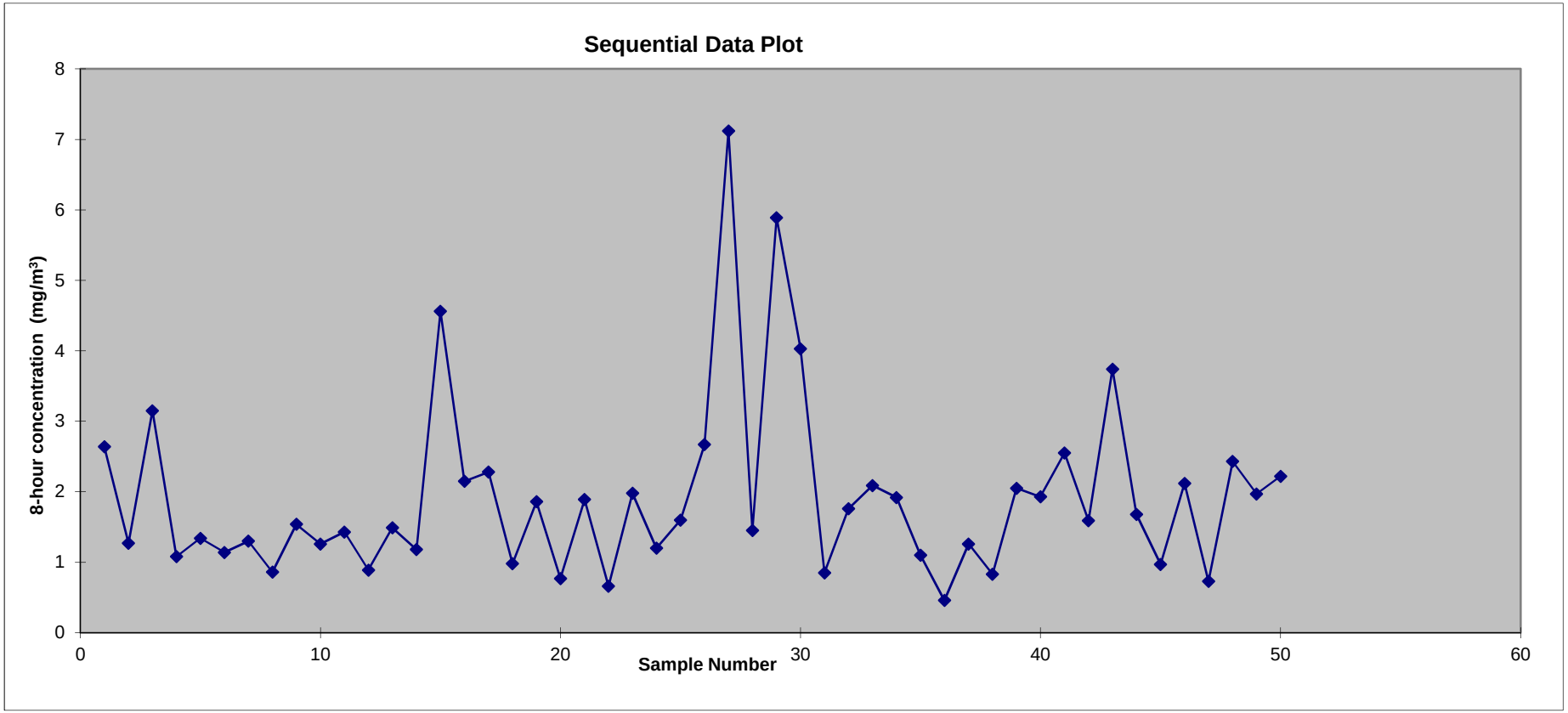


Figure 5: Sequential representation of personal occupational exposure measurements to total welding fumes.

The distribution of personal occupational exposure to total welding fume concentrations were modelled using the logprobability plot and the best fit line was drawn through the points as indicated in figure 6 below.

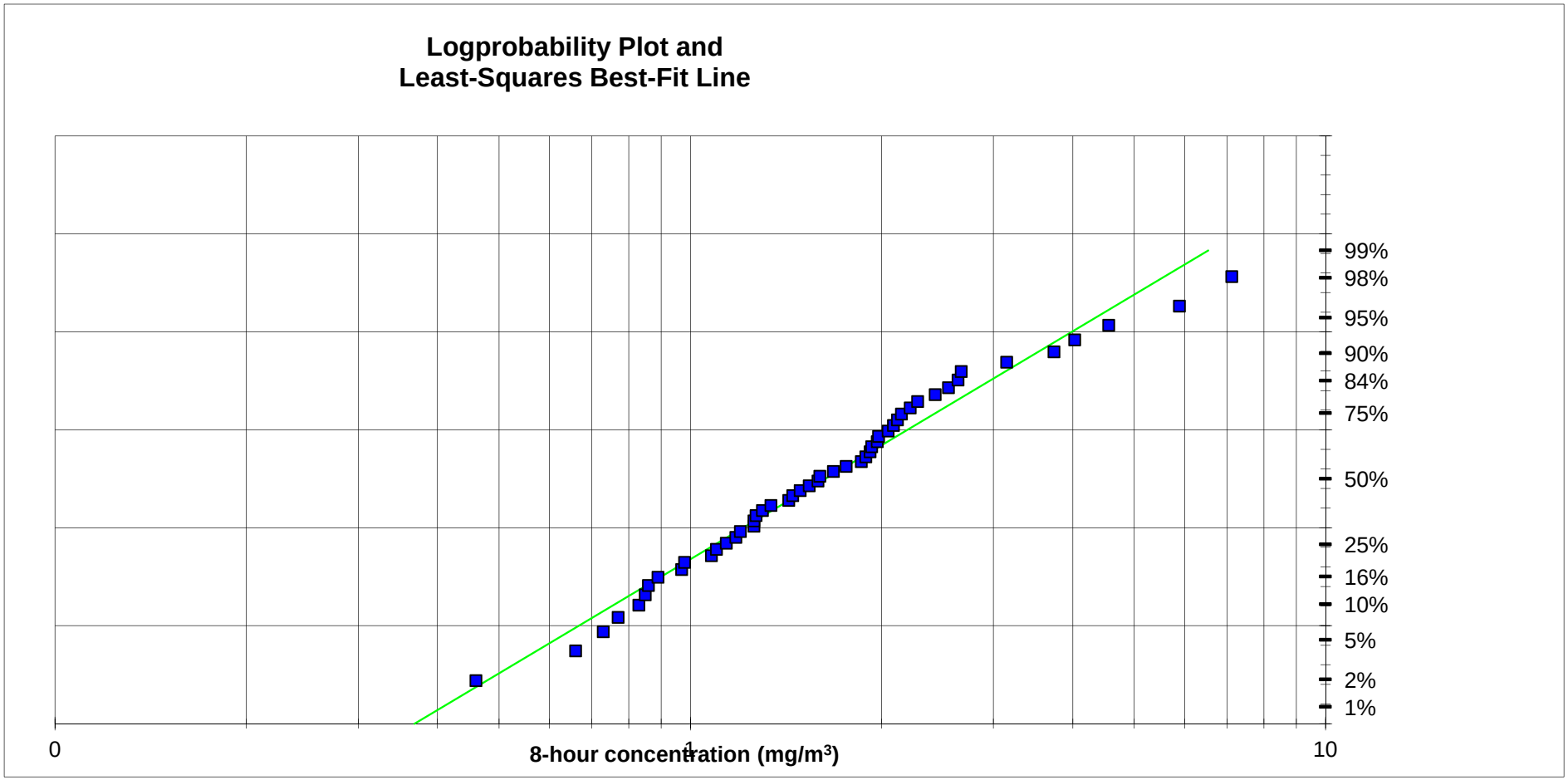


Figure 6: Logprobability plot and least-squares best fit line of personal occupational exposure to total welding fume concentrations in mg/m^3

The total number of samples of personal occupational exposure to total welding fume was 50. The descriptive statistical data is represented in the table below:

Table 3: Descriptive statistical representation of personal occupational exposure to total welding fume concentrations in mg/m^3

DESCRIPTIVE STATISTICS	
Number of samples (n)	50
Maximum (max)	7.12
Minimum (min)	0.46
Range	6.66
Percent above OEL (%>OEL)	4.000
Mean	1.918
Median	1.595
Standard deviation (s)	1.278
Mean of log transformed data (LN)	0.489
Std. deviation of log transformed data (LN)	0.555
Geometric mean (GM)	1.631
Geometric standard deviation (GSD)	1.742

The distribution of personal occupational exposure to total welding fume concentrations was determined to establish if the data fits a normal (i.e. bell curve) or log normal distribution (i.e. skewed curve). This data is recorded in the table below

Table 4: Statistical representation of the distribution of the data of personal occupational exposure to total welding fume concentrations

TEST FOR DISTRIBUTION FIT	
W-test of log transformed data (LN)	0.982
Lognormal (a = 0.05)?	Yes
W-test of data	0.784
Normal (a = 0.05)?	No

A = 0.05 is referring to the confidence level which means that the data has a confidence level of 95%. IHSTAT uses the confidence level of 95% for all tests and confidence limits are calculated by Land's Exact Method. The data fits the lognormal distribution and confidence limits were determined and presented in the table and figure below.

Table 5: Lognormal parametric statistics of personal occupational exposure to total welding fume concentrations

LOGNORMAL PARAMETRIC STATISTICS	
Estimated Arithmetic Mean - MVUE	1.896
$LCL_{1,95\%}$ - Land's "Exact"	1.667
$UCL_{1,95\%}$ - Land's "Exact"	2.213
95th Percentile	4.064
$UTL_{95\%,95\%}$	5.131
Percent above OEL (%>OEL)	2.177
$LCL_{1,95\%}$ %>OEL	0.778
$UCL_{1,95\%}$ %>OEL	5.448

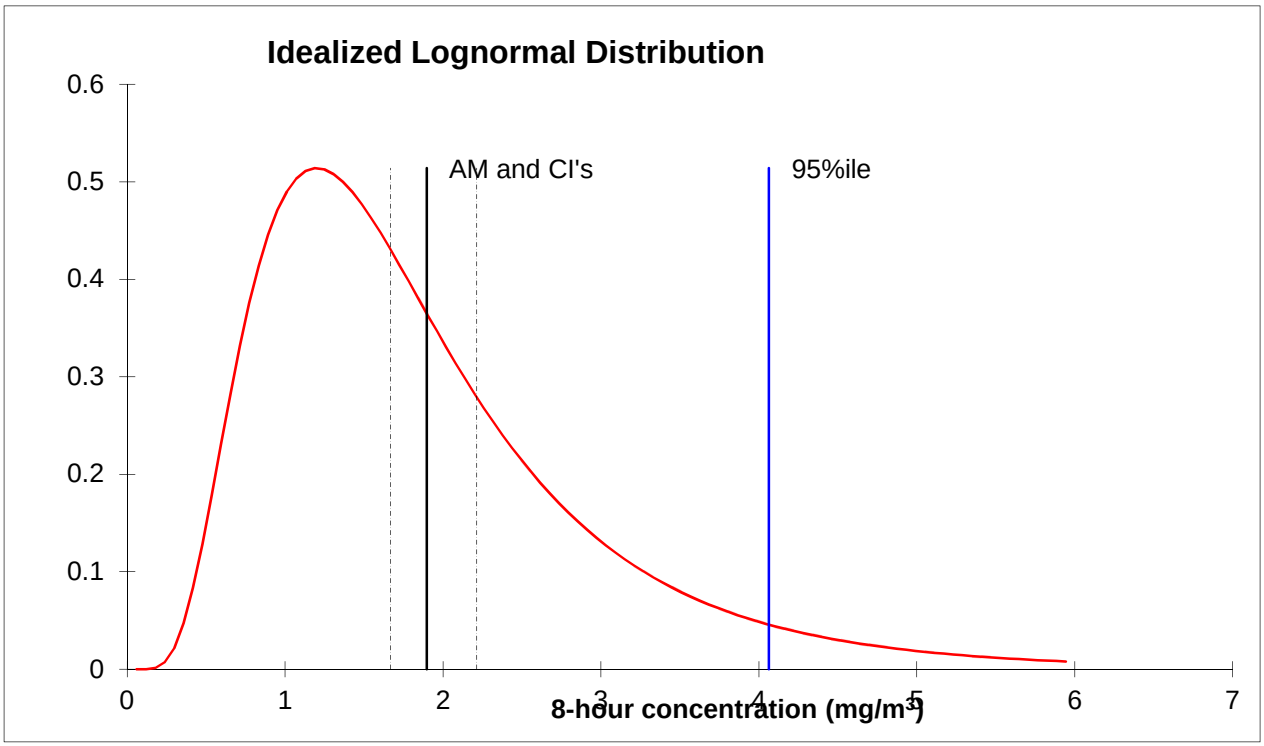


Figure 7: Idealized lognormal distribution curve of personal occupational exposure to total welding fume concentrations in mg/m^3

The determination of the most exposed occupations amongst utility men, students, boilermakers and welders was carried out by means of the arithmetic averaging of the measured exposure concentrations per each job category. The comparison of personal occupational exposure to total welding fumes amongst various occupations is provided in the histogram below.

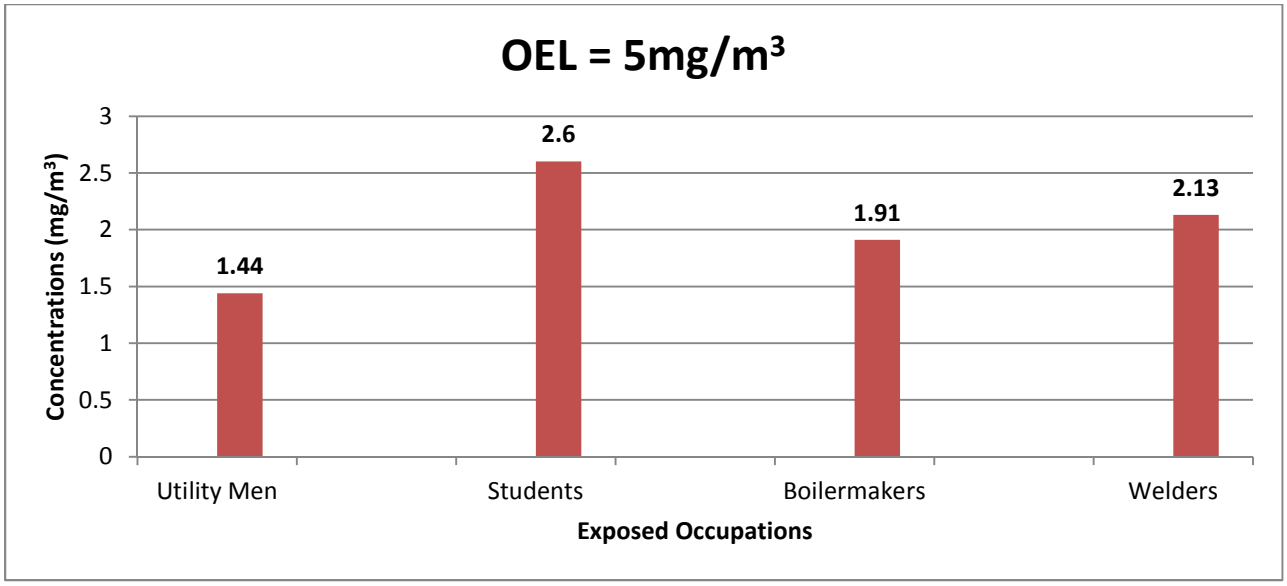


Figure 8: Schematic representation of the most exposed occupations to personal occupational exposure to total welding fume

CHAPTER 4: DISCUSSION

The aim of this study was to describe personal occupational exposure to total welding fume during MMA welding operations in a workshop environment of a power utility in the Free State Province of SA. Fifty personal occupational exposure measurements to total welding fumes were taken from a group consisting of utility men, boilermakers, welders and students on various days. Out of the fifty personal occupational exposure measurements two exceeded the occupational exposure limit of 5 mg/m^3. Various measured personal occupational exposure to total welding fume concentrations and comparison against the occupational exposure limit are schematically presented in figure 5.

The descriptive statistical analysis on the central tendency of the personal occupational exposure to total welding fume concentrations as reflected in table 3 indicated the arithmetic mean of 1.918 mg/m^3 and median 1.595 mg/m^3. The highest (maximum) measured personal occupational exposure concentration was 7.12 mg/m^3 whilst the lowest (minimum) was 0.46 mg/m^3. The geometric mean was 1.631 mg/m^3, geometric standard deviation 1.742 mg/m^3 while the standard deviation was 1.278 mg/m^3. The percentage exceedance of the occupational exposure limit was 4%.

The graphic function of the IHSTAT indicated the distribution of the personal occupational exposure to total welding fume concentrations as lognormal as evidenced in table 4. The IHSTAT made this easier by providing the w-test statistic function and a simple way of interpreting it with yes meaning it fits distribution and no meaning it does not fit distribution). In this case the values fit the lognormal distribution with a 95% confidence level.

The table 5 of the results indicated that the measured exposure concentrations had a 95% confidence level and only 5% of errors, which is reasonable. The confidence interval of the mean lied between 2.213 mg/m^3 (upper confidence level) and 1.667 mg/m^3 (lower confidence level).

Figure 6 indicated a strong positive trend on the measured personal occupational exposure to total fume concentrations. This is an indication of the strong correlation between the measured exposure concentrations and occupational exposure limit. This indicated that the modelling was 98% fit and 2% unfit.

The measured personal occupational exposure to total welding fume indicated right-skewed distribution. The data skewed towards the right. The right-skewed distribution is also called positively-skewed distribution. There is a long tail distribution towards the right and the mean, confidence interval and 95% confidence level are on the right as reflected in figure 8.

The student D was the most exposed employee followed by the boilermaker A, exposed at concentrations above the exposure limit. Their exposures were measured at the different dates / days. The over exposure was mainly due to duration of welding, work habits and visual inspection of the welded components whereby the visor was flipped open.

The other boilermakers, students and utility men as well as welders were exposed to total welding fume at concentrations below the occupational exposure limit. The comparison of personal occupational exposure to total welding fume amongst various occupations indicated that students were the most exposed employees / occupations, followed by welders, boilermakers and utility Men.

This study also indicated that employees within similar exposure groups (occupations) can be exposed to different personal occupational exposure concentrations on the very same day. The study conducted in Saudi Arabia in four of the six factories and Malaysia in automotive industry also indicated that welders were exposed to welding fumes at different concentrations on different days.

Two out of fifty samples exceeded the occupational exposure limit of 5 mg/m^3 from this study which differs with the study that was conducted in Malaysia were all the five sampled assemblers performing welding on an assembly line in an automotive industry were exposed to welding fume at concentrations below the ACGIH & OHSA occupational exposure limit/s. However, it must be noted that there was a difference in the sampling size (50 versus 5) and setting (power utility versus automotive industry)

between these two studies. However, the study conducted in US amongst 200 welding apprentice indicated that they were all exposed to total welding fume at concentrations below the occupational exposure limit. The Health hazard evaluation at Morton Metalcraft, North Caroline in US also indicated that employees were exposed below the occupational exposure limit.

A study conducted in Saudi Arabia indicated that welders in four of the six factories, performing MMA welding operations, were exposed to total welding fume at concentrations above Saudi Standards, Metrology & Quality Organization (SASO)'s limit of 5 mg/m^3

All the 320 samples of occupational exposure to total welding fume taken in a big production plant in Arak, Iran exceeded the occupational exposure limit of 5 mg/m^3, during MMA and MIG welding operations.

The difference between these studies and my study is mainly in the sector (industry), simple size and environment in which studies were conducted. However, other studies as discussed above indicated that, personal occupational exposure to total welding fume exceeded the occupational exposure limit of 5 mg/m^3 in certain instances regardless of the nature of the industry.

A study conducted between 2008 and 2011 by Weldox Study Group in a plant indicated that the use of exhaust ventilation system and air-supplied welding helmets reduced welders' exposure considerably. The ability of the extraction ventilation system and air-supplied welding helmets to reduce welders' exposure to total welding fume is also confirmed in this study and other studies as mentioned above.

In this study all employees (boilermakers, welders, utility men and students) performed manual metal arc (stick) welding by means of vitemax electrode (2.50 mm, 3.15 mm and 4 mm), a minimum grade general purpose rutile electrode and stainless steel electrode (1.16 mm and 2.50 mm). The stick welding was conducted mainly on the unpainted mild steel components as part of repairs and maintenance.

In this study the existing control measures entailed the use of local extraction ventilation system for the extraction of total welding fume, blower fans for dilution and transportation of the total welding fume and the use of the personal protective

equipment which reduced occupational exposure to total welding fume to a larger extent. The personal protective equipment observed used during this study entailed:

- various types of visors (welding helmets) which were: auto darkening welding helmet, variable shade 4/9-13 BLI /1/1, DIN EN 379 and Afrox CE ENT 755 (all carried CE approval mark)
- particulate mask (carried SABS approved mark) with a protection factor of FFP2
- safety shoes
- elbow length leather gloves
- leather aprons
- disposable corded earplugs

However, it was noted that the issued particulate masks were not lined up with the activated carbon layer to ensure the capturing of the gaseous components of the welding fumes. In this case it will not provide adequate inhalation protection against the gaseous components of the welding fumes. Boilermakers, welders, students and utility men were subjected to medical examination which included lung function testing to determine the functional lung capacity.

In considering the findings of this study it is important to note the following limitations:

- The study was conducted in a workshop of a power utility which falls under an industry. In South Africa, personal occupational exposure to total welding fume is regulated by the Hazardous Chemical Substances Regulations, 1995 incorporated in the Occupational Health and Safety Act, 1993 (Act 85 of 1993). However, the Hazardous Chemical Substances Regulations, 1995 do not stipulate the occupational exposure limit to total welding fume but to the elementary composition of total welding fume. For this reason, the measured personal occupational exposure concentrations to total welding fume were evaluated against the South African Mine Health and Safety Act, 1996 (Act 29 of 1996) occupational exposure limit of 5 mg/m^3.
- The 5 mg/m^3 occupational exposure limit is calculated over an 8-hour exposure, which requires sampling to be conducted over an 8-hour period. The sampling was conducted over 6-hour duration due to welding activities occurring over 6-

hour period. The remaining 2 hours were spent on housekeeping during which they were exposed to zero total welding fume. The personal occupational exposure concentrations were normalized to 8-hour by means of standard calculations.

- During measurements grinding and oxy-acetylene gas cutting activities were performed in between MMA welding. It was impossible to exclude personal occupational exposure during these activities and may have contributed to the measured exposure concentrations.

Despite the above-mentioned study limitations the measured personal occupational exposure concentrations to total welding fume were representative of the conditions that existed during sampling and MMA welding. The measured personal occupational exposure concentrations represent exposure concentrations of typical workshop environment in a power utility.

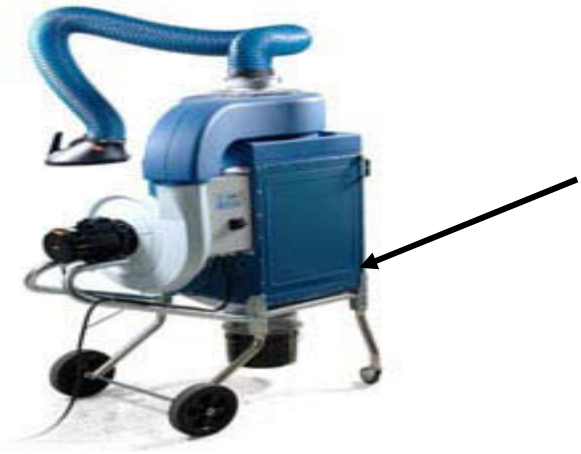
This study excluded the measurement of gases as some of the welding pollutants emitted during MMA welding. The study focussed only on the personal occupational exposure to total welding fume and thus excluded analysis of the elementary composition of the total welding fume which differed with the studies conducted in by Weldox Study Group, health hazard evaluation at Morton Metalcraft, North Caroline in US and study in Malaysia where elementary analysis was conducted to determine the concentrations of total welding fume compositions to allow for direct comparison to their respective occupational exposure limits.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

Fifty personal occupational exposure total welding fume samples were taken to describe the exposure of boilermakers, utility men, welders and students in a workshop environment of a power utility. Two samples out of fifty personal occupational exposure to total welding fume samples exceeded the occupational exposure limit of 5 mg/m^3. The percentage exceedance of the occupational exposure limit was four.

The existing engineering control measures, blower fans, local extraction ventilation system must be sustained and maintained in good working order to reduce occupational exposure to total welding fume. Additional to these existing control measures the following control measures are recommended in order to further reduce boilermakers, welders, students and utility men's occupational exposure to total welding fume:

- Provision of mobile local extraction ventilation system in order to capture and extract the welding fumes at the source during welding activities



- The fume extraction hood must be positioned close to and above the arc at an angle of about 45°C.
- To avoid a risk of inhalation of the total welding fume, the welder's head must be kept outside the extraction hood (not in the way of the extraction hood).
- During stick welding activities instruct boilermakers, students, welders and utility men to place the nozzle on the work surface so as to increase the extraction efficiency.

- All the local extraction ventilation system, including the wall mounted blower fans, should be placed on a planned maintenance schedule to ensure optimal operation / sufficient extraction of the airborne pollutant.
- The maintenance should include routine replacement of components known to have a limited life span and prompt repair or replacement of worn or damaged components as well as frequent replacement of filters.
- The local extraction ventilation system should be tested for efficiency on a two yearly basis by an Approved Inspection Authority. This should include the measurement of the capture velocity, face velocity, transport velocity, static pressure and assessment of physical condition of the fan, hood, ducting and stack.
- Substitute the issued ventilated particulate mask with protection factor of FFP2 with the ones that are lined with activated charcoal layer. The particulate mask with protection factor of FPP2 has a protection factor of 10 x the OEL, which will offer adequate inhalation protection against the measured total welding fume concentrations. The activated carbon layer will ensure the capturing of gaseous welding fume pollutants (ozone, carbon monoxide, carbon dioxide and oxides of nitrogen)
- The selection of the appropriate respiratory protective devices (FFP2) should include the respirator fit testing to consider employees' facial characteristics. This will ensure proper fitting.
- For hygienic reasons, the respiratory protective devices should not be shared amongst employees and should be discarded as soon as it becomes dirty.
- It is therefore recommended to establish and implement a respiratory protective program
- Encourage all boilermakers, welders, students and utility men not to grow beards as this practice will prevent proper sealing of the respiratory protective devices.
- Encourage all boilermakers, welders, students and utility men not to stand in the direction of the oncoming air as this will aggravate their exposure to total welding fume concentrations. They must always stand in the opposite direction to the oncoming air

- Biological monitoring (urine and blood sampling) in addition to the existing medical examination should be conducted in order to determine the concentrations of total welding fume absorbed in the bodies of boilermakers, welders, students and utility men.
- These employees (boilermakers, welders, students and utility men) must be trained on the correct use of the engineering control measures (local extraction ventilation system), care, use and maintenance of the personal protective equipment.

8. REFERENCES

1. **South African Department of Labour.** *Occupational Health & Safety Act, 1993 (Act 85 of 1993).* Pretoria : Government Printers, 1993.

2. **Stanton DW., Kielblock JJ, Schoeman JJ and John R.** *Handbook on Mine Occupational Hygiene Measurements.* Johannesburg : Mine Health and Safety Council, 2007. 978-1-9198-5324-6.

3. **Centers for Disease Control and Prevention.** Welding and Manganese: Potential Neurological Effects. *http://www.cdc.gov/niosh/topics/welding/.* [Online] NIOSH, August 25, 2010. [Cited: May 25, 2011.]

4. **South African Department of Labour.** *Hazardous Chemical Substances Regulations, 1995.* Pretoria : Government Printers.

5. **ACGIH.** *Threshold Limit Values for Chemical Substances, Physical Substances & Biological Exposure Indices.* Cincinnati : ACGIH, 2010. 978-1-607260-19-6.

6. **Oberg F, Jones D.F, H. L.,Horton HL and Ryffel HH.** *Machinery's Handbook - A reference for Mechanical Engineer, Designer, Manufacturering Engineer, Draftsman, Toolmaker and Machinist, 25th Edition.* New York : Industrial Press, 1996.

7. **Kim JY, Chen JC, Boyce DC and Christian PD** *Welding Fumes Hazards & Prevention, with special focus on exposure to Manganese and Hexavalent Chromium.* Nederman : s.n., 2005.

8. **(NIOSH), National Institute of Occupational Safety & Health.** NIOSH Criteria Documents, Criteria for a Recommended Standard: Welding, Brazing and Thermal Cutting: Characteristics of Welding Processes. *http://www.cdc.gov/niosh/88-110.html.* [Online] April 1988. [Cited: May 25, 2011.]

9. **Plog A**., *Fundamentals of Industrial Hygiene. Chicago, National Safety Council*, 4th Edition, 1996.

10. **Executive Health and Safety.** Summary of Chronic Obstructive Pulmonary Diseases statistics. *http://www.hse.gov.uk/statistics/causdis/copd/index.htm.* [Online] 2009. [Cited: May 25, 2011.]

11. **Pourtaghi G, et al.** 3, *Pulmonary Effects of Occupational Exposure to Welding Fumes.* Australia : Basic Applied Science Journal, 2009.

12. **Hannu T, et al.** Occupational Asthma due to manual metal-arc welding of special stainles steels. *http://erj.ersjournals.com/content/26/4/736.full.* [Online] Finnish Institute of Occupational Health, March 08, 2005. [Cited: May 19, 2011.] 736-739.

13. **Antonini J, et al.** 3, *Pulmonary Responses to Welding Fumes: Role of Metal Constituents*, Cincinnati, Ohio, USA : Taylor and Francis Ltd, 2003, Vol. 67. 1991-8178.

14. **United States Department of Labour.** Occupationl Safety and Administration, United States of America

15. **South African Department of Mineral Resources.** Mine Health & Safety Act 29 of 1996. *Mine Health & Safety Act 29 of 1996.* Pretoria : Government Printers, 1996. 6th Edition. 11340.

16. **Guild R, Ehrlich RI, Ross JR, and Johnston MH.** *Handbook of Occupational Health Practices in the South African Mining Industry.* Johannesburg : Safety in Mines Research Advisory Committee, 2001. 1-919853-02-2.

17. **DiNardia R.** *The Occupational Environment: Its Evaluation, Control and Management.* USA : ACGIH, 2003.

18. **NIOSH.** Toxicological Review of Selected Chemicals-525. *http://www.cdc.gov/niosh/pel88/welding.html.* [Online] NIOSH, January 19, 1989. [Cited: May 16, 2011.]

19. Section 16 Various Work-Related Respiratory Conditions. *http://www.cdc.gov/niosh/docs/2008-143/pdfs/2008-143a-xvii.pdf.* [Online] NIOSH, 2004. [Cited: May 25, 2011.]

20. **Leonard, Stephen S., et al.** Comparison of stainless and mild steel welding fumes in generation of reactive oxygen species.

http://www.researchgate.net/publication/47675242. [Online] ResearchGate, November 2010. [Cited: May 25, 2011.] 10.1186/1743-8977-7-32.

21. **Hannu T, et al.** Occupational asthma caused by stainless steel welding fumes: a clinical study. *http://erj.ersjounals.com/content/29/1/85.full.* [Online] Finnish Institute of Occupational Health, August 13, 2006. [Cited: 05 19, 2011.]

22. **Hariri A, Leman M, Zainal M, Yusof N, Paiman A, Noraishah M:** *Preliminary measurement of welding fumes in automotive plants, Malaysia:* International journal of Environmental Science and Development, Vol 3, No. 2, April 2012

23. **NIOSH.** Analytical Methods: 7300, *Elements by inductively coupled argon plasma, atomic emission spectroscopy*

24. **NIOSH.** Niosh Criteria Documents: Criteria for a Recommended Standard: Welding, Brazing and Thermal Cutting: Health & Safety Hazards. *http://www.cdc.gov/niosh/88-110.html.* [Online] April 1988. [Cited: May 05, 2011.]

25. **Meo, Sultan A. Azeem & Abdul M. Subhan***, Lung function in Pakistani welding workers***.** 10, Parkistani : Journal of Occupational and Environmental Medicine, 2003, Vol. 45. 107627752.

26. **Esterhuizen TM, et al.** *Occupational respiratory diseases in South Africa.* Johannesburg : SORDSA, 1999. 02569574.

27. **NIOSH.** *Nomination of welding fumes for toxicity studies,* 2007.

28. **Blosser F.** *NIOSH strategic research on welding identifies data needs and advances studies*, August 20, 2003.

29. **Holcroft, Wegman-D, Woskie S, Song MY, Naparstek R:** *Initial respiratory responses in welding apprentices*, NIOSH Publication.

30. **King B and Adebayo A:** *NIOSH health hazard evaluation report, 2003-0237-2986*, Morton Metal Craft, North Caroline, December 2005.

31. **Lehnert M, Wesis T, Pesch B, Lotz A, Zilch-Schoenweis, Heinze E, Gelder R, Hahn J, Bruning T:** *Reduction in welding fume & metal exposure of stainless steel welders*, Weldox Study Group

32. **Balkhyour MA and Khalid M***.Total fume and metal concentrations during welding in selected factories in Jeddah, Saudi Arabia.***.** Jeddah : International Journal of Environmental Research and Public Health, 2010. 1660-4601.

33. **Antonini JM:** Health effects of welding, NIOSH; 2003

34. **Botma Y, Greeff M, Mulaudzi FM and Wright SCD.** *Research in Health Sciences.* Cape Town : Clyson Printers, 2010. 9780796228406.

35. **Ehrlich R and Joubert G.** *Epidemiology: A research manual for South Africa.* Cape Town : Oxford University Press Southern Africa (Pty) Ltd, 2007. 9780195762778.

36. **International Standard Organization (ISO).** ISO 10882-1: Health and Safety in welding and allied processes - sampling of airborne particles and gases in the operator's breathing zone - part 1: sampling of airborne particles. *ISO 10882-1: Health and Safety in welding and allied processes - sampling of airborne particles and gases in the operator's breathing zone - part 1: sampling of airborne particles.* Switzerland : s.n., 2001.

37. **American Industrial Hygiene Association (AIHA)**; IHSTAT software, version 2008

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I __Dave Pooke Seleme (Student number: 0708102N) am a student registered for the degree of COMH7175 in the academic year _2015

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission

  and/or without acknowledging the original source) is wrong.

- I confirm that the work submitted for assessment for the above degree is my own unaided

  work except where I have explicitly indicated otherwise.

- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against

  me if there is a belief that this is not my own unaided work or that I have failed to

  acknowledge the source of the ideas or words in my writing.

Signature: _____ Date: _____

ANNEXURE A

SUMMARY OF MANUAL METAL WELDING TECHNIQUE & WELDING FUME INDUCED OCCUPATIONAL DISEASES

Manual metal arc welding technique

Manual metal arc (MMA) welding is the most flexible and one of the most widely used arc welding process. It involves striking an arc between a covered metal electrode and a workpiece. The heat of the arc melts the parent metal and electrode which mix together to form, on cooling, a continuous solid mass.

The central metal electrode or core wire acts as consumable, providing the filler metal for the weld. MMA welding can be used to join most steels, stainless steels, cast irons and many non-ferrous materials. For many mild and high-strength carbon steels, it is the preferred joining method (67)

Welding fume induced occupational diseases

Arc Welder's Siderosis:

Is caused by the inhalation of iron oxide fumes, which are emitted during welding on mild steel base. The clinical signs and symptoms resemble that of pneumoconiosis.

Chronic Bronchitis:

Is the most common illness caused by the welding rods in which inflammation of the bronchi (tubes carrying air to and from the lungs) narrows and causes chronic bronchial secretions.

Chronic obstructive pulmonary disease (COPD)

It describes a group of lung conditions / diseases that make it difficult to empty the air out of the lungs. This difficulty can lead to shortness of breath. COPD is a word that can be used to describe a person with chronic bronchitis, emphysema or a combination. COPD is a different condition from asthma, but it can be difficult to distinguish between COPD and asthma.

Lung cancer

Is an uncontrolled growth of abnormal cells that start off in one or both lungs, usually in the cells that line the air passage. As they grow, the abnormal cells can form tumours and interfere with the functioning of the lung.

Manganese poisoning:

Is a condition resulting from chronic exposure to manganese. It is commonly known as manganese poisoning / parkinsonian syndrome.

Metal Fume Fever:

Is an acute respiratory disease which usually last for 6 to 24 hours. The clinical signs and symptoms of the metal fume fever resemble those of an upper respiratory infection such as influenza, acute bronchitis or pneumonia, or upper gastrointestinal infection.

Occupational Asthma:

Is a lung disorder in which substances causes the airways of lungs to swell and narrow. This leads to attacks of wheezing, shortness of breath, chest tightness and coughing.

ANNEXURE B:

COPY OF ELECTRONIC BUBBLE FLOW METER CALIBRATION CERTIFICATE

envirocon instrumentation cc
environmental and occupational hygiene instruments

SERVICE & CALIBRATION CERTIFICATE

THIS IS TO CERTIFY THAT THE FOLLOWING GILIBRATOR, WAS SERVICED AND VERIFIED USING A MASTER GILIBRATOR, SERIAL NO: ***1104053-S*** AS A REFERENCE, WHICH HAS BEEN CALIBRATED TO THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

CERTIFICATE NUMBER: R0023-1/3

CUSTOMER	DATE	CELL SERIAL NO.	BASE SERIAL NO.
ROTEK ENGINEERING	*22/06/2011*	*0804071-S*	*0804072-B*

CELL NO: **0804071-S**

	CC/MIN
1.	**2205**
2	**2205**
3.	**2206**
4.	**2207**
5.	**2209**
6.	**2208**
7.	**2207**
8.	**2208**
9.	**2208**
10.	**2208**
AVG.	**2207**

REFERENCE CELL NO: **1104053-S**

	CC/MIN
1.	**2205**
2.	**2206**
3.	**2206**
4.	**2206**
5.	**2210**
6.	**2206**
7.	**2205**
8.	**2209**
9.	**2206**
10.	**2206**
AVG.	**2207**

ATTACHED PLEASE FIND A COPY OF THE REFERENCE CELL CALIBRATION CERTIFICATE

CALIBRATED BY:

NEXT SERVICE / CALIBRATION DUE

JUNE
2012

T. MOITSHEKI
For and on behalf of ENVIROCON INSTRUMENTATION

ANNEXURE C: HAZARDOUS CHEMICAL SAMPLING SHEET

BU / Client:		**Assessor Names:**		
Location:		**Date:**	**Assessor Signature:**	
Sampling Media Type: **Filter:** PVC ☐ MCE ☐ PTFE ☐ GF ☐ Asbestos ☐ **Tube:** Charcoal ☐ Silica ☐ XAD ☐ **Electronic:** **Other:** Cyclone ☐ Impinger ☐ Bellows ☐ Other:			**Sampling Media Number:**	
			Chemical to be sampled:	
			Lab analysis:	**Yes:** ☐ **No:** ☐
Specific Sampling Media:			**Sampling Pump No.:**	
Personal: ☐	**Strategic:** ☐		**Time:** **Start:** _____ **Stop:** _____ **Total:** _____ **min**	
Name of the person exposed / Area :				
Job Category:				
Shift: **D** ☐ **A** ☐ **N** ☐	**From:**	**to:**	**Pre Calibration:** _____ **Post Calibration:** _____ **Ave Flow Rate:** _____ **l/min**	
Demarcated as respirator zone?	**Yes:**	**No:**		
RPD	**Provided?**	**Worn?** / **Programme?**	**Deviation < ± 5%:**	**Yes:** ☐ **No:** ☐ Discard Results
RPD Brand & Type:			**Mass: (w)**_____**mg**	**Vol: (** $\frac{vt \times t}{1000}$ **)**_____ **m^3**
RPD Protection Factor:			**Conc: (** $\frac{w}{v}$ **)** _____ **mg/m^3**	
RPD Supplier info:			**TWA Conc: (** $\frac{t}{480}$ **X Conc)** _____ **mg/m^3**	

ENGINEERING CONTROL MEASURES					
Local Extraction Ventilation System	☐	**Dust Suppression**	☐	**Enclosure**	☐
Automation	☐	**Natural Ventilation**	☐	**Other (specify)**	☐

OBSERVATION / REMARKS ON EXPOSURE CONDITIONS / ENVIRONMENTAL & EQUIPMENT ANOMALIES (BREAKDOWNS, DEVIATIONS, MALFUNCTIONS, POSSIBLE TAMPERING, ETC.)

I have checked the calculations and I confirm that the results are correct.

Technical Signatory:_____

ANNEXURE D:

COPY OF PROFESSIONAL REGISTRATION CERTIFICATE



The Southern African Institute for Occupational Hygiene

This is to certify that

DP Seleme

ID No. 790801 5358 08 5

Has satisfied the requirements of section 3.4
of the Constitution of the Institute
and on recommendation of the Certification Board
is registered as an

Occupational Hygienist

Registration No. 0357

Chairman: Certification Board

IOHA Recognised Certification Scheme

IOHA

valid until **2011/12/31**

ANNEXURE E:

COPY OF METTLER CALIBRATION CERTIFICATE

SOMANDLA
CALIBRATION SOLUTIONS CC
P.O. BOX 17409
SUNWARD PARK, 1470
P.O. BOX 10776
FONTEINRIET 1464
PHONE & FAX 011 823 2944
PHONE 011 913 8110
FAX 086 210 4243

CAL CERTIFICATE No.
№ 4630
JOBCARD No.
1289

sanas Calibration Laboratory 1426

CALIBRATION CERTIFICATE

(This on-site calibration certificate is issued under the authority and conditions granted by SANAS. It may not be reproduced except in full without the written approval of the laboratory)

Customer: ESKOM
Environment: CLEAN
Address: LOWER GERMISTON RD. ROSHERVILLE
Due: September 2013
Location: OCCUPATIONAL HYGIENE

DETAILS OF INSTRUMENT

Make: SARTORIUS Model: R200D
Serial No: 10802494 Capacity: 200g
Graduations: 0,1mg / 0,01mg

CALIBRATION PROCEDURE

The instrument has been calibrated with standard weights of known value traceable to the national standard in accordance with Procedure No: SCS001/CP.

TRACEABILITY

Certificate No M10-82 Dated: Dec 2010
Dated:
Dated:

CALIBRATION RESULTS

ACCURACY AND LINEARITY ☐mg ☑g ☐KG

REPEATABLITY ☐mg ☑g ☐KG		LOAD APPLIED	BEFORE	AFTER
1	100.0000	0	0.00000	0.00000
2	100.0000	9.999968	10,00006	10.00000
3	100.0000	20.000016	20,00020	20.00000
4	100.0000	40.000056	40,00032	40.00002
5	100.0000	99.99987	100,0004	100.0000
6	100.0000	199.99985	E1	200.0000
Standard Deviation:	0			

ECCENTRIC ERROR			DISCRIMINATION		
Load Applied: 50g	Maximum Error: +/- 0,0001g		Weight Added	At Load of	Response
	49.9999		0,099977g	1g	1.10000g
49.9999	50.0000	50.0001	0,010003g	1g	1.01000g
	50.0001				

REMARKS: INT CAL. STABILITY IS SHOWN WHEN 'g' SYMBOL APPEARS

EXPANDED UNCERTAINTY +/- 0,4mg / 0.05g

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2 providing a level of confidence of approximately 95%, the uncertainty of measurement has been estimated in accordance with the principles defined in *GUM, Guide to Uncertainty of Measurement, ISO, Geneva, 1993*

VALIDITY OF CALIBRATION

This calibration was done on-site. The values in this certificate are correct at the time of calibration. Subsequently the accuracy will depend on such factors as care exercised in handling and use of the instrument as well as the frequency of use. Re-calibration should be performed after such a period which is chosen to ensure that the instruments accuracy remains within the desired limits.

CALIBRATED BY F. FES
DATE CALIBRATED AND ISSUED 17/10/2012

W Mandslor
TECHNICAL SIGNATORY

ANNEXURE F:

COPY OF ETHICS CLEARANCE FORM

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Mr Dave P Seleme

CLEARANCE CERTIFICATE	**M120234**
PROJECT	Personal Occupational Exposure to Tatal Welding Fume in a Workshop Environment from August to September 2011 in the Free state Province of RSA
INVESTIGATORS	Mr Dave P Seleme.
DEPARTMENT	School of Public Health
DATE CONSIDERED	24/02/2012
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 20/04/2012 **CHAIRPERSON** .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Dr Andrew Swanepoel

DECLARATION OF INVESTIGATOR(S)
To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

ANNEXURE G

LETTER REQUESTING PERMISSION

P.O. Box 1090

Sunninghill Place

Megawatt Park

2000

13 June 2011

Cell: 073 770 0890

Lethabo Power Station

Workshop

Dear Shireen Prince

A PERMISSION TO PERFORM RESEARCH PROJECT AT THE LETHABO POWER STATION, WORKSHOP

In fulfilment of Masters in Public Health – Occupational Hygiene, the students are required to perform a research on Occupational Hygiene. Dave Pooke Seleme, an Eskom Holding (Pty) Ltd employee and a 3rd year University of Witwatersrand student, is hereby requesting a permission to perform research project at Lethabo Power Station, Workshop.

My research project is titled “personal occupational exposure to total welding fume during Manual Metal Arc (stick) welding in a workshop from August to September 2011, in the Free State Province of SA” with the following specific objectives:

- To determine personal occupational exposure to total welding fume during manual metal arc (MMA) welding in a workshop environment from August to September 2011, in the Free State Province of SA;
- To describe personal occupational exposure to total welding fume during MMA welding in a workshop environment from August to September 2011, in the Free State Province of SA;
- To compare the personal occupational exposure to total welding fume during MMA welding in a workshop environment from August to September 2011, in the Free State Province of SA to international and national OEL of 5 mg/m^3.

Lethabo Power Station Management will derive the following benefits from this proposed study:

- Detailed report on personal occupational exposure to total welding fume;
- Appropriate and feasible recommendations;

I will work closely with the resident Health & Safety Department and the Workshop management. The high level of confidentiality and respect to all participants shall be maintained at all times. Please advise if my request has been accepted.

Yours sincerely

Dave Seleme

ANNEXURE H

CONSENT TO PARTICIPATE IN THE RESEARCH STUDY

CONSENT FORM

TITLE OF RESEARCH PROJECT

Personal occupational exposure to total fume during MMA welding

PRINCIPAL RESEARCHER

Mr. Dave Pooke Seleme

MPH Students, Wits University, Faculty Of Health Science

RESEARCH PURPOSE

The study purpose is to measure & describe personal occupational exposure to total welding fume during MMA welding operations in a workshop from August to September 2011.

DESCRIPTION OF THE RESEARCH PROJECT

If you agree to participate in the study, you may be asked to:

Personal Sampling: the principal researcher will attach the sampling train to your and you must wear it for the entire monitoring period (which could be 8 hours) a day for 5 days. The principal researcher will explain to you the do's and don'ts before he can give you the sampling trains. The filter paper will draw air and will be sent to the laboratory for analysis. This will help us determine if your occupational exposure to welding fumes is above the prescribed occupational exposure limit followed by recommendations on the implementation of necessary control measures.

CONFIDENTIALITY OF INFORMATION COLLECTED

Your participation in this study is voluntary and the records of questionnaires and personal sampling will be kept highly confidential (through a code numbering system). However, should you wish to have the information released to any person of your choice, you shall give us a written consent to do so.

DOCUMENTATION OF THE CONSENT

One copy of this consent form will be kept together with research records on this study. A second copy will be given to you to keep.

CONTACT PERSON.

You may contact the following person for answers and to further question about the research, your rights, or any problem you may feel is related to the study.

MR. DAVE POOKE SELEME

Mobile phone: 073 770 0890, Tel: 011 800 8533 Email: selemedp@eskom.co.za

CONSENT OF THE PARTICIPANT

I have read [or been informed] and understood the information given above. I understand the meaning of this information. **MR. DAVE POOKE SELEME** has offered to answer any questions I may have and I am hereby consenting to participate in his study.

_____ _____

Printed name of participant Participant signature

DATE: _____