ITEM 9.5 REFERS

Safety in Mines Research Advisory Committee

Final Project Report

Cost, Appropriate Use and Effectiveness of Personal Protective Equipment Including Improved Footwear for the Mining Industry

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Executive Summary

In terms of the Mine Health and Safety Act (Act 29 of 1996) 'every manager must ensure that sufficient quantities of all necessary personal protective equipment (PPE) are available so that every employee who is required to use that equipment is able to do so' (Section 6 (2)). Every employee at a mine, while at the mine, must 'use and take proper care of protective clothing, and other health and safety facilities and equipment provided for the protection, health or safety of that employee' (Section 22(c), Act 29 of 1996). The selection of proper PPE is crucial, therefore, since exposure to hazards will occur if PPE is inappropriate or fails.

From statistics obtained during the study it is obvious that PPE plays a major role in health and safety initiatives on mines and that PPE is used on a regular basis. A conservative estimate is that at least R 333 million is spent annually on PPE for mines. Ideally, PPE should only be used when engineering and administrative controls of hazards are not practicable, or when engineering controls are being installed or repaired, or when emergencies or other temporary hazardous situations arise.

The objective of the present study is to produce guidelines on the appropriate selection and use of PPE in relation to the risk of exposure in the South African mining industry. In the study emphasis was placed on PPE available for eye and face protection, respiratory protection, torso protection, arm and hand protection, and leg and foot protection.

Hazards identified were typical of a mining environment and environments where standard PPE items are used in general. Only a few of the mines approached for information had comprehensive PPE programmes. Successful PPE programmes require commitment and active participation at the planning, development, and implementation stages from all levels: senior management, supervisors, and employees.

Owing to shortcomings in the SAMRASS database, valuable and detailed information regarding the mechanism/events leading to injury or disease and the efficacy of PPE could not be established. As a result of this, it was impossible to establish if engineering controls might prove to be a more cost-effective solution in the long term and should, therefore, be considered more important than PPE.

A pilot study was conducted at two occupational health clinics to assess workers' education in and knowledge of footwear and foot hygiene, and also to identify the potential link between foot complaints and protective footwear. Foot infections, corns and calluses were common ailments among the mineworkers assessed. Working in a hot environment, wearing gumboots, and the steel cap found in safety boots and gum boots were identified as being significantly associated with these ailments.

Foot hygiene among the workers assessed was satisfactory. However, its role in foot infections was not fully appreciated by these mineworkers. Mineworkers assessed did not seek medical treatment for foot infections because foot infections would recur and they felt the medical treatment was not effective. They also believed that the workplace, especially the "dirty water" found underground, was causing the foot infections and that only being away from work would resolve the problem. Mineworkers had good knowledge of the importance of protective footwear. However, the associated complaints outweighed the benefits of protective footwear for many.

In general, the major ergonomics-related problem experienced with PPE was related to size and fit. In most of these items the anthropometry of the mining population (especially the female mineworkers) was not considered in the design of the PPE items. Measurements of the functional anthropometry of mineworkers that are being collected as

part of SIM 04 09 01 at present could address this problem and should provide the designers of PPE with much needed information.

User-friendly information to assist in the selection of appropriate PPE is provided in this report. The information, guidelines and suggestions are based on information obtained from documents and the web sites of the Occupational Health and Safety Administration, the Centres for Disease Control and Prevention, and the National Institute for Occupational Safety and Health in the United States of America, the Canadian Centre for Occupational Health and Safety, the Health and Safety Executive in the United Kingdom, MINEsafe, and the Queensland Government's Division of Workplace Health and Safety in Australia. Owing to the generic nature of the information and guidelines available from the above institutions, information has been presented verbatim in many instances. For obvious reasons no specific products have been listed in the report.

A large number of items of PPE are available that are applicable to the broad spectrum of hazards associated with the diverse occupations involved in mining. The available data on PPE, hazards, and mining occupations were incorporated into a relational database, which can be accessed by users via a simple software application as presented in the report.

The shortcomings in the SAMRASS database need serious consideration and should be addressed in a research project under the auspices of the Safety in Mines Research Advisory Committee (SIMRAC) planned for 2005/2006 (SIM 04 09 07: Recommendations for improvements in the reliability, accessibility and usefulness of OHS data and statistics). Provision should be made for inputs relating to the type of PPE used, the mechanism/events leading to injury or disease, and the efficacy of PPE.

Mines should consider the implementation of comprehensive PPE programmes as a matter of priority. Hazard identification should form an integral part of the programme and should precede the selection of any PPE item.

As a second phase of the current study, the compilation of a Best Practice Document on the selection, use and management of PPE should be considered. This document must comprehensively cover several aspects of a PPE programme, including programme design criteria, management structure, promotional strategy, hazard identification, selection of appropriate PPE, fitting and wearing procedures, maintenance and inspection, training and education, and the auditing of a PPE programme.

The Best Practice Document must also assist both employers and employees with the basics to conduct a hazard assessment of the workplace, the understanding of the limitations of PPE, and the training that is needed to ensure the proper use and care of PPE. Most of the mining countries in the world have such documents, and these cover all aspects of the use of PPE in mines.

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Grootegeluk Coal Mine

Gold Fields Limited

Health and Safety Executive, United Kingdom

Hotazel Manganese Mine

Industrial Safety Services

Kleinkopje Colliery

Kloof Gold Mining Company Limited

Matla Coal Limited

MSA (Africa) (Pty)

New Vaal Colliery

Pittsburgh Research Laboratory, NIOSH, United States of America

Sishen Iron Mine

Trader Vic (Pty) Limited

Wayne Plastics

Table of contents

List of Figures

List of Tables

1 Introduction

Although personal protective equipment (PPE) is regarded as a last resort in the prevention of exposure and disease, it remains an essential component of worker protection in the mining industry. In many workplaces, several hazardous conditions may occur simultaneously, and the protection system in place has to withstand several hazards. The wide variety in environmental conditions and the needs for PPE, as well as a wide range of models of PPE and anthropometric differences in the worker population, make best practice extremely challenging in the mining industry. A 'one design will fit all users under all conditions' approach is simply not good enough.

In terms of the Mine Health and Safety Act (Act 29 of 1996) 'every manager must ensure that sufficient quantities of all necessary personal protective equipment are available so that every employee who is required to use that equipment is able to do so' (Section 6 (2)). Every employee at a mine, while at the mine, must 'use and take proper care of protective clothing, and other health and safety facilities and equipment provided for the protection, health or safety of that employee' (Section 22(c), Act 29 of 1996). The selection of proper PPE is, therefore, crucial since exposure to hazards will occur if PPE is inappropriate or fails.

Although Health 612 has provided some guidelines for the use of PPE in Chapter 15 of the Handbook of Occupational Health Practice in the mining industry (Guild et al., 2001) and other SIMRAC research has focused on particular items of PPE (GEN 103, dealing with protective footwear, for example), there is a need for research into the effectiveness, the appropriate use, and the cost of PPE.

2 Objective of the study

The objective of the study is to produce guidelines on the appropriate selection and use of PPE in relation to the risk of exposure to occupational health and safety hazards in the South African mining industry. In the study, emphasis was placed on PPE available for eye and face protection, respiratory protection, torso protection, arm and hand protection, and leg and foot protection.

3 Research methods

3.1 Review of local and international information on PPE

A literature survey was conducted to obtain information on the role of PPE in the prevention of injuries and occupational disease. In order to obtain information regarding injury patterns in mining and the efficacy of interventions based on PPE, the South African Department of Minerals and Energy and the National Institute for Occupational Safety and Health (NIOSH) were approached. These institutions were requested to provide information on the mechanism/events leading to injury or disease, the agent(s) and consequences of injury/disease, the assessment of severity and overall impact, and the efficacy of PPE.

Data on the injury profile of miners in the USA was obtained from their Mine Safety and Health Administration (MSHA) and covered injuries occurring between 1999 and 2003 (Patel, 2005). The analysis of the data was restricted to injuries that occurred in metal, nonmetal, and coal mines and only those injuries that were either fatal or resulted in days lost from work were included. Workers who were employed in office locations only were excluded from the analysis, along with anyone who was under 17 years of age. Some information on the distribution of injuries by body part was also obtained from the Queensland mines and quarries in Australia for the year 2003 – 2004 (State of Queensland, 2004).

3.2 Identification of mining-related exposures requiring the use of PPE

A workshop was held with experts in occupational health and occupational hygiene and safety to identify mining-related exposures requiring the use of PPE. Emphasis was placed on health and safety hazards requiring eye and face protection, respiratory protection, torso protection, arm and hand protection, and leg and foot protection. In addition to the workshop, a number of occupational hygienists, occupational medicine practitioners, and occupational safety practitioners were interviewed.

3.3 Evaluation of the 'wearability' of PPE

3.3.1 Ergonomic evaluation

The "wearability" and suitability of a number of PPE items generally used in the South African (SA) mining industry were evaluated by considering certain ergonomics design criteria and the anthropometry of the SA user population (RSA-MIL-STD-127). Items evaluated included half-masks, safety spectacles and safety goggles, a full-face mask, head protection, gloves and protective footwear. Samples of protective footwear used in the Australian, the Canadian, the French and the USA mining industry were obtained and compared to protective footwear generally used in the South African mining industry. The test procedures used to evaluate the masks and protective eyewear are given in Appendix 1.

3.3.2 Assessment of workers' education in and knowledge of footwear

A pilot study was conducted at two occupational health clinics (one at a gold mine and one at a colliery). The objective of the pilot study was to assess workers' education in and knowledge of footwear and foot hygiene, and also to identify the potential link between foot complaints and protective footwear.

A descriptive cross-sectional study design was employed. The study population consisted of mineworkers at a coal mine and a gold mine. Owing to limited resources, 80 to 100 consecutive mineworkers during their annual periodical examination at a coal mine and a gold mine were selected. There was a hundred per cent response rate. Ethics approval was obtained before the fieldwork began from the Committee for Research on Human Subjects (medical) at the University of the Witwatersrand (Clearance Certificate M03-06-09).

Mineworkers presenting to the occupational health clinic for their annual periodical examination were selected and referred to a medical practitioner for an interview and an assessment after their informed consent was obtained (Appendix 2). Mineworkers were assessed on:

- Their medical history;
- Their surgical history; and
- Foot complaints.

An evaluation of both feet (shape and size, skin and nails) was undertaken. Comments on mineworkers' knowledge of or education received in the footwear used at the two mines were also elicited.

3.4 Identification of suitable PPE

A literature review was conducted using publications and the web sites of the Occupational Health and Safety Administration (OHSA), the Centers for Disease Control and Prevention (CDC), and the National Institute for Occupational Safety and Health (NIOSH) in the United States of America, the Canadian Centre for Occupational Health and Safety (CCOHS), the Health and Safety Executive (HSE) in the United Kingdom, MINEsafe, and the Queensland Government's Division of Workplace Health and Safety in Australia. Discussions were also held with various occupational hygienists, safety practitioners and occupational medicine practitioners in the South African mining industry, as well as manufacturers and distributors of PPE.

3.5 PPE matrix

Occupational hygienists, safety practitioners, and occupational medicine practitioners at a number of mines were approached to assist with the development of a detailed exposure/ task/worker/PPE matrix for appropriate and effective personal protection. In view of the objective of the study, emphasis was placed on eye and face protection, respiratory protection, torso protection, arm and hand protection, and leg and foot protection. In addition, criteria to assist with the evaluation and selection of PPE were sourced from available literature.

The information obtained was incorporated into a relational database designed in a way that would make it easily accessible for the end-user. More information on the database and design parameters is given in Section 4.7.

4 Discussion of results

4.1 Protection afforded by PPE

Statistics on the efficacy of PPE are rather scarce. The Bureau of Labour Statistics in the United States has published some statistics obtained in general industry, including Fact Sheet No. OSHA 92-08, which reported that approximately 40 per cent of workers who suffered eye injuries were wearing eye protection at the time the injuries were sustained (OSHA, 1992). In contrast, only 16 per cent of those who sustained head injuries were wearing hard hats, and only one per cent of the study population who suffered face injuries were wearing face protection. Injuries to the head involved cuts or bruises to the scalp and forehead (85 per cent of reported cases) and concussion (26 per cent of cases). More than one-third of head injuries were caused by falling objects. No clear indication is given in Fact Sheet No. OSHA 92-08 as to whether the wearing of head protection was mandatory.

According to the Bureau of Labour Statistics, approximately 33 per cent of face injuries were caused by metal objects, most of which were blunt and weighed more than 500 g. Injuries included cuts, lacerations, or punctures (48 per cent of cases), and fractures, including broken or lost teeth (27 per cent of all face injuries). Only 23 per cent of workers who suffered foot injuries were wearing protective footwear but, of those who were, 85 per cent of the injuries affected part of the foot that was not adequately protected by the footwear.

Information from another Bureau of Labour Statistics fact sheet on eye protection (Fact Sheet No. OSHA 93-03) indicated that approximately 1 000 eye injuries occurred in American workplaces daily, and that 60 per cent of those injured were not wearing eye protection at the time of the accident (OSHA, 1993). Use of inappropriate eye protection was also identified as a major factor contributing to eye injuries, since approximately 40 per cent of workers injured were wearing some form of eye protection at the time, but most often without side shields. Nevertheless, injuries also occurred among employees who wore full-cup or flat-fold side shields. Nearly 70 per cent of eye injuries studied were caused by flying/falling objects or sparks striking the eye, of which nearly 60 per cent were smaller than a pin head according to the injured workers. Approximately 20 per cent of eye injuries were the result of contact with chemicals. Others were caused by objects swinging from a fixed or attached position, including tree limbs, ropes, chains or tools that were pulled into the eye while the worker was using them.

When engineering controls fail to maintain adequate air quality, personal protection devices (respirators) are required. A respirator's assigned protection factor (APF) indicates the level of protection that a properly functioning device can be expected to provide for a population of properly fitted and trained users. For example, an APF of ten means that a user should inhale no more than one-tenth of the airborne contaminants present.

OSHA also uses a term "Maximum Use Concentration" (MUC) in Standard 29 CFR 1910.134. "Maximum Use Concentration" refers to the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected when wearing a respirator, and is determined in accordance with the assigned protection factor of the respirator or class of respirators and the exposure limit of the hazardous substance. The MUC can usually be determined by multiplying the assigned

protection factor by the permissible exposure limit, the short-term exposure limit, ceiling limit, peak limit, or any other exposure limit used for the substance in question.

The problem with respirator protection is that under real-world conditions of use, some respirators fail to provide the level of protection indicated by their APF. Shortfalls are generally attributed to estimates that are based on inadequate test data and failure to fully consider the complexities of real-world variables (Kretchik, 2003). Protection factor studies generally determine the ratio of an agent's concentration outside the respirator to its concentration inside, with higher ratios corresponding with higher protection factors.

According to Kretchik (2003) workplace studies involve a less controlled environment, in which a greater number of real-world variables are encountered. However, one problem with workplace studies is that agent concentrations are seldom high enough for an adequate evaluation of the upper limit of PPE protection factors. Simulated workplace protection studies can provide higher concentrations under controlled conditions, using simulated work activities to assess respirator performance. Both types of testing have been used to determine APF for individual respirators and for classes of respirators.

There are several variables affecting the degree of protection provided by respiratory protective devices. These include equipment selection, maintenance, and fit on the face of the user (OHSA, 2003). Performance can also be degraded by use of a full-face respirator, which may interfere with vision, communication, respiration, heat loss, psychological well-being, and other PPE used (Coyne et al., 1998). Performance degradation can be costly, because of reduced quality of work, and may contribute to inappropriate responses in cases of emergency (Johnson et al., 1994).

With regard to hearing-protection devices (HPDs), the level of attenuation claimed by manufacturers, which is based on laboratory tests, is invariably higher than that achieved under actual conditions of use. For example, the full-spectrum protection that users receive from off-the-shelf earplugs is typically 10 to 20 dB less than indicated by the device's noise reduction rating (NRR). For earmuffs, which require less skill and care to fit correctly, the corresponding differences are between 8 and 12 dB. Berger (2000) reviewed data from 22 studies of the real-world attenuation provided by HPDs, involving a total of nearly 3 000 subjects. The level of attenuation actually provided was only 25 to 60 per cent of the devices' labelled values, depending on type. The greatest discrepancy was found for pre-moulded earplugs (25 per cent of NRR), followed by formable foam plugs (40 per cent of NRR), and then muffs (60 per cent of NRR). These figures indicate that, despite its ease of application, noise reduction rating is not a reliable indicator of HPD performance, and should only be used for initial comparisons (see Section 4.5.6.9).

4.2 Injury profiles

4.2.1 SAMRASS

According to the South African Mining Reportable Accident Statistics System (SAMRASS), 20 439 employees had had injuries to the body regions under investigation during the period 1999 – 2003 (Table 4.2.1). Of this total, 422 employees died as a result of the injuries sustained. Injuries to the skull and scalp resulted in the most fatalities on gold and platinum mines. On coal mines, multiple injuries to head, face and neck were associated with the most fatalities.

The body parts or regions injured most frequently are remarkably similar for the three mining commodities that formed part of the study. On gold mines 23,0 per cent of the injuries involved a single finger, 8,0 per cent the leg below the knee, and 7,0 per cent the metatarsal region of the foot. The statistics for platinum mines are almost identical: 23,0

per cent of the injuries involved a single finger, 11,0 per cent the leg region below the knee, and 7,0 per cent the metatarsal region of the foot. On coal mines, 14,0 per cent of the injuries involved a single finger, 10,0 per cent the leg below the knee, and 8,0 per cent the ankles.

The possible mechanism/event leading to injury and the efficacy of PPE could not be established with any certainty because of certain SAMRASS-related shortcomings, such as the broad classification system and the lack of relevant information. These shortcomings need serious consideration and should be addressed in a research project under the auspices of the Safety in Mines Research Advisory Committee (SIMRAC) planned for 2005/2006 (SIM 04 09 07: Recommendations for improvements in the reliability, accessibility and usefulness of OHS data and statistics).

Table 4.2.1: Total number of employees involved in injuries to selected body parts (1999 – 2003)

Body part injured	Gold	Coal	Platinum	Total
Skull and scalp (occipital, frontal , maxilla)	359	20	89	468
Eyes and orbit (eye socket)	370	17	93	480
Face	44	11	38	93
Neck (throat)	119	20	32	171
Multiple injuries to head, face and neck	162	28	28	218
Thorax (chest – excluding spinal region)	100	3	20	123
Thoracic region (chest, spinal region, lungs, sternum, ribs)	455	38	83	576
Abdomen (include lumbar spine, back)	674	60	105	839
Pelvic girdle	387	28	81	496
Shoulder blade (scapula)	59	5	6	70
Collar bone (clavicle)	82	13	20	115
Shoulder (acromion)	308	13	64	385
Forearm	751	28	110	889
Elbow	163	3	19	185
Arm	396	16	70	482
Wrist	276	23	52	351
Palm	98	3	14	115
Back of hand	358	23	66	447
Thumb	738	27	127	892
Single finger	3 633	128	781	4 542
Thumb and one or more fingers	106	8	30	144
Two or more fingers (excluding thumb)	564	43	131	738
Multiple to one hand (hand general)	191	12	42	245
Thigh	398	40	98	536
Knee joint (including patella)	752	38	133	923
Leg (below knee)	1 356	93	376	1 825
Ankle	886	77	208	1 171

Foot (including toes)	485	18	137	640
Foot (excluding toes)(metatarsal)	1 130	38	242	1 410
Toes (one or more)	617	34	149	800
Whole of lower limb	51	6	13	70
Total	**16 068**	**914**	**3 457**	**20 439**

Despite the lack of relevant information, the current statistics suggest that most of the injuries involve body parts and regions that could be protected, at least in part, by PPE (gloves, leg guards and protective footwear, for example). Conversely, it could be argued that injuries occurred despite the fact that employees had been issued with PPE. It should, however, be stressed that PPE does not reduce the hazard itself, nor does it guarantee permanent or total protection.

4.2.2 Mine Safety and Health Administration

Data on the injury profiles of miners in the USA were obtained from its Mine Safety and Health Administration (MSHA) for injuries sustained from between 1999 and 2003 (Patel, 2005). The injury statistics obtained from the USA provide some insight into the nature and possible causes of accidents occurring in its mining industry. MSHA classifies part of body injured as the part of the body that was most severely affected by the injury. Therefore, if a miner sustained injuries to both his hands and legs, only one of these body parts would be reported. The MSHA classification regarding the part of body involved was as follows:

- Eyes
- Face (including ears, jaw, mouth, nose)
- Head (including head, brain, scalp, skull)
- Hands (including wrist, fingers)
- Arms (including elbow, forearm, upper extremities, upper arm, shoulders)
- Legs (including lower extremities, thigh, knee, lower leg)
- Feet (including ankle, toes).

The total number of injuries by body part classification over the period 1999 to 2003 is given in Figure 4.2.2.

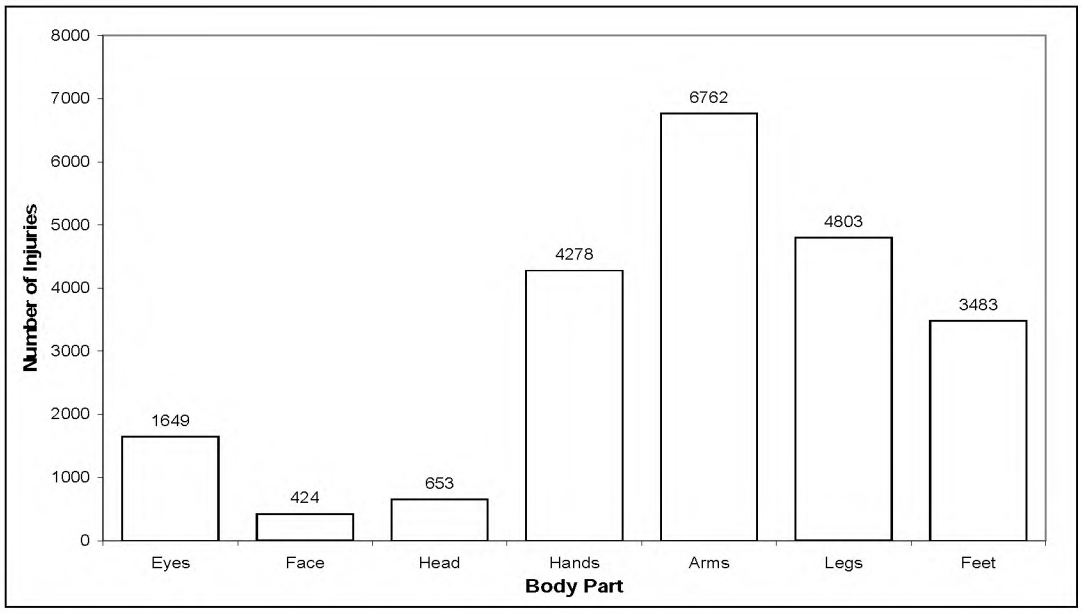

Figure 4.2.2: Injuries by body part classification within coal, metal and nonmetal mines

From Figure 4.2.2 it is evident that most of the injuries occurring in the coal, metal and nonmetal mines as a group involved the arm region (30,7 per cent). Injuries to the leg region amounted to 21,8 per cent, while 19,4 per cent of the injuries were associated with the hands and 15,8 per cent with the feet region. Eye injuries represented 7,5 per cent of the total injuries. The corresponding figures for injuries to the face and head regions were 1,9 per cent and 3,0 per cent, respectively.

In the MSHA study, most of the injuries at coal mines were associated with the leg region, followed by injuries to the arms, hands and feet. In nonmetal and metal mines the injury profiles were very similar, with injuries to the arms being the most prominent. At both metal and nonmetal mines, injuries to the hands, legs and feet were far more numerous than injuries to the eyes, face and head regions.

The specifics about the injuries referred to above are given in the following tables. Table 4.2.2a deals with the source of the injury, Table 4.2.2b with the nature of the injury, and Table 4.2.2c with the accident type or causal factor. In all of these tables the most frequent (greater than five per cent) classification within each variable by part of body across the three mining commodities is given.

Finally, information on the median number of work days lost by part of body and commodity that could serve as an indication of the severity of the injury is given in Table 4.2.2d.

Table 4.2.2a: Source of injury and body part or body region

Body part/region involved	Source of injury	% of total injuries to body part/region
Eyes	Metal NEC	26,4
	Pulverised metal	18,3
	Machines NEC	5,9
Face	Metal NEC	15,2

	Caving rock, coal ore, waste	14,4
	Conductors, electric cable	5,1
Head	Caving rock, coal ore, waste	21,0
	Metal NEC	10,6
	Metal covers and guards	6,0
	Back, mine roof, hanging wall	5,5
Hands	Caving rock	10,3
	Metal NEC	8,3
	Stairs, steps	6,6
	Metal covers and guards	6,0
	Mine floor, bottom	5,0
Arms	Metal NEC	14,9
	Caving rock, coal, ore	9,3
	Underground mining	5,5
	Drill steel	5,0

Body part/region involved	Source of injury	% of total injuries to body part/region
Legs	Mine floor bottom	21,3
	Ground	10,9
	Caving rock, coal, ore, waste	9,2
	Broken rock, coal, ore	6,3
	Metal NEC	5,4
Feet	Caving rock, coal, ore, waste	14,1
	Mine floor bottom	13,3
	Ground	11,7
	Broken rock, coal, ore, waste	10,3
	Metal NEC	6,1

NEC = not elsewhere classified

From Table 4.2.2a it is evident that the category “caving rock, coal, ore” was the prominent source of the injuries reported. Unfortunately, MHSA has no statistics on whether PPE was worn by the injured miners at the time of their injuries. It is, however, doubtful that PPE would have prevented injuries caused by caving rock or coal. Engineering controls and interventions have, potentially at least, a better chance to contain this source of injury. On the other hand, appropriate eye and face protection has the potential to prevent eye injuries caused by pulverised metal.

The nature of injury and the body part or body region injured are given in Table 4.2.2b.

Table 4.2.2b: Nature of injury and body part or body region

Body	Nature of injury	% of total injuries

part/region involved		to body part/region
Eyes	Cut, laceration, puncture	34,9
	Scratches/abrasions	16,7
	Dust in eyes	15,1
	Burn, chemical	13,4
	Non-contact electric arc burn	6,7
	Other injury, NEC	5,5
Face	Cut, laceration, puncture	35,2
	Fracture, chip	31,9
	Multiple Injuries	13,7
	Contusion, bruise	5,8
Head	Cut, laceration, puncture	39,0
	Concussion, brain	15,2
	Contusion, bruise	12,2
	Fracture, chip	5,8
Hands	Sprain, strains	51,5
	Contusion, bruise	15,5
	Fracture, chip	10,9
Body part/region involved	**Nature of injury**	**% of total injuries to body part/region**
Arms	Cut, laceration, puncture	28,8
	Fracture, chip	28,6
	Multiple injuries	8,9
	Contusion/bruise	8,3
	Sprain, strains	8,1
	Amputation	5,5
Legs	Sprain, strains	57,6
	Contusion, bruise	16,1
	Fracture, chip	11,2
Feet	Sprain, strains	36,4
	Fracture, chip	34,1
	Contusion, bruise	16,2

Further information on the accident type is given in Table 4.2.2c.

The information given in Tables 4.2.2b and 4.2.2c suggests that appropriate PPE could potentially play a role in the reduction of injuries, especially in terms of head, face, eye, and leg and foot protection.

Table 4.2.2d contains information on the median number of work days lost by part of body and commodity, which information serves as an indication of the severity of the injury. On this basis it is evident that injuries to the hands, arms, legs and feet were more severe than injuries to the other body parts or regions.

Table 4.2.2c: Accident type and body part or body region

Body part/region involved	Accident Type	% of total injuries to body part/region
Eyes	Struck by flying object	32,4
	Struck by NEC	32,3
	Absorption of substances	14,4
	Flash burns (welding)	5,9
Face	Struck by NEC	45,6
	Struck by falling object	19,2
	Struck by flying object	10,9
	Struck against stationary object	5,5
Head	Struck by falling object	26,3
	Struck by NEC	21,2
	Struck against stationary object	12,5
	Struck against moving object	11,5
	Fall onto/against object	5,8

Body part/region involved	Accident Type	% of total injuries to body part/region
Hands	Over-exertion NEC	19,5
	Over-exertion in lifting	14,5
	Struck by falling object	13,2
	Fall to walkway/surface	7,7
	Struck by NEC	6,8
Arms	Caught in-under-between NEC	21,1
	Struck by NEC	18,5
	Caught in-under-between moving/stationary object	17,1
	Struck by falling object	16,2
	Struck against stationary object	5,6
Legs	Over-exertion NEC	30,4
	Struck by falling object	11,5
	Fall to walkway or surface	9,4
	Struck by NEC	7,9
	Struck against stationary object	6,9
	Fall from machine/vehicle	6,6
Feet	Struck by falling object	26,7
	Over-exertion NEC	19,6
	Struck against stationary object	8,9

	Fall from machine/vehicle	6,6
	Struck by NEC	6,5
	Fall to walkway or working surface	6,2
	Caught in-under-between moving/stationary object	5,8
	Caught-in-under-between NEC	5,0

NEC = not elsewhere classified

Table 4.2.2d: Median number of days lost due to injury

Part of body	Commodity	Median days lost from work
	Coal operator	2.0
	Metal operator	1.0
	Non-metal operator	1.0
	Total	2.0
	Coal operator	8.0
	Metal operator	3.0
	Non-metal operator	3.0
	Total	7.0
	Coal operator	6.0
	Metal operator	1.0
	Non-metal operator	6.0
	Total	6.0
	Coal operator	27.0
	Metal operator	4.0
	Non-metal operator	2.0
	Total	17.0
	Coal operator	12.0
	Metal operator	0.0

	Non-metal operator	0.0
	Total	7.0
	Coal operator	31.0
	Metal operator	9.0
	Non-metal operator	5.0
	Total	25.0
	Coal operator	18.0
	Metal operator	0.0
	Non-metal operator	1.0
	Total	12.0
	Coal operator	18.0
	Metal operator	1.0
	Non-metal operator	1.0
	Total	12.0

4.2.3 Queensland mines and quarries

The distribution of injuries by body part from the Queensland mines and quarries in Australia for the year 2003 – 2004 indicates that most injuries occurred in the upper- and lower-back region (28,0 per cent), followed by the hand/finger/thumb (12,0 per cent), the knees (9,5 per cent), and ankles (8,5 per cent). Fewer injuries (4,5 per cent) involved eyes and 4,7 per cent involved the foot and toe region. As far as the nature of the injuries is concerned, 46 per cent were ascribed to sprains and strains, 14 per cent to fractures (excluding the vertebral column), seven per cent to contusion with intact skin, four per cent to foreign bodies, and the same proportion to poisoning and toxic effect (State of Queensland, 2003). No specific information on the mechanism/event leading to injury or the role of PPE is contained in the report.

4.3 Mining-related hazards requiring the use of PPE

Discussion at a workshop with occupational hygienists, safety practitioners and occupational health practitioners at mines identified a number of health and safety hazards present in the mining environment. All individuals agreed that PPE is the last resort and that priority should be the elimination and control of hazards at their source or along the path between the source and the worker. PPE should only be used when engineering and administrative controls are not practicable, when engineering controls are being installed or repaired, or when emergencies or other temporary hazardous situations arise.

Hazards identified include:

- Noise
- Thermal stress
- Falling or rolling objects
- Respiratory hazards
- Hazardous substances (chemicals)

- Airborne particles and dust
- Flying fragments/chips
- Slipping and falling (wet slippery surfaces)
- Welding (fumes, molten metal, harmful optical radiation)
- Abrasion
- Electricity
- Sharp objects
- High pressure water
- Bumping against objects
- Water jets
- Hot surfaces
- Falling ground

PPE currently in use typically includes:

- Hard hats
- Hearing protection devices
- Goggles
- Safety spectacles
- Protective footwear
- Gloves
- Waist belts
- Overalls
- Seat protectors
- Leg guards
- Knee protectors/pads
- Respirators
- Safety belts/harnesses/fall arrest systems
- Reflective bibs
- Rain suits

- Protective chemical clothing

4.4 Cost of PPE

The total cost of PPE supplied to the mining industry is difficult to determine, because mines use different suppliers and methods to acquire these items. In many instances mines and suppliers were also very reluctant to provide information on the amounts spent on PPE. As one would expect, the price per item varies considerably with quantity ordered and supplier. One major manufacturer and supplier of PPE to the mining industry conservatively estimated that mines which his company supplies spend nearly R 333 m each year on PPE. Of this amount, 69 per cent is for protective footwear, overalls and gloves, 16 per cent for respiratory protection, five per cent for eye and face protection, four per cent for fall protection, and another four per cent for hearing protection.

Despite the reluctance of mines to provide information on the amounts spent on PPE, the information contained in Table 4.4, based on information obtained from four mines (two gold mines, one manganese mine and one iron ore mine), provides an indication of such costs. Tabulated values are for monthly expenditure on PPE.

Table 4.4 Expenditure per month for PPE by four mines

	Mine A (gold)		Mine B (gold)		Mine C (iron ore)		Mine D (manganese)	
	Total (R)	% of total	Total (R)	% of total	Total (R)	% of total	Total (R)	% of total
Head & eye protection	16 666	3,0	49 247	5,0	15 189	6,0	5 209	3,0
Hearing protection	10 857	2,0	16 266	2,0	16 810	6,0	2 150	1,0
Respiratory protection	11 514	2,0	14 893	2,0	11 276	4,0	59 926	36,0
Hand & arm protection	90 276	16,0	264 491	27,0	23 270	9,0	17 278	11,0
Torso protection	103 572	18,0	86 629	9,0	110 008	42,0	44 556	27,0
Leg & foot protection	267 059	47,0	411 806	42,0	9 166	4,0	26 992	17,0
Other PPE	68 659	12,0	144 737	13,0	73 535	28,0	7 839	5,0
Total	**568 603**		**988 069**		**259 254**		**163 950**	
Number of employees	15 000		15 000		3 000		1 300	
R/employee	37,91		65,87		86,42		126,12	

per month								

From Table 4.4 it is evident that the amount spent on PPE per worker per month varies from R 37,91 to R 126,12. For the four mines combined, 36 per cent of the total PPE costs were for leg and foot protection, 20 per cent for hand and arm protection, and 17 per cent for torso protection. The corresponding figures for head and eye protection and hearing protection were four per cent and two per cent, respectively. This last figure may, however, be distorted as most of the employees at Mine D are issued with pre-moulded earplugs.

In general, one of two strategies is followed when a decision is made on what PPE to issue to employees. Some mines issue PPE to employees to protect them against any possible hazard that potentially exists in a work area. For example, an employee will be issued with knee protectors even when there is no chance that the employee will crawl on his knees. Other mines will issue PPE appropriate only to specific hazards identified in the employees' place of work.

4.5 Wearability of PPE

PPE items are not 'one size fits all'. PPE that fits poorly will not properly protect the wearer and may make it more difficult for work to be done.

4.5.1 Ergonomic evaluation

In order to identify potential problems areas in terms of PPE fit various items were evaluated in terms of the ergonomics of their design. Employees' education in and knowledge of footwear and foot hygiene, specifically, were also assessed.

4.5.1.1 Protective masks and protective eyewear

The results of the evaluation of different types of protective masks and safety eyewear to determine dimensional fit for the SA population are summarised in Table 4.5.1.1.

Table 4.5.1.1: Results of consolidated fit evaluation

Items evaluated	Head models on which a poor fit was observed*	Reasons for poor fit
Item A (half-mask)	Acceptable fit on all heads	Not applicable
Item B (half-mask)	Smaller heads: 1S-F and 2S-F	Mask too long: if it rests on the nose bridge, it gapes below chin
Item C (safety spectacles)	Largest head: 4L-F	Insufficient coverage on sides of eyes; temples too tight over sides of forehead
Item D (safety spectacles)	Larger heads: 2L-F, 3L-F, 4L-F	Too narrow over the nose; on the largest head insufficient coverage at bottom of eyes
Item E (safety spectacles)	Smaller head: 4S-F, Larger heads: 2L-F, 3L-F and 4L-F	On the smaller head, insufficient coverage on sides and bottom of eyes. On the larger heads: too narrow over the nose; insufficient coverage on sides and bottom of eyes; and too

		much space between eyewear and face on largest head
Item F (safety spectacles)	Largest head: 4L-F	Too narrow over nose
Item G (safety spectacles)	Larger heads: 2L-F and 4L-F	The temples too tight over sides of forehead and thus the eyewear sits too far from the face
Item H (safety spectacles)	Largest head: 4L-F	Temples too tight over sides of forehead
Item I (safety goggles)	Acceptable fit on all heads	Not applicable
Item J (safety goggles)	All small heads: 1S-F, 2S-F, 3S-F, 4S-F; and some large heads: 1L-F, 2L-F, 4L-F	The distance (when observed from the front) between the eyes and the inside of the eyepieces was too short.
Item K (safety spectacles)	Smaller heads: 1S-F and 2S-F	The distance between the temples is too large
Item L (full-face mask)	Acceptable fit on all	Not applicable

* See Appendix 1 for legend on head model sizes.

Item A was a rubber half-mask with provision for one filter. Two adjustable rubber bands were provided on the half-mask to keep it in place on the face. An acceptable fit was obtained on all the head models with this half-mask. This implies that an acceptable dimensional fit should be obtained for at least 90 percent of the SA population.

Item B was a silicone half-mask with provision for one filter. Two adjustable rubber bands were provided on the half-mask to keep it in place on the face. An acceptable fit was obtained on six of the eight head models with this half-mask. Poor fit was observed on the smaller heads, 1S-F and 2S-F, as the mask was too long. If the mask rests as high as possible on the nose bridge (before interfering with the eyes) it forms gaps under the chin on these smaller heads.

Item C was a pair of safety spectacles with clear eyepiece temples that are adjustable in length. The eyepieces were shaped to follow the contours of the face and nose, and rubber pieces were provided for over the nose bridge. This eyewear achieved an acceptable fit on seven of the eight heads. A poor fit was observed on the largest head model, 4L-F, because insufficient coverage was provided on the sides of the eyewear and the temples fitted too tightly over the front-to-temporal (sides of forehead).

Item D was a pair of safety spectacles with clear eyepieces, with a black rim over the top and temples that were adjustable in length. The eyepieces were contoured to follow the shape of the face and nose, and rubber pieces were provided over the nose bridge region. An acceptable fit was obtained for five out of the eight head models.

Poor fits were observed for the larger heads, that is 2L-F, 3L-F and 4L-F. Poor fit was observed to be due mainly to the contour provided for the nose not being large enough. For the largest head, 4L-F, poor fit was also observed to be due to insufficient coverage being provided at the bottom of the eyepieces.

Item E was a pair of safety spectacles with clear eyepieces with a slightly reflective finishing and clear rim. They were shaped to closely follow the contours of the face and nose. No rubber pieces were provided for comfort over the nose bridge and the temples were not adjustable and not bent to curve around the back of the ears. Poor fit was observed for this eyewear on one small and three larger head models, that is 4S-F, 2L-F, 3L-F and 4L-F. Poor fit observed on the smaller face was due to insufficient protection provided at the bottom of the eyewear. The main reason for poor fit on the larger faces was insufficient eye coverage for ensuring adequate protection at the bottom and the sides of the eyes. The area provided for the nose was also too small. On the largest head, the distance between the eyewear and the face was too large.

Item F was a pair of safety spectacles with clear eyepieces. The spectacles were roughly square in shape and did not follow the contour of the face. Provision had been made for the contour of the nose bridge. In order to ensure that the eyes were not exposed by the large gaps at the top and sides of the eyepieces, shielding that followed the contours of the face was provided. No rubber pieces were provided for comfort over the nose bridge. The temples ware adjustable and shaped to follow the contour of the back of the ear, and the edge of the temples was shaped to follow the shape of the head and bottom section of the back of the ear. An acceptable fit was obtained for seven out of the eight head models. Poor fit was observed on the largest head, the 4L-F, because the area provided for the nose was too small.

Item G was a pair of safety spectacles with clear eyepieces and no rim. The eyewear was shaped to follow the contour of the face and nose. It had rubber nose rests at the nose area as well as temples that were adjustable in length. Poor fit was observed on the two largest heads, 2L-F and 4L-F. The main reason for the poor fit was the distance between the temples being too narrow towards the front of the eyewear, which meant that the fit across the front-to-temporal bones (sides of forehead) was too tight.

Item H (a pair of safety spectacles) had clear eyepieces with a rim at the top and between the eyes up to the curvature provided for the nose. The eyepieces followed the contours of the face and nose, and rubber nose rests had been provided for the nose bridge. The temples were adjustable and had a very slight curve towards the back of the ear. Poor fit was observed on the largest head model, 4L-F.

The poor fit resulted from insufficient protection being provided on the side of the eyes, and the fact that the temples fitted too tightly over the front-to-temporal sides of the forehead

Item I was a pair of safety goggles with clear lenses that were roughly square in shape and followed the contours of the face. Shielding was provided around the top, bottom and side edges of the eyepieces and ensured protection for the eyes from any harmful objects. An elastic band was provided to secure the eyewear to the head. For these goggles, an acceptable fit was obtained for all the head models.

Item J was a pair of safety goggles consisting of two eyepieces that had a black rim and a red shielding edge around the top, bottom and sides. Additional flip-up and flip-down eyepieces were provided to provide protection against high-intensity light. An adjustable elastic band was provided to secure the eyewear to the head. This eyewear did not provide fit for seven out of the eight head models. Although acceptable-to-good fits were observed for the majority of the dimensional factors investigated, the distance between the eyepieces was too big and resulted in unacceptable distances between the inside of the eyepieces and the inner eye

Item K (a pair of safety spectacles) had clear lenses with a rim at the top of the eyepieces and had shielding at the sides where the eyepiece might be too far from the face. The

eyewear was shaped to follow the contours of the nose, but no rubber pieces were provided over the nose bridge. The temples were adjustable and curved to follow the shape of the back of the ear. This eyewear provided an acceptable fit on six of the eight head models. The main reason for the unacceptable fit on two models was that the temple was too wide for smaller faces.

Item L was a full-face rubber protective mask. The mask had two eyepieces and made provision for one respirator filter. There were three mask sizes in the range for this protective mask type. An acceptable fit was obtained from the three mask sizes on all of the head models. This indicates that this full-face protective mask would provide an acceptable fit for at least 90 percent of the SA population.

The results set out in this section indicate that only 25 per cent of the items evaluated for face fit would actually fit 90 per cent of the SA user population. This observation underlines the importance of considering the anthropometry of the user population when PPE is designed. In this way, optimal protection can be ensured.

4.5.1.2 Protective footwear

A large variety of protective footwear is worn in the South African mining industry. The selection of protective footwear is in most instances based on the outcome of a risk assessment of the areas where the employee is destined to work. In general, employees in workshops (artisans) and at mines other than coal, platinum and gold mines are issued with ankle-length leather lace-up boots with steel or non-metallic toe caps. Metatarsal guards are not generally used and, when they are, they are usually loose guards (polycarbonate material) strapped onto the top of the wearer's normal safety footwear, using the laces of the footwear to secure them in position.

Protective footwear used in the local mining industry may be comprise of leather, rubber or PVC construction depending on whether a mine is 'dry' or 'wet'. Under the latter conditions, miners prefer 'gumboots' to 'keep their feet dry'. Protective features such as impact- and compression-resistance (steel or non-metallic toe cap), penetration-resistant soles and metatarsal guards are available to the mining industry. The fact that these protective features are not generally present in protective footwear used on mines could be attributed, at least in part, to the fact that falling objects or crushing from heavy rolling objects and the penetration of sharp objects through the sole of protective footwear are not always seen as major occupational hazards. Manufacturers and suppliers of footwear indicated that some employers consider the cost of these protective features to be too high relative to the overall price of protective footwear.

As part of the current study, the protective footwear used in mines elsewhere in the world was compared with that used in the local mining industry. In the USA there is no 'standard' protective footwear. OSHA's foot protection standard, 1910.136(a), requires protective footwear to be used when employees are working in areas where there is a danger of foot injuries due to falling or rolling objects, or objects piercing the sole, and where such employees' feet are exposed to electrical hazards.

Protective footwear must comply with American National Standards Institute standard ANSI Z41-1991, which categorises footwear into six categories:

- Impact- and compression-resistance, where a steel or non-metallic toe cap is used to protect against falling objects or crushing from heavy rolling objects.

- Metatarsal footwear, which provides similar protection against falling objects to the area of the foot between the ankle and the toes.

- Electrical hazard, where the sole of the shoe or boot is designed to protect workers from electric shock from 600 volts or less, under dry conditions.

- Conductive footwear, which prevents the build-up of static electricity.

- Puncture-resistance, where the sole resists penetration from sharp objects such as nails or broken glass.

- Static-dissipative, which reduces the build-up of static electricity by conducting body charge to ground, while protecting the employee from electrical hazards.

The type of footwear used in mines in the USA is determined by the anticipated hazard. Samples of protective footwear used by general miners (as observed during a recent visit by a project team member to NIOSH's Pittsburgh Mining Research Laboratories) had steel toe caps, metatarsal protectors, and puncture-resistant soles (Lazzara, 2005). Miners wear either ankle-height leather boots or rubber gum boots. As is the case in the local industry the choice is determined by the conditions underground ('dry' or 'wet'). According to staff from the Health and Safety Laboratory in Buxton (Mark, 2005), miners in the UK typically wear protective footwear (ankle-height leather boots or Wellington-type boots) with steel toe caps and steel mid-soles. Unfortunately, only the ankle-height leather boots were made available for assessment during a recent visit to the laboratory.

With the assistance of local manufacturers and suppliers of footwear, a number of items of gumboot-type protective footwear used in the Australian and North American mines, as well as a French mining boot, were obtained and compared with some of the protective footwear that is generally used in local mines. Examples of the boots are given in Figure 4.5.1.2a.

Figure 4.5.1.2a Examples of protective footwear assessed

The boot worn in American mines is on the left in Figure 4.5.1.2a, the Australian boot in the middle, and the South African boot on the right. It is interesting to note the differences in metatarsal protection and the fact that the South African boot's sole is moulded in such a way (not flat on the ground) to accommodate the position of the foot when wearers are crouching on their haunches.

A Wellington-type foot protection that is used in mines in North America is made of rubber. The boots comply with ANZI Z41, have metatarsal impact protection, heavy canvas lining on the inside, steel mid-soles, as well as ankle, shin and heel-tendon protection. The boots have cushioned insoles, and heat- and oil-resistant anti-slip soles. Each boot also has a lace-up feature on the front top of the leg of the boot (Figure 4.5.1.2b).

Figure 4.5.1.2b Lace-up feature on safety boot

The other mining boot used in North America also has a steel toe cap and a steel mid-sole, as well as metatarsal, ankle and heel-tendon protection. The metatarsal protection is in the form of rather flimsy and thin rubber ribs. The boot has a heat- and oil-resistant sole and a built-in sponge sole.

The boots from Australia comply with the relevant Australian standard and have penetration-resistant mid-soles and a safety toe cap. They have some form of metatarsal and shin protection in the form of PVC ribs. The boots also have canvas lining on the inside and both sides of the ankle areas on the legs of the boots are provided with 'ankle patches'.

The French boot also has a steel toe cap and a steel mid-sole with a very thin lining on the inside of the boot. The thickness of the sole was also considerably less than that of the other boots assessed.

From the assessments made, the general conclusion is that all of the relevant protective features are available in locally manufactured protective footwear, if the relevant standards are observed. It remains the responsibility of the employer to ensure that the footwear selected is of a design, construction, and material appropriate to the protection required.

Typical mining-related factors to consider include slipping, uneven terrain, abrasion, ankle protection and foot support, crushing potential, temperature extremes, chemical substances, and puncture hazards.

All gumboots, including those used in other mining countries, have an inherent shortcoming, namely, poor ankle support. From discussions with various individuals in the mining industry it is obvious that there is also a need for protective footwear that can be used in both wet and dry conditions. Neither gumboots nor leather protective footwear currently available are able to offer a complete solution to the problems experienced by those who work in both wet and dry conditions in mines.

Gumboots do not provide the sound ankle support required for walking on uneven and slippery surfaces associated with many workplaces, or the comfort required by those who walk substantial distances in their workday. Heat and discomfort due to the lack of air circulation, muscle fatigue, fungal infections and skin abrasions are some of the problems resulting from extended occupational usage of gumboots. Leather protective footwear, on the other hand, also has its disadvantages. Even when it is polished and sealed, leather requires ongoing maintenance for it to remain durable. Furthermore, it cannot be used continuously in wet applications regardless of frequent maintenance, because surface abrasion caused by scuffing and contact with sharp objects in the workplace opens up the natural skin of the leather. Once moisture penetrates the surface, it is absorbed, and a sponge action causes the leather to swell and deteriorate.

In order to address the need for protective footwear that combines the comfort and support features of leather footwear with the waterproof nature of a gumboot, a prototype ankle-height boot has been designed by a local supplier of protective footwear. The boot is manufactured from a fabric woven in South Africa under licence from an international company and it is waterproof to a two-metre water head resistance level, is oil and acid resistant, breathable, and has high abrasion resistance. It is lined with an anti-microbial fabric that combats foot hygiene problems. The boot also has a moulded polyfoam in-sole that hugs the foot and supports the arch area. The sole is manufactured from a PVC/Nitrile blend that is considered to be an adequate soling material for wet and dry conditions. The manufacturer has lodged a patent application with the South African Registrar of Patents.

From the information shown in Table 4.2.1a, it is obvious that injuries to the metatarsal region of the foot cannot be ignored as being insignificant.

While the polycarbonate and polypropylene metatarsal protectors have been available for many years, these guards do not meet the standards of Canada, for example. Metatarsal protectors that only attach to the laces or are only strapped in place are not used in Canada because there is no assurance the metatarsal protector is properly supported by the toecap. (http://regulation.healthandsafetycentre.org/s/Part8.asp#SectionNumber:8.22).

In view of the above, it is evident that metatarsal protectors should be part of the protective footwear. A local manufacturer of protective footwear has patented a metatarsal protector specifically for use on gumboots. The metatarsal guard offers protection from the steel toecap to the shin, without impeding the flexibility required to work in bending, kneeling, or crouching positions. The guard is ‘factory fitted’ - being bonded directly onto the boot during manufacture - to ensure lasting protection.

As far as the ergonomics of available protective footwear is concerned, some employees complained about the difficulty to don gum boots, mainly as result of the lack of space in the instep and calf area of the leg of the boot. Female miners were also issued with protective footwear designed for their male counterparts, and females with small feet are not accommodated by the sizes available.

4.5.1.3 Other PPE

The major ergonomics-related problem experienced with PPE such as gloves, leg protectors, knee protectors and overalls was related to size and fit. For most of these items, the anthropometry of the mining population was not considered in the design of the product. In many cases, gloves were uncomfortable, clumsy and not entirely suitable for the South African user population. Despite the fact that various sizes are available, even the smallest sizes did not suffice for the smaller females in the population.

Many female miners complain of ill-fitting personal protective clothing and equipment. Overalls (especially the one-piece garments) proved to be problematic as they did not cater for the needs of females. Clothing or equipment that is not sized or does not fit properly can compromise personal safety, and may not function effectively in the manner for which it was designed. Ill-fitting personal protective equipment may be due to unavailability of the correct sizes (i.e., manufacturers do not make or distributors do not stock them), limited availability, or lack of knowledge among employers and workers about where equipment designed for women can be obtained. It should be stressed that PPE intended for use by female workers should be based upon female anthropometric (body measurement) data.

The above findings are not unique. Studies by NIOSH and the U.S. Army found that most tools, equipment, and clothing are not designed for a female physique. When asked if they could easily find protective clothing to fit them, 46 per cent of women interviewed replied that they could not find work shoes that fitted and 41 per cent could not find work gloves. One survey of manufacturers of protective equipment, taken at a National Safety Council annual meeting, found that only 14 per cent offered ear, head, and face protection in women's sizes. The highest percentage, 59 per cent, was for manufacturers who offered foot protection in women's sizes (Gordon, 1996).

4.5.2 Pilot study at occupational health clinics

One-hundred-and-eighty-seven mineworkers were interviewed and their feet examined at the coal and gold mines used in the study. At the coal mine three females were part of the group of 84 mineworkers assessed. All of the 103 mineworkers assessed at the gold mine were males.

The mean age of the mineworkers was 41. There was no significant difference in the ages of mineworkers at the coal mine and at the gold mine. The coal miners were significantly ($p<0,005$) taller than the gold miners (1,72 as opposed to 1,68 m). The coal miners (76,9 kg) were significantly ($p=0,009$) heavier than the gold miners (69,8 kg). The body mass index ($p=0,009$) and the body fat percentage ($p=0,008$) of coal mineworkers showed that a significant percentage were overweight or obese compared to the gold mineworkers.

There was no significant difference in the number of mineworkers with hypertension, arthritis, or eyesight problems among the coal and gold mineworkers interviewed. However, significantly more coal mineworkers than gold mineworkers had diabetes. A third of the coal (28) and gold mineworkers (36) were currently smokers.

4.5.2.1 Foot complaints

From the interviews with mineworkers it was evident that the main foot complaint (Table 4.5.2.1) was foot infections (27 per cent), followed by burning feet (26 per cent), and corns (26 per cent). Corns develop from an accumulation of dead skin cells on the foot that form thick, hardened areas. They contain a cone-shaped core with a point that can press on a nerve at the base, causing pain. Corns are very common and usually form on the tops,

sides and tips of the toes. Corns can become inflamed as a result of constant friction and pressure from footwear.

Some of the common causes of corn development are tight-fitting footwear, high-heeled footwear, tight-fitting stockings and socks, deformed toes, or the foot sliding forward in a shoe that fits too loosely.

For the gold mineworkers, foot infections (33 per cent) were the main foot complaint followed by hammer toe (30 per cent) and burning feet (28 per cent). For the coal mineworkers foot corns were the main complaint (27 per cent) followed by burning feet (23 per cent) and painful feet (21 per cent). Discomfort, tiredness, and sore feet after long hours of standing are the combined effect of several factors, namely the nature of the work, the workers' footwear, and the flooring material or being overweight (i.e. mechanical overload) (Chester et al., 2002). Hot and sweaty feet will increase the discomfort and symptoms of burning feet. Neuropathy due to diabetes, HIV etc must also be considered.

Table 4.5.2.1: Number and percentage of foot complaints of mineworkers at the coal and gold mine

Foot complaints	Total number of foot complaints	Percentage of foot complaints (%)	Total number of foot complaints at the coal mine	Percentage of foot complaints at the coal mine (%)	Total number of foot complaints at the gold mine	Percentage of foot complaints at the gold mine (%)
Infections	51	27	17	20	34	33
Burning	49	26	20	23	29	28
Corns	48	26	23	27	25	25
Pain	44	23	18	21	26	26
Hammer toe	35	17	4	5	31	30
Cold feet	28	15	13	16	15	15
Stiffness	27	14	9	11	18	18

Foot complaints	Total number of foot complaints	Percentage of foot complaints (%)	Total number of foot complaints at the coal mine	Percentage of foot complaints at the coal mine (%)	Total number of foot complaints at the gold mine	Percentage of foot complaints at the gold mine (%)
Calluses	25	13	11	13	14	14
Swelling	25	13	7	8	18	18
Discoloration	14	7	6	7	8	8
Tingling	11	6	12	14	0	0
Numbness	11	6	7	8	4	4
Painful toe-nails	11	6	6	7	5	5
Bunions	11	6	6	7	5	5

Figure 4.5.2.1 demonstrates the percentage of foot complaints for mineworkers using either gumboots or safety shoes. There were an increased number of complaints of infection (31 per cent versus 21 per cent) and pain (26 per cent versus nine per cent) for mineworkers wearing gumboots. However, for mineworkers wearing safety shoes there was an increased number of complaints of bunions (13 versus two per cent, which is statistically significant), calluses (20 per cent versus 12 per cent), and burning (30 per cent versus 22 per cent) compared to mineworkers using gumboots.

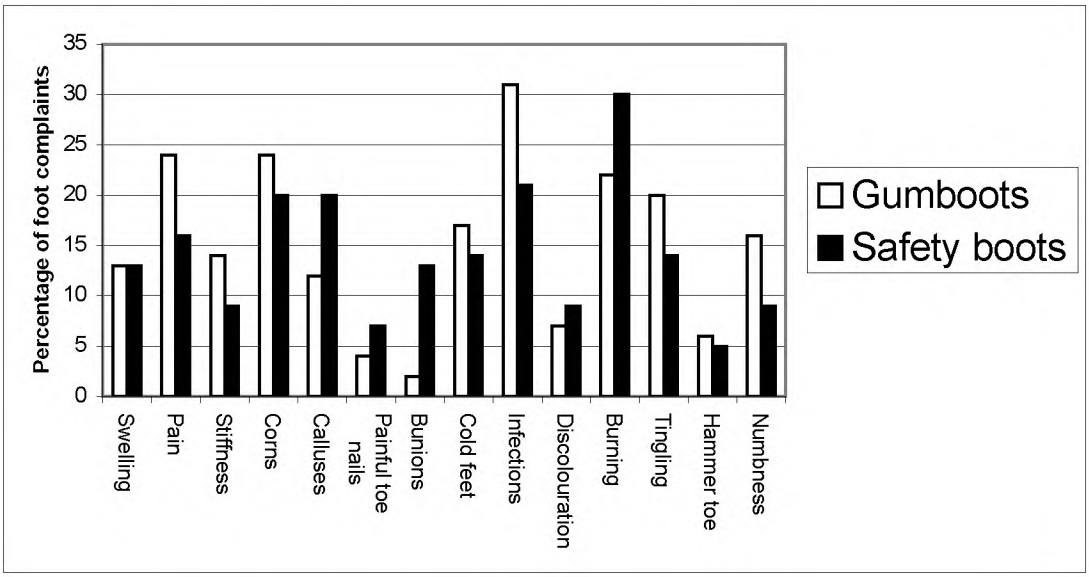

Figure: 4.5.2.1 Foot complaints for mineworkers wearing gumboots and safety shoes

4.5.2.2 Foot pathology

All the mineworkers interviewed agreed to have their feet examined by a medical practitioner. The skin, nails, and shape and size of the foot were assessed (Appendix 2). The list of foot pathology found on examination is given in Table 4.5.2.2a. Mineworkers were not asked what type of footwear they wear when they are not at work. Skin calluses were found in most mineworkers examined (92 per cent). The majority had thin calluses (53 per cent); however, eight per cent had very thick calluses. Skin infection (46 per cent) and corns (35 per cent) were also seen in many of the mineworkers assessed. The formation of calluses is caused by an accumulation of dead skin cells that harden and thicken over an area of the foot. This callus formation is the body's defence mechanism to protect the foot against excessive pressure and friction. Calluses are normally found on the ball of the foot and the heel. Some common causes of callus formation are high-heeled dress shoes, shoes that are too small, obesity,1 abnormalities in the gait cycle (walking motion), flat feet, high-arched feet, bony prominences, and the loss of the fat pad on the bottom of the foot.

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[1] The study population had a significant percentage of overweight/obese mineworkers. Thirty-one per cent of the study population was overweight (Body Mass Index (BMI) 25.0 – 29.9) and 14 per cent were obese (BMI equal to or above 30.0).

Table 4.5.2.2a: Number and percentage of foot pathology of coal mineworkers and gold mineworkers examined

Foot pathology	Total number with foot pathology	Percentage of foot pathology (%)	Total number with foot pathology at coal mine	Percentage of foot pathology at coal mine (%)	Total number with foot pathology at gold mine	Percentage of foot pathology at gold mine (%)
Calluses	154	92	58	69	96	92
Skin infections	86	46	26	31	60	58
Nail Discolouration	66	35	29	35	37	36
Corns	65	35	30	36	35	34
Nail thickness	64	34	30	36	34	33
Fungal Infection of nail	32	17	11	13	21	20
Bunion	27	14	15	18	12	12
Hammer toes	14	7	2	2	12	12
History of ulcerations	11	6	5	6	6	6
Ulcerations	9	5	3	4	6	6
General foot deformity	3	2	2	2	1	1
Fissures	3	2	1	1	2	2
Bony outgrowths	2	1	0	0	2	2
Nail infection	6	3	3	4	3	3

The right foot of all the study participants was measured. The selection of which foot to measure was not dependent on the handednesses of the study participant; handedness or height of the study participants was not addresses in the study. Eighty-one percent of the feet examined were normal in shape, 15 per cent were flat, and 8 per cent had a high instep. An outline of the feet of most of the mineworkers was made to determine their foot length, the width over the toes, the width over the ball of the foot, and the width over the waist of the foot. The average foot dimensions for the mineworkers assessed are shown in Table 4.5.2.2b

Table 4.5.2.2b: Foot dimensions for mineworkers at the coal and gold mines

Males at coal mine (n=79)	Mean (cm)	Min (cm)	Max (cm)
Foot length	26,3	23,4	29,0
Foot width over toes	10,1	5,9	11,9
Foot width - ball of foot	10,6	8,8	12,0
Foot width - waist of foot	7,6	5,2	10,8
Foot length	26,1	20,1	29,1
Foot width over toes	9,7	7,5	16,0
Foot width - ball of foot	10,6	8,6	12,0

Foot width - waist of foot	7,9	6,0	10,0
Females at coal mine (n=3)	**Mean (cm)**	**Min (cm)**	**Max (cm)**
Foot length	25,5	23,0	28,0
Foot width over toes	11,0	9,5	12,5
Foot width - ball of foot	10,6	9,8	11,2
Foot width - waist of foot	8,2	7,2	9,2
Total group (excluding females) (n=181)	**Mean (cm)**	**Min (cm)**	**Max (cm)**
Foot length	26,2	20,1	29,0
Foot width over toes	9,9	5,9	16,0
Foot width - ball of foot	10,6	8,6	12,0
Foot width - waist of foot	7,7	5,2	10,8

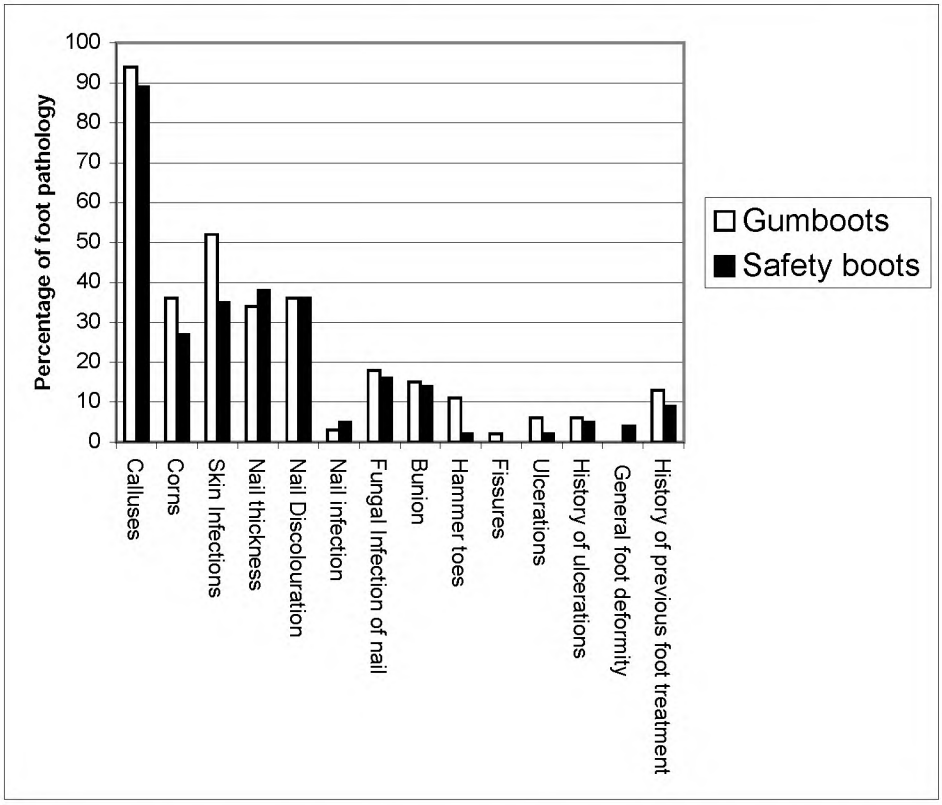

Figure 4.5.2.2: Foot pathology of mineworkers wearing either gumboots or safety shoes

Figure 4.5.2.2 demonstrates the percentage of foot pathology of mineworkers using either gumboots or safety shoes. The only significant difference (p=0,049) was the increased number of foot infections in mineworkers using gumboots compared to mineworkers wearing safety shoes (52 per cent as opposed to 35 per cent).

4.5.2.3 Medical history of foot complaints

Seven coal mineworkers (8 per cent) and 15 gold mineworkers (14 per cent) interviewed had consulted a medical practitioner for a foot condition since being employed at the mine

they currently worked at. The majority of foot consultations at the gold mine (4 per cent) were for work-related injuries and most had required surgery. At the coal mine, only one mineworker presented with a work-related foot injury. In an earlier survey (Watts, 1989), a similar finding was shown: underground lower-leg injury rate for gold mineworkers exceeded that for coal mineworkers by a factor of more than two.

Two coal mineworkers and one gold mineworker who consulted a medical practitioner for a foot infection had a fungal infection. Most of the mineworkers complaining of foot infections or assessed to have a foot/nail infection did not seek medical help for their feet. Often their foot infection would 'resolve' when they were on leave (Watts, 1989).

For this reason, they felt the infection was caused by work, either because of the protective footwear they wore or because of the working environment, i.e. the dirty water found underground. They also showed little confidence in the treatment given at the medical centre because the foot infection would either not resolve or reoccur shortly after treatment was complete.

4.5.2.4 Foot hygiene

Nearly 50 per cent of the mineworkers assessed in the current study had good foot hygiene. Twenty-five per cent had fair, and 12 per cent had poor hygiene. Only two mineworkers could not reach their toes and all claimed to be able to remove their socks. Twenty-four per cent did not wear any socks, 46 per cent used cotton socks, and 20 per cent nylon socks. Most of the mineworkers claimed to wash their feet daily except for two mineworkers. Five per cent of the mineworkers claimed not to wear a clean pair of socks every day. All the mineworkers claimed to use nail clippers to cut their nails but this did not always appear to be the case. Very few of the interviewed mineworkers showed any insight into the association of poor foot hygiene and foot infections.

Mineworkers who claimed not to use a clean pair of socks every day had the following reasons for not maintaining good foot hygiene:

- Their socks did not dry in time for the next shift (especially during winter);
- There was no time to wash socks after the shift; and
- They had no money to buy more socks.

Table 4.5.2.4: Level of foot hygiene of mineworkers at the coal mine and the gold mine

Level of hygiene	Coal mine	Gold mine
Excellent	2 (2%)	0 (0%)
Good	43 (52%)	46 (47%)
Fair	25 (31%)	45 (26%)
Poor	12 (15%)	7 (7%)

The level of hygiene observed was significantly worse for coal miners than for gold miners (p=0,051) (Table 4.5.2.4). This result may be biased since all the gold mineworkers assessed had recently come back from leave, whereas all coal mineworkers assessed were currently working.

Foot infections may be due to the mineworkers' poor foot hygiene, the work environment, or the PPE footwear the mineworkers are using (Stratigos & Katsambas, 2003). From the results obtained in the present study there was no association between the level of foot

hygiene and complaints (p=0,69) and/or observed evidence of foot infection (p=0,08). However, mineworkers working at the gold mine (warm/hot environment) were more likely to complain of foot infections (p=0,056) and/or have a foot infection (p=<0,005) at the time of the medical assessment. Since the mineworkers claimed that the work environment was affecting their feet it might be important to determine what percentage of the mineworkers' feet get wet, and emphasise the importance of keeping the skin of the feet intact. Fifty-one per cent of mineworkers who wore gumboots had skin infections compared to 35 per cent of mineworkers who wore safety boots (p=0,049). Most mineworkers complained that gumboots caused their feet to sweat, and that often their feet got wet despite the gumboots.

The above results provide evidence that the increased rate of infection in mineworkers was due to warmer working conditions, feet getting wet, poor foot hygiene, and the use of gumboots. Most mineworkers claimed that their foot infections recovered while they were on leave, suggesting that lack of knowledge of foot hygiene may not be the most important reason for the high percentage of complaints and the observed evidence of skin infections. Therefore, the general foot care guidelines given in Appendix 3 could be applied for the mining industry. The importance of footbaths at change houses, clean boots, and the wearing of socks should also be highlighted.

Foot care guidelines for use in the mining industry are given in Appendix 3.

4.5.2.5 Assessment of education in and knowledge of footwear

The types of footwear used by the study participants are given in Table 4.5.2.5.

Table 4.5.2.5: Type of footwear worn by coal mineworkers and gold mineworkers

Type of footwear	All	All (%)	Coal	Coal (%)	Gold	Gold (%)
Gumboots	108	59	19	23	89	89
Safety boots	56	31	52	63	4	4
Gumboots and safety boots	9	5	6	7	3	3
Normal shoes	6	3	3	4	3	3
Normal shoes & safety boots	3	2	2	2	1	1
Normal shoes & gumboots	1	1	1	1		
Socks	137	76	56	67	81	83

Fifty-nine per cent of the mineworkers interviewed wore gumboots, 31 per cent wore safety boots and the rest wore a combination of these. At the coal mine, the majority of the mineworkers interviewed (63 per cent) wore safety boots whereas the majority of the gold mineworkers interviewed (89 per cent) wore gumboots. All participants in the study were aware that they were wearing protective footwear to protect their feet from injury. Many of the mineworkers wearing gumboots said that the footwear protected them from water as well. The steel cap was seen as protecting the toes from crush injuries.

Ninety per cent of the coal miners felt the safety boots protected their feet whereas fewer of the gold miners (75 per cent) held this opinion. Protection from falling rocks was stated

by 36 per cent of the mineworkers as a reason for wearing safety boots. However, one mineworker did not see how the safety boot could protect the foot from falling rocks. Forty-two per cent felt the steel cap provided protection for the foot. However, mineworkers complained that the steel cap hurt their toes and made the shoe heavy. Mineworkers suggested that the steel cap should be placed on the outside of the safety boot. Many complained that the safety boot was very uncomfortable when new and caused many blisters, especially in hot environments. At the coal mine, the safety boots lasted on average 12,8 months (a range of three months to four years), which was similar for gold mineworkers wearing safety boots.

Only six study participants (i.e. clinical and administration staff) wore shoes of their choice to work. They all felt the shoes were comfortable. Since their shoes were closed-toes, they stated their feet were protected from falling objects and blood spillage. They all felt their shoes were comfortable and lasted between three-and-a-half months and three years.

Eighty-nine per cent of the coal miners felt the gumboots protected their feet compared to 83 per cent of the gold miners. Protection from water was mentioned by approximately 50 per cent of the mineworkers as a reason for wearing gumboots. Many of the mineworkers, especially at the coal mine, described the underground water they walk through as hazardous. Besides the water being dirty, mineworkers often urinated in the water and injured mineworkers bled into the water. (HIV infection was a concern for the mineworkers despite the risk being minimal.) Between 16-25 per cent of mineworkers wearing gumboots claimed the gumboot protected the foot from falling rocks, and over eight per cent felt that the steel cap provided protection for the foot. Only three mineworkers complained that the steel cap hurt their feet. Many complained that the gumboots made their feet sweat and burn, resulting in their not being able to work properly. Often the feet got wet, especially if the mineworker was drilling.

Although the gumboot protected the foot from the 'infected' underground water, ironically it was also the cause of the foot infections they complained about. At the coal mine, the gumboots lasted on average eight months (ranging from one month to two years) which was longer than for gold mineworkers (the average was four months). This difference could possibly be due to the difference in working environments or the amount of walking taking place at the two mines.

Nine mineworkers used both gumboots and safety shoes. Although this is a small group and no statistical significance can be shown, the following findings are included, since these mineworkers were using both types of protective footwear and were therefore able to compare the one with the other. Coal mineworkers who alternated between gumboots and safety boots felt the safety boot protected their feet and the gumboot did not because the gumboot caused their feet to sweat and caused foot infections. Conversely, all the gold mineworkers felt the gumboot protected their feet better than the safety boot because it was more suitable for 'wet' working environments.

4.5.2.6 Link between foot complaints/injuries/disorders and protective footwear

Mineworkers who wore safety boots at work were more likely to complain of their bunions than mine workers using gumboots ($p=0,05$). The other foot complaints did not show any association with type of protective footwear. However, during the examination mineworkers wearing gumboots were more likely to have a foot infection ($p=0,05$) or hammer toes ($p=0,04$) than mineworkers using safety boots. No other foot conditions significantly associated with the protective footwear the mineworkers wore were noted during the medical assessment.

The steel cap is probably the main reason for the increased number of mineworkers complaining of corns. Suggestions to place the steel cap on the outside of the shoe and increase the width of the shoe over the toes could, at least theoretically, decrease the incidence of corns and the discomfort they cause. Another concern was the high percentage of bunions (14 per cent) (referred to in the medical community as Hallux Valgus), which is one of the most common forefoot problems among mineworkers. Tight, narrow dress shoes with a constrictive toe box can cause the foot to begin to take the shape of the shoe, leading to the formation of a bunion. Similarly, toes squeezed together into the steel cap may result in a bunion

There are two major categories of work-related foot injuries. The first includes injuries from punctures, crushing, sprains, and lacerations. The second group of injuries includes those resulting from slips, trips, and falls. Slips and falls do not always result in a foot injury but lack of attention to foot safety plays an important role in their occurrence. In the mining industry, a comparative ranking of major causes of lower-leg injuries in a survey over the period 1992-1995 listed rock falls (32 per cent), rolling/loose rock stones (29 per cent), hoppers/tippers (15 per cent), and metal objects (15 per cent) as the major causes of lower-leg injuries (Kielblock & MacKay, 1996). Other conditions resulting in foot problems at work include calluses, ingrown toenails, or simply tired feet. There are also numerous conditions affecting the feet that are associated with medical disorders such as diabetes, rheumatoid arthritis, or peripheral vascular disease (Sprinett, 2002). Although these are not work related, they can have serious consequences for health and safety in the workplace.

Improvements in the working environment have made the simple puncturing and laceration of the worker's foot by protruding floor nails and other sharp hazards less common, but accidents from working on damp or wet floors still occur, particularly when workers are wearing unsuitable foot wear.

4.6 Appropriate PPE for the mining industry

The information, guidelines and suggestions contained in this part of the report are based on information obtained from documents and the web sites mentioned in Section 3.4. Owing to the generic nature of the information and guidelines available from these institutions, information has been presented verbatim in many instances.

For obvious reasons no specific products can be listed here. Emphasis has, therefore, been placed on the provision of relevant information to assist in the selection of appropriate PPE.

4.6.1 General considerations

The primary objective of a PPE programme is to protect employees from health or safety risks by creating a barrier against workplace hazards. PPE is not a substitute for engineering or administrative controls or safe work practices. In practice, PPE is used as the last line of defence. A well designed and organised PPE programme is essential and the programme should ideally be linked to existing health and safety programmes at mines.

A comprehensive PPE programme requires commitment and active participation at the planning, development, and implementation stages from all levels: senior management, supervisors, and workers. According to CCOHS (1997) a good PPE programme consists of the following elements:

- Workplace survey (hazard identification);

- Selection of appropriate controls;
- Selection of appropriate PPE;
- Fitting of PPE;
- Training in the use and limitations of PPE;
- Management support;
- Maintenance; and
- Auditing of the programme

(A checklist to assist with the design of a PPE programme is given in Appendix 4).

As is the case in any occupational health and safety programme, the success of any PPE programme depends upon the cooperation and support of all those concerned. This can best be achieved by helping employees understand the need to wear the PPE, and by encouraging them to want to wear it rather than by demanding that they do so. Supervisors and managers should lead by example.

CCOHS points out that PPE programmes are often plagued by the belief that once a piece of protective equipment is put on, the worker is totally protected. This belief gives a false sense of security. Basic safety principles, such as housekeeping and environmental controls, must not be ignored.

4.6.2 Selecting PPE

During the selection of PPE, the following factors should be considered:

- Results of a proper hazard identification and risk assessment survey;
- The working environment;
- The physical effort required to do the job;
- The required protection in terms of duration;
- The appropriateness of the PPE decided upon;
- The ergonomics and physical comfort of the PPE;
- The need for adequate visibility and communication when PPE is being worn;
- The compatibility of equipment if more than one piece of PPE is used;
- The state of health of those who will wear the equipment; and
- PPE standards and certification (a list of standards from the SABS is given in Appendix 5).

As a result of the considerable differences in the anthropometry of different workers, more than one type or size of PPE needs to be provided. Gender difference in physique and

physical dimensions cannot be ignored. In all cases, the general rule to follow is that PPE should fit the wearer, not the other way round.

It is also important to discuss basic PPE needs with trained representatives from the manufacturers and suppliers of PPE to obtain advice on specific products and viable alternatives. In this regard, it is essential to try out particular PPE and test it to see that a product meets the set criteria before it is approved for purchase and use.

One of the most effective ways of ensuring suitable PPE is provided is to consult the workforce during the selection process. As well as often being best placed to understand the demands of the job, employees who are involved in selecting PPE are more likely to accept the need for the equipment and to use and wear it properly.

The performance requirements of PPE must be reviewed under operational conditions at regular intervals to ensure that exposure to injury will be minimised or eliminated by using PPE. If PPE is subjected to exposure levels greater than those for which it was designed, it will not deliver adequate protection.

It is important to note that protective clothing and equipment themselves can create hazards. Protective gloves that can become caught between rotating parts, or a respirator face piece that can hinder the wearer's vision, for example, require attention and carefully supervised use.

4.6.3 Head protection

Protecting employees from potential head injuries is a key element of any safety programme. A head injury can impair an employee for life or it can be fatal. Any persons likely to bump or scrape their heads or to be hit by falling objects in the workplace must wear head protection.

4.6.3.1 Safety helmets

The most commonly used head protection is safety helmets (hard hats and hard caps) and these are compulsory for all employees, contractors and visitors in designated Safety Helmet Areas. Hats differ from caps in that they have a full brim rather than just the front peak. This has the advantage of shedding water in mines which are very wet. Hats represent a very small percentage of the head protection worn in mines.

SABS 397-1983 is the standard specification for safety helmets for industrial use. Some protective headgear allows for the use of various accessories to help employees deal with changing environmental conditions, such as slots for earmuffs, safety glasses, face shields, mounted lights, and ventilation openings in the shell. Protective headgear accessories must not compromise the safety elements of the equipment.

Periodic cleaning and inspection will extend the useful life of protective headgear. A daily inspection of the hard hat shell, suspension system and other accessories for holes, cracks, tears or other damage that might compromise the protective value of the hat is essential. Paints, paint thinners, and some cleaning agents can weaken the shells of hard hats.

4.6.3.2 Bump hats

Another class of protective headgear on the market is the ‘bump hat’. Bump hats are designed for applications where there may be a risk of a minor bump or scrape to the head. Bump hats cannot be used as substitutes for safety helmets because they do not afford protection from high-impact forces or penetration by falling objects.

4.6.3.3 Wide-brimmed hats

Wide-brimmed hats are available for employees working outdoors in the sun for protection against excessive exposure to ultraviolet radiation (UVR). Optional brims fitted to hard hats or hard caps may provide additional protection from the sun.

Hoods are available that can be used on their own or in conjunction with other PPE items for specific hazards; for example, radiant heat, hazardous vapours, gases, chemicals, and paint spray.

4.6.3.4 Hair nets

Workers with long hair that could be caught in machines should tie their hair back or wear protective hair nets.

4.6.4 Eye and face protection

Appropriate eye or face protection is needed when employees are exposed to eye and face hazards from flying particles, dust, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapours, or potential harmful optical radiation (OSAH, 2003).

Many occupational eye injuries occur because workers do not wear any eye protection or wear poorly fitting eye protection. Employers must be sure that their employees wear appropriate eye and face protection and that the selected form of protection is appropriate to the work being performed and properly fits each worker exposed to the hazard.

Factors that should be considered in the selection of eye protection include:

- The nature of the risk to the eyes;
- The conditions under which the employee is working;
- The visual requirements of the task;
- The personal preference of the wearer, with comfort and appearance being the main factors in wearer preference; and
- The condition of the operator's eyesight.

4.6.4.1 Prescription lenses

Everyday use of prescription corrective lenses will not provide adequate protection against most occupational eye and face hazards, so employers must make sure that employees with corrective lenses either wear eye protection that incorporates the prescription into the design or wear additional eye protection over their prescription lenses. It is important to ensure that the protective eyewear does not disturb the proper positioning of the prescription lenses so that the employee's vision will not be inhibited or limited. Also, employees who wear contact lenses must wear eye or face PPE when they work in hazardous conditions.

4.6.4.2 Protective devices

Devices used to protect the eyes and face from injuries from impact, non-ionising radiation and chemical exposure in workplaces include:

- Safety spectacles (plano and prescription);

- Goggles; and
- Face shields.

Safety spectacles have frames constructed of metal or plastic and impact-resistant lenses. They are also designed to prevent the lenses from being pushed into the eyes. Side shields are available on some models.

Goggles are tight-fitting eye protection that completely cover the eyes, eye sockets and the facial area immediately surrounding the eyes and provide protection from impact, dust and splashes. Some goggles will fit over corrective lenses.

Face shields are transparent shields extending from the eyebrows to below the chin and across the entire width of the wearer's head. Face shield windows are made with different transparent materials and in varying degrees or levels of thickness. Face shields provide additional protection for high temperatures, high density/impact particles or against chemical splashes. Some shields are polarised for glare protection and heat-reflective and wire-screen face shields are intended to shield the entire face from a range of heat hazards.

A comparison of the characteristics of lenses generally used in safety glasses is given in Table 4.6.4.2 (CCOHS, 2003).

Table 4.6.4.2: Characteristics of lenses used in safety glasses

Comparison of Lens Materials	
Material	**Characteristics**
Polycarbonate	Strongest material for impact resistance Lightweight Can be coated for scratch resistance Most have built-in UV radiation protection
Plastic (CR39)	About one-half the weight of glass Resistant to solvents and pitting More choices for coatings and tinting
Glass	High-density material (heavy lenses) Loses impact resistance if scratched

Source: "Z94.3.1-02 Protective Eyewear: A User's Guide" (Canadian Standards Association, 2002)

4.6.4.3 Protection against impact hazards

Safety spectacles are the primary protectors intended to shield the eyes from a variety of impact hazards such as flying fragments, objects, large chips, and particles. Employees are required to use safety spectacles with side shields when there is a hazard from flying objects. The side shields on safety spectacles provide angular protection from impact hazards in addition to frontal protection. Side protection includes side shields and wraparound-style safety glasses.

The lenses of safety spectacles are designed to resist moderate impact from flying objects and particles. Two types of lenses are available, namely plano lenses and prescription

lenses. Plano lenses can be used by employees who do not require vision correction. These lenses may be flat or curved and are available in clear, filtered, or tinted lenses.

Prescription lenses should be used by workers who require vision correction. Prescription safety lenses with tempered glass or acrylic plastic lenses are not suitable for high impact and should be discouraged for work in debris areas unless they are covered by goggles or a face shield. Polycarbonate lenses should be used for work in high-impact areas. Polycarbonate lenses are lightweight and provide the best impact protection. The lenses are generally not as scratch resistant as glass unless they are treated with a hard coating.

Safety goggles are protectors intended to shield the wearer's eyes from impact hazards such as flying fragments, objects, large chips, and particles. Goggles fit the face immediately surrounding the eyes and form a protective seal around the eyes. This prevents objects from entering under or around the goggles.

Safety goggles may incorporate prescription lenses mounted behind protective lenses for individuals requiring vision correction. It is important to consider specific lens, frame, and ventilation options when safety goggles are selected.

Safety goggles provide higher impact protection than safety glasses. Goggles are available with removable lenses and may incorporate prescription lenses. Safety goggle frames must be properly fitted to the worker's face to form a protective seal around the eyes, as poorly fitting goggles will not offer the necessary protection. Two types of goggles (frames) are available, namely eyecup safety goggles that cover the eye sockets completely, and cover safety goggles that may be worn over corrective spectacles without disturbing the adjustment of the spectacles. Cover goggles are available in direct, indirect, or non-ventilated types. Ventilated goggles allow air circulation and prevent the fogging of the goggles.

Face shields are also available to protect the entire face or portions of it from impact hazards such as flying fragments, objects, large chips, and particles. In certain instances the face shields could be used in combination with safety spectacles or goggles, for additional protection beyond that offered by spectacles or goggles alone. Face shield windows are made with different transparent materials and in varying degrees or levels of thickness. These levels should correspond with specific tasks. Window and headgear devices are available in various combinations to enable the selection of the appropriate equipment.

Face shield windows extend from the brow to below the chin and across the entire width of the face and are available in both removable and lift-front designs. Plastic, polycarbonate and wire-screen windows are available. Headgear to support the window shield and secure the device to the head, as well as hard hats with face shields, is also available.

4.6.4.4 Protection against chemical hazards

A high percentage of eye injuries are caused by direct contact with chemicals. These injuries often result from an inappropriate choice of PPE that allows a chemical substance to enter from around or under protective eye equipment. Serious and irreversible damage can occur when chemical substances contact the eyes in the form of splash, mists, vapours, or fumes.

Safety goggles protect the eyes, eye sockets, and the facial area immediately surrounding the eyes from a variety of chemical hazards. Goggles form a protective seal around the eyes, preventing objects or liquids from entering under or around the goggles. This is especially important for work with or around liquids that may splash, spray, or mist.

Safety goggles may incorporate prescription lenses mounted behind protective lenses for individuals requiring vision correction. It is important to consider specific lens, frame, and ventilation options when safety goggles are selected. Two types of goggles (frames) are available, namely eyecup safety goggles and cover safety goggles.

Face shields are available to protect the entire face from a variety of chemical hazards. All face shields are considered secondary protection and must be used *in addition* to safety goggles to provide adequate protection. Face shield windows are made with different transparent materials and in varying degrees or levels of thickness. These levels should correspond with specific tasks. Window and headgear devices are available in various combinations in order to enable the selection of the appropriate equipment. Visors fitted to head harnesses or safety helmets are widely used, particularly in chemical process areas. The lift-up hinged type is preferred for intermittent use.

4.6.4.5 Protection against heat hazards

Injuries may occur to the eye and face when workers are exposed to high temperatures, splashes of molten metal, or hot sparks. Eye and face protection is indicated when workplace operations involve pouring, casting, hot dipping, furnace operations, and other similar activities. Burns to eye and face tissue are the main concern for work that brings exposure to heat hazards.

Such work requires eye protection such as goggles or safety spectacles with special-purpose lenses and side shields. However, many heat-hazard exposures require the use of a face shield in addition to safety spectacles or goggles. Examples of special-purpose lenses for safety spectacles are photo-chromic lenses, didymium-containing lenses, and cobalt-containing lenses. Face shields with polycarbonate visors with a stainless steel mesh in front, aluminised polycarbonate visors, and infra-red radiation-absorbing windows are examples of items available. It is important to consider the source and intensity of the heat and the type of splashes that may occur in the workplace when the appropriate PPE is being selected.

4.6.4.6 Protection against welding hazards

Welding goggles and welding helmets are recommended for welding tasks. Welding helmets are usually constructed of vulcanised fibre or fibreglass and fitted with a filtered lens. They protect the eyes from burns caused by infra-red or intense radiat light. They also protect both the eyes and face from flying sparks, metal spatter and slag chips produced during welding, brazing, soldering and cutting operations. Filter lenses should have a shade number appropriate to protect against the specific hazards of the work being performed in order to protect against harmful light radiation.

The intense light associated with welding operations can cause serious and sometimes permanent eye damage if operators do not wear proper eye protection. The intensity of light or radiant energy produced by welding, cutting or brazing operations varies according to a number of factors, including the task producing the light, the electrode size, and the arc current.

Table 4.6.4.6 is an example of filters recommended for various welding-related activities by OSHA (2003). A filter is basically a coloured component that is used in an eye-protector and that permits an operator to see the work but absorbs or reflects (or both) harmful light radiation during welding and cutting operations.

Table 4.6.4.6: Filter lenses for protection against radiant energy

Operations	Electrode size in 0.8mm	Arc current	Minimum protective

			shade
Shielded metal arc welding	< 3	< 60	7
	3 - 5	60 – 160	8
	5 – 8	160 – 250	10
	>8	250 – 550	11
Gas metal arc welding and flux cored arc welding		< 60	7
		60 – 160	10
		160 – 250	10
		250 – 550	10
Gas tungsten arc welding		< 50	8
		50 – 150	8
		150 – 500	10
Air carbon	Light	< 500	10
Arc cutting	Heavy	500 – 1000	11

Operations	Electrode size in 0.8mm	Arc current	Minimum protective shade
Plasma arc welding		< 20	6
		20 – 100	8
		100 – 400	10
		400 – 800	11
Plasma arc cutting	Light	< 300	8
	Medium	300 – 400	9
	Heavy	400 – 800	10
Torch brazing			3
Torch soldering			2
Carbon arc welding			14
Gas welding: Light	< 1/8	< 3.2	4
Gas welding: Medium	1/8 – 1/2	3.2 – 12.7	5
Gas welding: Heavy	> ½	> 12.7	6
Oxygen cutting: Light	< 1	< 25	3
Oxygen cutting: Medium	1 – 6	25 – 150	4
Oxygen cutting: Heavy	> 6	> 150	5

Source: OHSA 29 CFR 1910.133 (A) (5).

The South African Standard SABS 1400: 1993 provides information on equipment for eye, face and neck protection against non-ionising radiation arising during welding or similar operations. This standard defines PPE typically associated with welding as follows:

Eye-protectors: Any form of protective equipment that covers at least the region of the eyes. For the purpose of the standard these include welding helmets, hand shields, goggles and welding spectacles.

Welding helmet: A device that is supported on the head to give protection to the face, ears and throat and part of the head of an operator. It is fitted with filters and, where appropriate, a filter cover or backing lens.

Hand shield: A device that is designed for holding in the hand and for protecting the face and neck of an operator while the operator is engaged in electric-arc welding and cutting, or for the observation of welding and cutting processes. It is fitted with filters and, where appropriate, a filter cover or backing lens.

Goggles: A device that encloses a space in front of the eyes and into which radiation arising from welding can only penetrate through filter(s) and, where provided, through filter cover(s) and backing lens(es). Goggles are fitted with a single ocular (box-type goggles) or two separate oculars enclosing the orbital cavities and are usually held in position by a headband.

Welding spectacles: An eye-protector, the oculars of which are mounted in a spectacle-type frame with lateral protection (side shields). These spectacles may either have eye bows or a headband fitting, and the oculars may be integral with the frame.

Annexure C of SABS 1400: 1993 provides a classification of welding and cutting work, as well as types of protective clothing for the different classes of operation. These classes are the following:

Class 1 operations: Cover work, other than actual welding, carried out close to welding operations, where some protection from harmful radiation is required but where good general vision is also necessary; for example, the work carried out by supervisory staff. PPE recommended for Class 1 operations includes welding spectacles, goggles, face shields, hand shields, welding helmets, or fixed shields.

Class 2 operations: Cover gas welding and cutting in which there is a direct exposure to heat, light, sparks and particles of metal and where moderate reduction of transmitted, ultraviolet and visible radiation is necessary. Types of PPE to be used in Class 2 operations include goggles, face shields, hand shields, welding helmets or fixed shields.

Class 3 operations: Cover electric-arc welding, cutting and similar processes in which there is a direct exposure to high-intensity radiation, sparks and pieces of metal, together with the risk of electric arcing from tools. In this work a large reduction in ultraviolet, infra-red and visible radiation is necessary. PPE recommended for Class 3 operations includes hand shields, welding helmets or fixed shields. Neck shields (an article of protective clothing that, when fitted to a welding helmet, protects the back and sides of the head and neck from reflected radiation) may also be necessary.

Class 4 operations: Cover gas-shielded arc welding and cutting in which there is direct exposure to high-intensity ultraviolet, infra-red and visible radiation both from direct radiation and from reflection, together with particles of metal ejected from the arc region. Welding helmets fitted with auxiliary heat-absorbing filters should be used for Class 4 operations. Neck shields may also be necessary.

4.6.4.7 Protection against solar ultraviolet radiation

Eye protection can be provided by sunglasses that comply with the safety requirements of SABS 1644 Lenses for sunglasses and fashion spectacles, or the Australian Standard AS

1067 Sunglasses and Fashion Spectacles (non-prescription types). Any provision of sunglasses will need to ensure that they have adequate peripheral protection from ultraviolet radiation (UVR). Squinting is a natural protective mechanism that cuts down the area of the eye into which UVR may enter. If sunglasses without side protection are worn, the squint mechanism is bypassed and the ocular UVR exposure may be two or more times greater than without the sunglasses (Queensland Government, 2001).

4.6.5 Hand and arm protection

Potential hazards that require hand and arm protection include skin absorption of harmful substances, chemical or thermal burns, electrical dangers, bruises, abrasions, cuts, punctures, fractures and amputations (OSHA, 2003). Most accidents involving hands and arms can be classified under four main hazard categories: chemicals, abrasions, cutting, and heat. There are gloves and arm coverings or arm guards available that can protect workers from any of the aforementioned individual hazards or any combination of them.

4.6.5.1 Types of protective gloves

There are many types of gloves available today to protect against a wide variety of hazards. It is, therefore, essential that employees use gloves specifically designed for the hazards and tasks found in their workplace. Gloves designed for one function may not protect against a different function even though they may appear to be an appropriate protective device.

The following guidelines from the OSHA (2003) and MINEsafe (2004) could assist with the selection of protective gloves.

Factors that may influence the selection of protective gloves for a workplace include:

- The hazards the hands will be exposed to;
- Type of chemicals handled;
- Nature of contact (total immersion, splash, etc.);
- Duration of contact;
- Area requiring protection (hand only, forearm, arm);
- The type of material(s) that will provide appropriate protection;
- Grip requirements (dry, wet, oily);
- Amount of manual dexterity needed;
- Thermal protection;
- Size and comfort; and
- Abrasion/resistance requirements.

Various types of gloves are commercially available for protection against heat (leather, synthetic fibre, treated wool, Kevlar), for protection against abrasion (leather, canvas, pigskin, PVC-impregnated fabric) and for protection against chemicals (PVC, Butyl, Nitrile, etc). In general, gloves fall into four groups (OSHA, 2003):

- Gloves made of leather, canvas or metal mesh;
- Fabric gloves;
- Coated fabric gloves; and
- Chemical-resistant and liquid-resistant gloves.

4.6.5.2 Leather, canvas or metal mesh gloves

Gloves made from metal mesh, leather or canvas provide protection against cuts and burns. Metal mesh gloves are used to protect hands from accidental cuts and scratches. Leather or canvas gloves also protect against sustained heat, and leather gloves protect against sparks, moderate heat, blows, chips and rough objects;

Gloves made from aluminised fabric are designed to insulate hands from intense heat and are most commonly used by persons working with molten materials. Aramid fibre gloves protect against heat and cold, are cut- and abrasive resistant and wear well. Synthetic gloves of various materials offer protection against heat and cold are cut- and abrasive resistant and may withstand some diluted acids. These materials do not stand up to alkalis and solvents.

4.6.5.3 Fabric gloves

Fabric and coated fabric gloves are made of cotton and other fabric to provide varying degrees of protection.

Fabric gloves protect against dirt, slivers, chafing and abrasions. They also help to insulate hands from mild heat or cold. Fabric gloves do not provide sufficient protection for use with rough, sharp or heavy materials. Adding a plastic coating will strengthen some fabric gloves.

4.6.5.4 Coated fabric gloves

Coated fabric gloves are normally made from cotton flannel with napping on one side. By coating the unnapped side with plastic, fabric gloves are transformed into general-purpose hand protection offering slip-resistant qualities. These gloves are used for tasks ranging from handling bricks to chemical laboratory containers. When gloves are selected to protect against chemical exposure hazards, it is important to check with the manufacturer or review the manufacturer's product literature to determine the gloves' effectiveness against specific workplace chemicals and conditions.

4.6.5.5 Chemical-resistant and liquid-resistant gloves

Chemical-resistant gloves are made with different kinds of rubber: natural, butyl, neoprene, nitrile and fluorocarbon (viton); or various kinds of plastic (polyvinyl chloride (PVC), polyvinyl alcohol and polyethylene. These materials can be blended or laminated for better performance. As a general rule, the thicker the glove material, the greater the chemical resistance, but thick gloves may impair grip and dexterity and have a negative impact on safety.

Some types of chemical-resistant gloves are described in the paragraphs below (OHSA, 2003).

Butyl gloves are made of a synthetic rubber and protect against a wide variety of chemicals, such as peroxide, highly corrosive acids (nitric acid, sulphuric acid and hydrofluoric acid), strong bases, alcohols, aldehydes, ketones, esters and nitro compounds. Butyl gloves also resist oxidation, ozone corrosion and abrasion, and remain

flexible at low temperatures. Butyl rubber does not perform well with aliphatic and aromatic hydrocarbons and halogenated solvents.

Natural (latex) rubber gloves are comfortable to wear, which makes them a popular all–purpose glove. They feature outstanding tensile strength, elasticity and temperature resistance. In addition to resisting abrasions caused by grinding and polishing, these gloves protect workers' hands from most water solutions of acids, alkalis, salts and ketones. Latex gloves cause allergic reactions in some individuals and may probably not be appropriate for all employees. Hypoallergenic gloves and glove liners are possible alternatives for workers who are allergic to latex gloves.

Neoprene gloves are made of synthetic rubber and offer good pliability, finger dexterity, high density and tear resistance. They protect against hydraulic fluids, gasoline, alcohols, organic acids and alkalis. They generally have chemical- and wear-resistant properties superior to those of gloves made of natural rubber.

Nitrile gloves are made of a copolymer and provide protection from chlorinated solvents such as trichloroethylene and perchloroethylene. Although intended for jobs requiring dexterity and sensitivity, nitrile gloves stand up to heavy use even after prolonged exposure to substances that cause other gloves to deteriorate. They offer protection when oils, greases, acids and alcohols are being used but are generally not recommended for use with strong oxidising agents, aromatic solvents, ketones and acetates.

It is evident that protective gloves are available in a wide range of natural and synthetic materials. However, there is no single glove material (or combination of glove materials) able to provide unlimited resistance to all individual chemical agents or combinations of these.

There are three ways in which any protective glove will, at some stage, fail to protect the wearer from exposure to any chemical agent. These are:

- Permeation – the process by which a chemical agent migrates through the protective glove at a molecular level;

- Penetration – the bulk flow of a chemical agent through closures, porous materials, seams and pinholes or other imperfections in the protective glove;

- Degradation – a damaging change in one or more physical properties of the protective glove as a result of exposure to a chemical agent.

The phrase commonly found on the Material Safety Data Sheet (MSDS): 'Wear impervious (or impermeable) gloves' has very limited value and is technically inaccurate. No glove material will remain impervious to a specific chemical indefinitely and no single glove material is resistant to all chemicals. Some chemicals will travel through or permeate the glove in a few seconds, while other chemicals may take days or weeks. Information specifying the best type of chemical protective material is what should appear on the MSDS (e.g., neoprene, butyl rubber). If this information is missing, it is recommended that the supplier or manufacturer of the chemical product be contacted. The manufacturers of chemical protective gloves and clothing may also be able to assist with the appropriate selection.

Because glove selection is a complex issue, the HSE (2000) has compiled a simple guide to help with glove material choice (Table 4.6.5.5a). This table indicates the most suitable glove materials to protect wearers from exposure. The importance of using a material depends on the extent of exposure. For chemical groups such as strong acids, only one choice of glove material is identified as most suitable, whereas a range of materials may

be suitable for other chemical groups, such as weak acids. Where there is a choice of glove material, the extent of exposure to the chemical agent will be a significant factor in choosing between, for example, a neoprene glove or a less costly natural rubber. If workers' gloves are significantly contaminated for extended periods, the neoprene glove may be required. If, however, there is only occasional splashing of chemical onto the glove, then the less costly natural rubber glove may be adequate provided that the wearer is not allergic to latex.

Other factors to consider in choice of gloves are the manual dexterity required for the job and required length of the glove (the need for gauntlets, perhaps). If workers cannot do their job because the glove material is too thick or stiff, then they may decide not to wear them.

Table 4.6.5.5a: Glove materials to protect employees from chemical exposures

Chemical group	Natural rubber	Nitrile rubber	Neoprene TM	PVC	Butyl	Viton TM
Water miscible substances, weak acids/alkalis	√	√	√	√	-	-
Oils	-	√	-	-	-	-
Chlorinated hydrocarbons	-	-	-	-	-	√
Aromatic Solvents	-	-	-	-	-	√
Aliphatic solvents	-	√	-	-	-	√
Strong acids	-	-	-	-	√	-
Strong alkalis	-	-	√	-	-	-
PCBs	-	-	-	-	-	√

(HSE, 2000)

Table 4.6.5.5b, adapted from the 'Personal Protective Equipment Program' issued by the Office of Health and Safety, Centers for Disease Control and Prevention (CDC) in 1997, provides further guidance with regard to the different types of glove materials and the chemicals they can be used against.

Table 4.6.5.5b: Guide to the selection of chemical-resistant gloves

Type	Advantages	Disadvantages	Use Against
Natural rubber	Low cost, good physical properties,	Poor versus. oils, greases, organics. Frequently imported;	Bases, alcohols, dilute water solutions; fair versus aldehydes,

Type	Advantages	Disadvantages	Use Against
	dexterity	may be poor quality	ketones.
Natural rubber blends	Low cost, dexterity, better chemical resistance than natural rubber versus some chemicals	Physical properties frequently inferior to natural rubber	Same as natural rubber
Polyvinyl chloride (PVC)	Low cost, very good physical properties, medium cost, medium chemical resistance	Plasticizers can be stripped; frequently imported may be poor quality	Strong acids and bases, salts, other water solutions, alcohols
Neoprene	Medium cost, medium chemical resistance, medium physical properties	NA	Oxidising acids, anilines, phenol, glycol ethers

Type	Advantages	Disadvantages	Use Against
Nitrile	Low cost, excellent physical properties, dexterity	Poor vs. benzene, methylene chloride, trichloroethylene, many ketones	Oils, greases, aliphatic chemicals, xylene, perchloroethylene, trichloroethane; fair vs. toluene
Butyl	Speciality glove, polar organics	Expensive, poor versus hydrocarbons, chlorinated solvents	Glycol ethers, ketones, esters
Polyvinyl alcohol (PVA)	Specialty glove, resists a very broad range of organics, good physical properties	Very expensive, water sensitive, poor versus light alcohols	Aliphatics, aromatics, chlorinated solvents, ketones (except acetone), esters, ethers
Fluoro-elastomer	Specialty glove, organic solvents	Extremely expensive, poor physical properties, poor vs. some ketones, esters, amines	Aromatics, chlorinated solvents, also aliphatics and alcohols
Norfoil (Silver Shield)	Excellent chemical resistance	Poor fit, easily punctures, poor grip, stiff	Use for Hazmat work

Reference: http://www.cdc.gov/od/ohs/manual/pprotect.htm

CCOHS (1999) provides the following guide to assist with the selection of gloves (Table 4.6.5.5c).

Table 4.6.5.5c: Guide to the selection of gloves

Hazard	Degree of Hazard	Protective Material
Abrasion	Severe	Reinforced heavy rubber, staple-reinforced heavy leather
	Less severe	Rubber, plastic, leather, polyester, nylon, cotton
Sharp Edges	Severe	Metal mesh, staple-reinforced heavy leather, Kevlar (TM), aramid-steel mesh
	Less severe	Leather, terry cloth (aramid fiber)
	Mild with delicate work	Lightweight leather, polyester, nylon, cotton
Chemicals and fluids	Risk varies according to the chemical, its concentration, and time of contact among other factors. Refer to the product MSDS or manufacturer.	Dependent on chemical. Examples include: natural rubber, neoprene, nitrile rubber, butyl rubber, PTFE (polytetrafluoroethylene), Teflon (TM), Viton (TM), polyvinyl chloride, polyvinyl alcohol,
Cold		Leather, insulated plastic or rubber, wool, cotton
Electricity		Rubber-insulated gloves tested to appropriate voltage with leather outer glove
Hazard	**Degree of Hazard**	**Protective Material**
Heat	High temperatures (over 350 °C)	Zetex (TM)
	Medium high (up to 350 °C)	Nomex (TM), Kevlar (TM), heat-resistant leather with linings
	Warm (up to 200 °C)	Nomex (TM), Kevlar (TM), heat-resistant leather, terry cloth (aramid fiber)
	Less warm (up to 100 °C)	Chrome-tanned leather, terry cloth
General duty		Cotton, terry cloth, leather
Product contamination		Thin-film plastic, lightweight leather, cotton, polyester, nylon
Radiation		Lead-lined rubber, plastic or leather

Note: The mention of trade name products in the above table is not intended as a recommendation or endorsement of any product.

4.6.6 Hearing-protection devices

In the South African context, SANS 10083/SABS 083: 2004 stipulates that hearing-protection devices (HPDs) issued in terms of a hearing-conservation or hearing-loss-prevention programme must meet the requirements specified in SABS 1451 (Part 1, 2 or 3 depending on the type of device), which include those of ISO 4869. The Mine Health and Safety Act requires that such devices be provided free of charge by the employer (MHSA 11(2)(d)), and properly used by employees (MHSA 22 (c)).

Conventional HPDs are passive devices that present an acoustic barrier to sound, thus reducing immission (energy incident on the ear) and the risk of noise-induced hearing

loss. Conventional HPDs are classified according to their manner of application, as follows (Franz, 2002):

Earplugs are devices inserted into the ear canal (intra-aural). They are further classified as disposable (unformed/formable earplugs) and reusable (pre-formed earplugs, the latter including standard off-the-shelf devices (which may be corded or un-corded) and custom-moulded earplugs;

Ear caps are band-mounted, semi-insertable caps or cones (supra-aural HPDs) that seal off the entrance to the ear canal; and

Earmuffs are devices that enclose or surround the ears (circum-aural HPDs).

4.6.6.1 Standard earplugs

Earplugs, be they unformed/disposable or pre-formed/re-usable devices, require a reasonable level of skill and care to ensure proper insertion and optimal protection. Despite some users' need for a period of adaptation, earplugs are generally more comfortable over extended periods than muffs, but are less convenient than muffs for users who enter and leave noisy areas frequently.

Unformed or disposable earplugs

Unformed/formable earplugs, often referred to as 'disposable plugs', are usually rolled down or shaped before insertion, placing additional demands on the user's skill. Disposable earplugs are not washable and regular users would require several pairs per week, making them far more costly in the long term than reusable plugs. Some disposable plugs are available with moulded-in cords to improve handling and safeguard against loss, and some are supplied with a carrying case.

Foam or roll-down plugs are made of high-density closed-cell foam, either polyurethane (PU) or polyvinyl chloride (PVC). PU plugs feel softer in the hand, but both types provide similar levels of comfort in the ear. Plugs made of PVC absorb less moisture, making them more suitable in hot areas or for individuals performing physically intensive work. Both types of foam plug are generally unsuitable for workers whose hands may be soiled with oil, grease or grit, given the need to compress or roll down the plugs before insertion.

Pre-formed or reusable earplugs

Pre-formed earplugs, commonly referred to as 'reusable plugs', only take the shape of the ear canal on insertion, unless they are custom moulded. They are washable, but standard devices generally provide lower levels of protection than disposable foam plugs, a disadvantage for users exposed to hazardous noise on a regular basis. Many standard pre-formed plugs have a stalk or tab to facilitate handling and insertion, and some are available with and without moulded-in cords. Certain models are also supplied with a storage case, making them easier to carry and keep clean when not in use.

Semi-insertable HPDs

These lightweight supra-aural devices are held in place over the opening of the ear canal by the compressive force of a metal or plastic band, which can be positioned either under the chin or behind the neck. The variously shaped tips, caps, pods or cones (depending on design) are made of soft vinyl, silicone, PU foam or composite material. Semi-insertable devices lend themselves to frequent application and removal, making them convenient for intermittent use, and they are easily worn around the neck when not in place. However, only the highest quality devices of this type provide levels of protection that compare favourably with fully insertable earplugs.

4.6.6.2 Earmuffs

Earmuffs use rigid, foam- or fibre-filled plastic earcups, with foam- or fluid-filled cushions and plastic outer seals to enclose the ears. The cups are held in place by a pre-tensioned metal or plastic band, which is normally positioned on top of the head. Some models have an adjustable head strap to allow the headband to be positioned behind the neck or under the chin when the muffs are worn with a hard hat.

Earmuff seals are susceptible to degradation by skin oils, perspiration and environmental contaminants such as dust, so they should be inspected on a regular basis and replaced when necessary. Replacement seals and cushions are available for the more expensive models, and some can be fitted with disposable hygiene cuffs to prolong the life of seals and protect sensitive users from skin irritation. Headbands may become de-tensioned after a period of time, especially if stored in the stretched position or subjected to temperature extremes, with direct impact on attenuation performance. Lower-quality muffs are more susceptible to this form of degradation, which can only be rectified by complete replacement.

Earmuffs provide a convenient form of protection for intermittent use, because they are easily fitted and removed, and require minimal skill and care to ensure effectiveness. However, muffs are less portable than plugs, and some users find the mass and clamping force uncomfortable. Muffs are also less suitable than plugs for use in hot or confined workplaces, especially for physically intensive tasks. Although the adjustable headband allows most users to be fitted successfully, this should be confirmed at the time of selection. Individuals with unusually large pinnas may require muffs with larger earcups, and muffs may be incompatible with certain hairstyles, earrings, spectacles or with other PPE.

4.6.6.3 Characteristics of conventional HPDs: Summary

Table 4.6.6.3 summarises certain characteristics of the three main types of conventional HPDs. Helmet-mounted muffs are not included, as the muffs and helmet tend to interfere with each other, and are regarded as an unsuitable combination of PPE by many hearing conservationists and users.

Table 4.6.6.3: Characteristics of the three main types of conventional HPDs

Issue	Earplugs	Banded Earplugs/Earcaps	Earmuffs
Comfort	Generally more comfort-able for prolonged use, especially custom-moulded plugs. Some individuals may require a period of adaptation, depending on the specific HPD, but this less common with custom-moulded plugs.	Relatively comfortable, but designed for intermittent use where minimal protection is required. Little or no adaptation required: not inserted as deeply as earplugs, and use light clamping pressure to hold plugs/ caps in place.	Less suitable for prolonged use. Little or no adaptation required, but some users find the bulk and clamping pressure unacceptable.
Sizing	Some types available in different sizes, others supplied in one size only. Correct sizing and satisfactory fit essential for effectiveness, especially for custom-moulded plugs.	Generally available in one size only: important to ensure that plug shape is compatible with ear canal. Band size suits most individuals, as band can be positioned below chin or behind neck.	Generally available in one size only. Headband can be too small for some heads; Earcups can be too small for some pinnas.

Issue	Earplugs	Banded Earplugs/Earcaps	Earmuffs
Ease of fitting: Skill and care required	Considerable level of skill and care required to ensure effectiveness, except with custom-moulded plugs.	Moderate level of skill and care required to ensure devices are securely fitted into opening of ear canal.	Minimal skill and care required.
Handling and storage, Loss and replacement	Easily carried in storage case where provided, or worn around neck/on hard hat when not in use if corded. Easily lost, but easily replaced, except custom-moulded plugs.	Easily worn around neck or inside hard hat when not in use. Not as easily lost as earplugs, but generally more difficult to replace than standard earplugs.	Bulky to store or carry when not in use. Not easily lost, but more difficult to replace than standard earplugs.
Interference factors, including use with other PPE	Compatible with earrings, long hair, spectacles, goggles, hard hats, and breathing apparatus.	Generally compatible with earrings, long hair, spectacles, goggles, hard hats, and breathing apparatus.	Earrings, long hair, spectacles or goggles may interfere with fit/seal. Head strap required when used with a hard hat. Incompatible with some types of breathing apparatus.
Mobility/use in confined spaces	No restriction on mobility.	Virtually no restriction on mobility.	May restrict mobility around obstacles or in confined spaces.
Workrate	Suitable for physically demanding tasks, but some users experience sweat build-up in ear canals especially with certain types.	Suitable for physically demanding tasks.	Unsuitable for physic-ally demanding tasks.
Thermal conditions	Suitable for hot areas but some users experience sweat build-up in ear canals, especially with certain types. Not easily inserted with gloves. Compatible with cold-weather headgear.	Suitable for hot areas: most users experience less sweat build-up than with fully insertable plugs. Easily fitted and adjusted with gloves. Compatible with most cold-weather headgear.	Unsuitable in hot areas Provide some warmth in cold areas. Easily fitted/adjusted with gloves. Incompatible with some cold-weather headgear. Cushions and seals may become stiff when stored in a cold place.
Hygiene: Infection, irritation and earwax	Re-usable and custom-mould-ed devices are washable. Not for use with ear canal irritation/infection, or with impacted earwax.	Washable. Not for use with ear canal irritation or infection. Banded earcaps (not banded earplugs) can be used with impacted earwax, but under medical supervision.	Cushions easily clean-ed, and replaceable hygiene cuffs available for some makes/ models. Can be used with ear canal irritation/infection under medical super-vision. Can be used irrespective of impacted earwax, but not with skin conditions involve-ing the pinna or surrounding tissue.
Monitoring/ enforcement	More difficult to confirm compliance.	Compliance easily confirmed, however,	Compliance easily confirmed, however,

Issue	Earplugs	Banded Earplugs/Earcaps	Earmuffs
and Sabotage	Easily cut, perforated or otherwise modified to improve comfort, but at expense of effectiveness. Identification of tampering requires removal and examination.	headband can be stretched to reduce clamping pressure at expense of effectiveness. Tampering more easily identified than with earplugs.	headband can be stretched to reduce clamping pressure and earcups can be perforated to increase ventilation, at expense of effectiveness. Tampering more easily identified than with earplugs.
Changes in barometric pressure	Not to be worn during vertical conveyance over more than 1 000 m		

The table does not include information on attenuation, which varies significantly among products, but Table 4.6.6.6 provides mean attenuation ranges for the various types of conventional HPDs. Nevertheless, manufacturers' data should be consulted to evaluate specific devices being considered.

4.6.6.4 Custom-moulded earplugs

Three different makes of custom-moulded earplugs are available in South Africa, all of which are fabricated from acrylic resin. In some countries such devices are also made from more resilient silicone putty or vinyl materials, improving comfort over extended periods of use. However, these materials are susceptible to shrinkage, hardening and cracking, particularly if the impression is used as the earplug (after curing and coating). In the case of acrylic earplugs, ear-canal impressions are taken and used to produce moulds in which the actual earplugs are cast. This procedure is followed by finish polishing and confirmation of suitable fit by leakage tests with the devices in the user's ears.

One of the custom-moulded earplugs locally available incorporates an adjustable attenuation valve to set the level of protection in accordance with prevailing workplace noise. This feature adds to the cost, and creates the need to periodically confirm the correct setting and function of the valve. It may also be susceptible to tampering by some users. The other products dispense with the adjustable valve, using an acoustically designed duct and various diaphragm-type filters to control the level of attenuation.

4.6.6.5 Dual protection

Dual protection most often involves the combined use of earplugs and earmuffs, although plugs can also be used with acoustic helmets or communication headsets. Such combinations typically provide more protection than either device used separately, but less than the sum of attenuation for the two. Dual protection is beneficial where TWA_{8h} exceeds 100 dB, particularly if the noise is predominantly at a frequency of 500 Hz or below. Combined use of muffs and plugs provides up to 15 dB more attenuation at frequencies below 2 000 Hz than the better device only, but at higher frequencies the enhancement can be as little as 0 dB, since bone conduction limits total attenuation to between 40 and 50 dB. It is normally the earplug, rather than the muff, that is most critical to performance where dual protection is used.

The limitations of earmuffs on mobility and thermal comfort also apply to dual protection, particularly in the case of physically demanding work. Where intense noise occurs only intermittently and more moderate levels prevail the rest of the time, the occasional donning of muffs over plugs should be acceptable to workers, even in relatively warm environments.

It should be considered that dual protection, because of the additional attenuation it provides, imposes a sense of isolation on users. Because this effect has implications for safety and productivity, employees should only use dual protection when conditions warrant it. It should also be noted that emission and exposure levels high enough to require the use of dual protection indicate an urgent need for engineering measures to reduce the noise.

4.6.6.6 HPD selection

Ensuring that only the most appropriate and acceptable devices are purchased requires input from the occupational health and safety/risk control departments, as well as from supervisors and workers.

Firstly, it is necessary to determine what types of HPDs are needed for the range of workplaces and occupations, taking into consideration worker/supervisor input regarding workplace ergonomics and environmental conditions. HPD performance specifications should be based on these factors, and on how much attenuation is needed. With regard to the latter, information on the level and dominant frequencies of noise is fundamental, and should be determined by direct measurement or reference to documented sources (e.g. Franz et al. 1997). It will also be necessary to ensure that HPDs are provided to satisfy special needs (anatomical abnormalities, existing hearing loss, etc.), which requires input from occupational health personnel. The steps and criteria outlined above constitute a risk- and usability-based approach to HPD selection, as opposed to the cost-based approach that is all too commonly applied.

Selection criteria for HPDs can be divided into two main categories, those that concern the user and those that concern the employer, with some criteria relevant to both. HPDs are a form of personal protection and, without due consideration to criteria that are important to the user, a personal protection strategy will not yield the benefits expected by employees or management. If both parties' requirements are appropriately ranked and balanced they should be compatible and complementary, and result in maximum benefits for all concerned.

Employees are only willing to tolerate a certain amount of discomfort and inconvenience to protect themselves against hearing loss. They are typically more concerned with comfort and their ability to communicate effectively in the workplace. It should be considered that low-attenuation HPDs are often more comfortable than high-attenuation devices, and if worn correctly and consistently they will give better protection than high-performance devices that are badly or irregularly applied. This indicates that HPD selection should place considerable emphasis on:

- Comfort, especially over extended periods of use;
- Convenience of handling, cleaning and storage;
- Individual anatomy and personal preference;
- Environmental conditions in the workplace;
- Ergonomics of the work task; and
- Compatibility with other PPE (hard hats, goggles, breathing apparatus, etc.).

Employer criteria

It is assumed that cost is not the employer's principal criterion for HPD selection, and that his or her main concerns relate to protection and effective communication. Table 4.6.6.6 provides typical attenuation ranges for various HPD types.

The tabulated ranges are based on results of attenuation tests for a number of HPDs of each type, from several manufacturers and using different designs and materials. Accordingly, the ranges are wide and "all-inclusive", but not specifically representative of any particular product. It is therefore possible that some devices may provide attenuation outside the tabulated ranges, and any HPDs being considered should be evaluated on the basis of product-specific data from the manufacturer.

Table 4.6.6.6: Attenuation values for various types of well-fitted HPDs under laboratory conditions

Type of HPD	Maximum-minimum mean attenuation incl. SD (dB) at given centre frequency (Hz)						
	125	250	500	1 000	2 000	4 000	8 000
Foam plugs	20-40	20-40	20-45	25-45	30-40	40-45	35-45
Pre-moulded plugs	20-40	20-30	20-30	20-35	25-35	30-45	30-45
Formable fibreglass plugs	20-30	20-30	20-30	25-30	25-30	35-40	35-40
Formable wax or silicone plugs	20-25	20-25	20-25	25-30	30-35	40-45	40-45
Custom-moulded plugs	15-35	15-35	15-35	20-35	30-40	35-45	30-45
Supra-aural caps (band-mounted)	15-30	15-30	10-30	15-30	25-35	25-45	30-45
Muffs	5-20	10-25	15-40	25-45	30-40	30-40	25-40
Dual protection (muffs & plugs)	20-40	25-45	20-45	30-50	35-45	40-50	40-50

4.6.6.7 Selection process

Franz (2002) has identified particular steps in the selection process. These steps are set out in the paragraphs that follow.

Ergonomics and environmental considerations

The first step to ensuring that employees are adequately and appropriately protected against noise is to determine whether workplace ergonomics (mobility requirements, physical workrate, other PPE used, intermittency/continuousness of noise emission, etc.) or thermal conditions (heat/cold, humidity) impose any constraints on the choice of HPD. It is essential to consider these issues first, to avoid the selection of devices that will ultimately prove unacceptable to employees and be disregarded.

Attenuation requirements

The next step is to determine the intensity and frequency characteristics of noise for each of the occupations and workplaces where emissions exceed safe levels, also considering any audible signalling devices that are in use. This requires sound level meter measurements with frequency analysis or, alternatively, reference to documented sources of such information (e.g. Franz *et al.*, 1997).

Once it has been established how much attenuation is required and which frequencies should be targeted (for each occupation/workplace), HPD manufacturers' octave-band attenuation data should be consulted and the octave-band method of HPD evaluation applied (Kroes *et al.*, 1975). The octave-band method, also called the Long Method or

NIOSH Method #1, is the most accurate means of estimating effective (protected) exposure for users of HPDs in a given noise environment. It also serves as the standard against which all other methods are evaluated. However, its accuracy depends on reliable HPD attenuation data (from manufacturers/suppliers) and representative workplace noise measurements (the employer's responsibility). Where frequency-specific A-weighted sound pressure levels have not been measured, values reported in SIMRAC Gen 011 (Franz *et al.*, 1997) for the relevant occupation, workplace or machinery, should provide a reasonable basis for determining attenuation requirements.

The preceding information should assist in the identification of devices that are potentially suitable, but it will be necessary to exclude any that would excessively reduce warning signal audibility. In this regard, it would also be prudent to confirm that signals are emitted at levels and frequencies that make them easily distinguishable from prevailing noise, by referring to signal manufacturers' product information for the devices in use. (Franz *et al.* (1997) provides frequency-specific data for a selection of commonly used signalling devices.)

Special needs: Existing hearing loss and anatomy/pathology

For individuals who already have appreciable hearing loss (determined by audiometry), it will be necessary to exclude any of the identified HPDs that would provide too much attenuation at those frequencies where hearing loss is greatest. Failure to do so could lead to overprotection and have an impact on safety and productivity. Anatomical or pathological abnormalities, e.g. large pinnas that are incompatible with certain earmuffs, abnormal ear canals or outer/middle ear infection, would also impose limitations on the choice of HPD.

Supervised individual selection

Once a reasonable number of devices that satisfy ergonomics, environmental and attenuation requirements have been pre-selected, these should be offered to users for a final choice. Given the importance of satisfactory fit to ensure adequate protection and comfort, final selection should be individualised, and preferably be done under the supervision of an appropriately qualified official, e.g. the occupational health practitioner (OHP). This will facilitate the resolution of any concerns or difficulties the employee may have regarding choice and fit, and provide an opportunity for instruction in the correct use and care of the chosen devices. The OHP involvement presently contemplated amounts to what can be termed "a risk-based medical examination", aimed at identifying any individual needs or constraints regarding choice of HPD, including anatomical abnormality, existing hearing loss or outer/middle ear infection.

Perhaps the greatest failing of personal protection strategies (and hearing conservation programmes that rely too much on them) is that employees do not use their HPDs properly. Supervised individual final selection and fitting with instruction is intended to prevent this shortcoming. Employee participation in the selection process will impart individual ownership and increase the likelihood of satisfactory compliance, thereby decreasing the risk of noise-induced hearing loss. However, these measures should be preceded by hazard-awareness education, to ensure that employees understand the risks and personal consequences of failing to protect themselves against dangerous noise.

4.6.7 Respiratory protection

Respiratory hazards can include airborne contaminants such as dusts, mists, fumes, and gases, or oxygen-deficient atmospheres. Respirators are devices worn by workers to

prevent the inhalation of harmful airborne substances and/or an oxygen-deficient atmosphere.

4.6.7.1 Types of respirators

Functionally, a respirator is designed as an enclosure that covers the nose and mouth or the entire face or head. Respirators are of two general "fit" types, tight-fitting and loose-fitting (OSHA, 1999).

A tight-fitting respirator is designed to form a seal with the face of the wearer. Three types are available: quarter mask, half-mask, and full face piece. The quarter mask covers the nose and mouth, where the lower sealing surface rests between the chin and the mouth. The half-mask covers the nose and mouth and fits under the chin while the full face piece covers the entire face from below the chin to the hairline.

Respirators are further categorised into two principal types, air-purifying and air-supplied. Air-purifying respirators remove contaminants from the ambient air while air-supplied respirators provide air from a source other than the surrounding atmosphere.

Air-purifying and air-supplied respirators can further be sub-classified by the manner in which they operate. For example, air-purifying respirators can be non-powered or powered. With non-powered air-purifying respirators, the user draws the air through particulate or gas/vapour filters by inhalation only, unassisted by a blower. Powered air-purifying respirators use a blower to draw air through a particulate or gas/vapour filter.

Air-supplied respirators are classified according to the method by which air is supplied and the way in which the air supplied is regulated. These methods include self-contained breathing apparatus, airline respirators, and combination airline and self-contained respirators.

The respirators described above are graphically presented in Chapter 15 of the Handbook of Occupational Health Practice in the Mining industry (Guild et al., 2001).

4.6.7.2 Respirator classifications

Air-purifying respirators are classified into three groups:

- Particulate-removing respirators;
- Vapour-and-gas-removing respirators; and
- Combination respirators (particulate- as well as vapour-and-gas filtering capacity).

In the case of particulate-removing respirators, the elements that remove particulates are called filters, while vapour-and-gas-removing elements are called either chemical cartridges or canisters. Filters and canisters/cartridges are the functional portion of air-purifying respirators and they can generally be removed and replaced once their effective life has expired. The exception would be filtering face piece respirators (commonly referred to as "disposable respirators" or "dust masks"), which cannot be cleaned, disinfected, or re-supplied with an unused filter after use (OHSA, 1999).

Particulate-removing respirators are designed to reduce inhaled concentrations of nuisance dusts, fumes, mists, toxic dusts, radon daughters, asbestos-containing dusts or fibres, or any combination of these substances, by filtering most of the contaminants from the inhaled air before they enter the breathing zone of the worker. Vapour-and-gas-removing respirators are designed with sorbent elements (canisters or cartridges) that adsorb and/or absorb the vapours or gases from the contaminated air before they can enter the breathing zone of the worker. Combination cartridges and canisters are available to protect against particulates, as well as vapours and gases (OHSA, 1999).

Table 4.6.7.2a shows the application and associated colour coding of the canisters/cartridges of gas-and-vapour-removing respirators.

Table 4.6.7.2a: Gas-and vapour-removing respirators

Type	Application	Colour code
A	Vapours of organic solvents (boiling point greater than 65ºC)	Brown
B	Inorganic gases and vapours (chlorine, hydrogen sulphide, hydrogen cyanide)	Grey
E	Sulphur dioxide, hydrogen chloride	Yellow
K	Ammonia	Green
Hg	Mercury	Red
NO	Oxides of nitrogen	Blue
CO	Carbon monoxide	Black

Table 4.6.7.2b shows the general coding and performance of the elements of vapour of the various respirators.

Table 4.6.7.2b: General classification for respirator elements

Type	Class	Element Performance
Gas-and-vapour respirator	1.	Low (L) absorption
	2.	Medium (M) capacity
	3.	High (H) capacity
Particulate respirator	P1	(L) - used for mechanically generated particulates
	P2	(M) - used for mechanically and thermally generated particulates
Type	**Class**	**Element Performance**
	P3	(H) - for all particulates, including highly toxic materials
"Combined" respirator	1- P2	Little capacity for gases and vapours; medium filtration efficiency for particulates
	2-P2	Medium capacity for gases and vapours; medium filtration efficiency for particulates
	3-P3	Medium capacity for gases and vapours; high filtration efficiency for particulates

Air-supplying respirators are respirators that provide air from a source independent of the surrounding atmosphere instead of removing contaminants from the atmosphere. As mentioned earlier, these respirators are classified by the method that is used to supply air and the way in which the air supply is regulated. These respirators include self-contained breathing apparatus where air or oxygen is carried in a tank on the worker's back or generated by a belt-worn device, or compressed-air respirators where compressed air from a stationary source is supplied through a high-pressure hose connected to the respirator. A combination self-contained and compressed-air respirator is also used under certain circumstances.

4.6.7.3 Selection of respirators

The selection of an appropriate respirator is a complex matter and it is recommended that experienced occupational hygienists and experienced safety practitioners who are familiar

with the actual workplace environments be given this responsibility. This selection cannot be done in isolation and should be part of a mine-specific respiratory-protection programme. Ideally such a programme must consist of worksite-specific procedures governing the selection, use, and care of respirators. The programme must be updated as often as necessary to reflect changes in workplace conditions and respirator use.

The respiratory protection programme must cover the following basic elements, as applicable (OSHA, 1999):

- Procedures for selecting respirators for use in the workplace;
- Medical evaluations of employees required to use respirators;
- Fit testing procedures for tight-fitting respirators;
- Use of respirators in routine and reasonably foreseeable emergency situations;
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, and otherwise maintaining respirators;
- Procedures to ensure adequate air quality, quantity and flow of breathing air for atmosphere-supplying respirators;
- Training of employees in the respiratory hazards to which they are potentially exposed;
- Training of employees in the proper use of respirators, including putting on and removing them, any limitations on their use, and maintenance procedures; and
- Procedures for regular evaluation of the effectiveness of the programme.

Respirator selection requires correctly matching the respirator with the hazard, the degree of hazard, and the user. According to CCOHS (2003) and OSHA (1999) respirator selection is determined by:

- Type and nature of the respiratory hazard (physical and chemical properties of the air contaminant);
- Concentrations of the contaminants to which employees may be exposed;
- Toxicity and health effects associated with the respiratory hazard;
- Exposure standards (relevant permissible exposure limit or other occupational exposure limit);
- Frequency and length of exposure (the time period the respirator will be worn);
- Nature and characteristics of the operations (e.g., hot temperature, confined space);
- Activities carried out while respiratory protection is being worn (e.g., strenuous work);
- Facial size of wearer and wearer's acceptance and comfort;

- Limitations of respirator (physical characteristics, functional capabilities and limitations of respirators); and

- Legal requirements.

In order to select the respirator type appropriate for a given hazard level, it is necessary to calculate the hazard ratio:

$$Hazard\ ratio = \frac{airborne\ contaminant\ concentration}{occupational\ exposure\ limit}$$

Each respirator has an assigned protection factor (APF) that reflects the level of protection that a properly functioning respirator would be expected to provide to a population of properly fitted and trained users. For example, an APF of ten for a respirator means that a user could expect to inhale no more than one tenth of the airborne contaminant present. The respirator to be selected must have an APF greater than or equal to the calculated hazard level (Guild et al., 2001).

Various groups such as the National Institute for Occupational Safety and Health (NIOSH), the Occupational Safety and Health Administration (OSHA), and the American National Standards Institute (ANSI) have proposed factors for the different types of respirators available. This information is available on the OSHA web site: (http://www.osha-slc.gov/SLTC/etools/respiratory/haz_expose/apf/apf.html) and is given in Table 4.6.7.3.

Table 4.6.7.3: Assigned protection factors (APF) for various types of respirators

Respirator Class and Type	OSHA Cadmium Std.	NIOSH
Air Purifying		
Filtering facepiece	10	10
Half-mask	10	10
Full-facepiece	50	50
Powered Air Purifying		
Half-mask	50	50
Full-facepiece	250	50
Loose fitting facepiece	25	25
Hood or helmet	25	25
Supplied Air		
Half-mask-demand	10	10
Half-mask-continuous	50	50
Half-mask-pressure demand	1 000	1 000
Full-facepiece demand	50	50
Full-facepiece continuous flow	250	50

Full-facepiece pressure demand	1 000	2 000
Loose fitting facepiece	25	25
Hood or helmet	25	25
Self-contained Breathing Apparatus (SCBA)		
Demand	50	50
Pressure demand	>1 000	10 000

4.6.7.4 Homologation of Respiratory Equipment

Once the factors listed in Section 4.6.7.3 have been taken into account, the employer must select an SABS-approved respirator. All respiratory protection used at a mine, other than body-worn self-contained self rescuers, must comply with the South African Bureau of Standards (SABS) Code of Practice, Homologation of Respiratory Equipment: SABS 0338. The latest homologation database for respiratory protection from the SABS is given in Appendix 6.

4.6.8 Torso protection

The purpose of torso protection is to provide protection from cold/heat, splashes from hot metals, sparks, liquids, impacts, abrasions, cuts, and chemicals. A variety of PPE is available: vests, jackets, aprons, coveralls, welding leathers, full-body suits, and protective clothing for temperature extremes.

Ordinary cotton overalls are the normal work wear in mines. A two-piece suit is available for females and takes their morphology into account. In the interests of safety, it is recommended that reflective material (strips) be added to overalls to make the miner more visible to drivers of moving underground vehicles. High-visibility bibs with reflective strips or harnesses made from reflective material are also available.

Wool and specially treated cotton are two natural fibres that are fire-resistant and comfortable since they adapt well to changing workplace temperatures. Duct, a closely woven cotton fabric, or any heavy-duty fabric can be used for protective clothing to protect against cuts and bruises when employees handle heavy, sharp, or rough material. Rubber and rubberised fabrics, neoprene, or plastic can give protection against some acids and chemicals. Disposable aprons/suits can be used as protection against certain hazards.

Heat-resistant material, such as leather, is often used to guard against dry heat and flame while aluminised suits and aprons will provide protection against extreme levels of radiant heat. Cooling vests are available to provide protection during exposure to abnormally hot conditions. Protection from heat stress can be provided by special garments that can accommodate frozen gel packs or that are constructed with a network of cooling tubes to circulate cooling fluids over the surface of the body and then through an external heat exchanger.

Appropriate clothing is needed to protect employees against harsh, cold working conditions and the development of hypothermia. Clothing should be worn in multiple layers which provide better protection than a single thick garment. The air between layers of clothing provides better insulation than the clothing itself. The inner layer of the clothing should provide insulation and be able to "wick" moisture away from the skin to help keep it dry. Thermal underwear made from polyesters or polypropylene is suitable for this purpose. For work in wet conditions, the outer layer of clothing should be waterproof. If the work area cannot be shielded against wind, an easily removable windbreak garment should be used. Almost 50 per cent of body heat is lost through the head and a woollen cap or a liner under a hard hat can reduce excessive heat loss.

Rain suits worn over overalls can be used to protect miners working with jumbo drills or other heavy equipment to protect them against cutting fluids and hydraulic and lubricating oils that can spray or leak from the equipment.

4.6.9 Foot and leg protection

The appropriate protection required for the feet and legs must be based on the outcome of a proper risk assessment. In order to determine appropriate protection, the following factors must be considered: slipping, uneven terrain, abrasion, ankle protection and foot support, crushing potential, temperature extremes, corrosive substances, puncture hazards, electrical shock and any other recognisable hazard. The anatomy of the wearer's foot - for example, high arches - should also be considered. Examples of types of safety footwear that could be used in mines are set out in the paragraphs that follow.

Safety boots and safety shoes are the most common types of safety footwear. Protective footwear in the impact- and compression-resistant category uses a steel or non-metallic toe cap (steel toe) to protect against falling objects or crushing from heavy rolling objects. Metatarsal footwear provides protection against falling objects to the area of the foot between the ankle and the toes. Protective footwear may also have other safety features including slip-resistant soles, puncture resistance (where the sole resists penetration from sharp objects) and insulation against extremes of heat and cold.

Foundry boots have steel toe caps, are heat resistant and are designed to keep out molten metal. They are without external features such as laces to avoid trapping molten metal blobs and should have velcro fasteners or elasticised sides for quick release.

Wellington boots or the so-called 'gumboots' protect against water and wet conditions. They are usually made from rubber, but are available in polyurethane and PVC, which are warmer and have greater chemical resistance. Gumboots can be obtained with corrosion-resistant steel toe caps, rot-proof insoles, steel mid-soles, ankle-bone padding and cotton linings.

Anti-static footwear prevents the build-up of static electricity on the wearer. It reduces the danger of igniting a flammable atmosphere and gives some protection against electric shock.

Conductive footwear also prevents the build-up of static electricity. It is particularly suitable for handling sensitive components or substances (e.g. explosive detonators). It gives no protection against electric shock.

Protective footwear protects against electrical hazard, where the sole of the shoe or boot is designed to protect workers from electric shock from 600 volts or less, under dry conditions.

In practice, the mining work boot may be of leather, or rubber, or PVC construction, depending on whether the mine is dry or wet. According to the International Labour Organization (Pickerill, 1998) the minimum protective requirements for a mining boot include a full puncture-proof sole with a composite outer layer to prevent slipping, a steel toe cap, and a metatarsal guard.

Leg protection is recommended against hazards such as molten metal, welding sparks, sharp objects, grinding and sawing. Ballistic nylon pads are recommended when a chain saw is being used. Information on foot and leg protection obtained from the Department of Labour and Industries (2003) in the USA is given in Table 4.6.9.

Table 4.6.9: Some types of protective foot/leg equipment

Type	Hazard Protection	Description
Steel-reinforced protective footwear	Protect feet from common hazards: falling objects rolling objects cuts punctures	Entire toe box and insole reinforced with steel Instep protected by steel, aluminium, or plastic May be designed to insulate against temperature extremes May be equipped with special soles to guard against slip, chemicals, heat, and/or electrical hazards
Safety Boots	More protection from splash or spark hazards or electrical hazards than shoes.	
	Chemicals - corrosives, caustics, cutting oils, petroleum products	Neoprene or nitrile boots to prevent penetration (the ability of a given chemical to break through the layer(s) of the boots to contact the skin)
	Molten materials	Foundry or gaiter-style boots. Have quick-release fasteners or elasticised insets to allow speedy removal if hazardous substances get into the boot
Type	**Hazard Protection**	**Description**
	Electricity (non-conductive)	Electrical boots designed with no conductive materials other than the steel toe (which is properly insulated) Insulated sole to prevent shock and static discharge Should be used in conjunction with other insulating equipment and precautions to reduce or eliminate the potential for bodies or parts of bodies to provide a path for hazardous
Leggings	Protect from heat hazards, like molten metal or welding sparks	Protect lower legs and feet Safety snaps allow for quick removal
Toe guards	Impact and compression hazards	Made of steel, aluminium, or plastic. Fit over the toes of regular shoes; protect only the toes

Metatarsal guards, leg guards	Protect from impact, compression, hazards, sharp objects Protect from splashes Additional leg and ankle protection	Made of aluminium, steel, fibre, or plastic May be strapped to the outside of shoes to protect the instep area

Knee pads are available to protect the knees against abrasion for work in stopes with low ceiling heights.

4.6.10 Fall protection

A fall-arrest system is an assembly of components and subsystems, including the necessary connectors, used to arrest the user in a fall from a working height and suspend the user until rescue can be effected. A fall-arrest system includes a full-body harness and a means of connecting the harness to an anchorage or anchorage connector. The harness should be worn with a suitable lanyard and shock-absorbing device by miners working in shafts, over crushers, or near open sumps and pits, for example. The appropriate SABS standards are given in Appendix 5.

4.6.11 Recommendations for chemical protective clothing

There are many chemicals that can have adverse effects on unprotected skin, ranging from contact dermatitis to permeation of the skin and systemic toxic effects. In addition, some chemicals (mostly solids) can present a contamination problem where inadvertent ingestion (e.g. lead) could occur or re-entrainment in the air stream (e.g. asbestos) could lead to inhalation. Chemical protective clothing (CPC), comprising gloves, boots, suits and other related components, can prevent direct skin contact and contamination. CPC can also prevent physical injury to the unprotected skin from thermal hazards, such as from rapidly evaporating gases freezing the skin.

Probably the most important consideration in selecting or developing CPC is the choice of materials. The major premise behind the CPC is that it acts as an “impervious” barrier to hazardous chemicals. Though much of this depends on how well CPC is constructed, the ability of the suit material(s) to resist chemical intrusion or “breakthrough” is paramount.

A document is available on the Internet to assist with the selection of appropriate CPC (http://www.cdc.gov/niosh/ncpc/ncpc1.html). This document provides CPC recommendations for the chemicals listed in the *NIOSH Pocket Guide to Chemical Hazards, June 1997 Edition* (Publication No. 97-140). These recommendations are based on another published work, *Quick Selection Guide to Chemical Protective Clothing, Third Edition*, by Forsberg and Mansdorf (1997).

The CCOHS database CHEMINFO also has occupational health and safety information, such as recommendations for chemical protective clothing for some 1 300 chemicals (http://www.ccohs.ca/products/databases/cheminfo.html).

4.6.12 Latex allergy

A wide variety of PPE products contain latex. Examples of PPE that may contain latex are gloves, surgical masks, goggles, respirators, and rubber aprons. Latex products are manufactured from a milky fluid derived from the rubber tree, *Hevea brasiliensis*. This milky fluid or latex sap is made up of tiny droplets that contain water and hydrocarbon

polymer and have a coating composed of proteins (CCOHS, 1997). Several chemicals are added to this fluid during the processing and manufacture of commercial latex and these chemicals may also cause skin rashes.

Three types of reactions can occur in persons using latex products, namely irritant contact dermatitis, allergic contact dermatitis (delayed hypersensitivity), and latex allergy (NIOSH, 1997). According to the aforementioned NIOSH document the most common reaction to latex products is irritant contact dermatitis - the development of dry, itchy, irritated areas on the skin, usually the hands. This reaction is caused by skin irritation from using gloves and possibly by exposure to other workplace products and chemicals. Irritant contact dermatitis is not a true allergy.

Allergic contact dermatitis (delayed hypersensitivity, also sometimes called "chemical sensitivity dermatitis") results from exposure to chemicals added to latex during harvesting, processing, or manufacturing. These chemicals can cause skin reactions, usually a rash that begins 24 to 48 hours after contact and may progress to oozing skin blisters or spread away from the area of skin touched by the latex (NIOSH, 1997).

Latex allergy (immediate hypersensitivity) is the most severe reaction to latex. Researchers have identified a protein substance in natural latex as a major source of the allergy. Although the amount of exposure needed to cause sensitisation or symptoms is not known, exposures at even very low levels can trigger allergic reactions in some sensitised individuals. Reactions usually begin within minutes of exposure to latex, but they can occur hours later and can produce various symptoms. Mild reactions to latex involve skin redness, hives, or itching. More severe reactions may involve respiratory symptoms such as runny nose, sneezing, itchy eyes, scratchy throat, and asthma (difficult breathing, coughing spells, and wheezing). Rarely, shock may occur; but life-threatening anaphylaxis is seldom the first sign of latex allergy. Such reactions are similar to those seen in some allergic persons after a bee sting (NIOSH, 1997).

It is estimated that approximately one to six per cent of the general population and about eight to 12 per cent of regularly exposed health care workers are sensitised to latex. Prevalence rates of up to 11 per cent have been reported for non-health care workers exposed to latex at work (NIOSH, 1997).

NIOSH (1997) and CCOHS (1997) recommend that employers take the following steps to protect workers from latex exposure and allergy in the workplace:

- Provide workers with non-latex gloves and PPE;
- If latex gloves are used, ensure they are the non-powered variety;
- Ensure that workers use good housekeeping practices to remove latex-containing dust from the workplace;
- Provide workers with education programmes and training materials about latex allergy; and
- Periodically screen high-risk workers for latex allergy symptoms.

These documents further recommend that employees who develop symptoms of latex allergy consult a physician experienced in treating the condition and carefully follow the physician's instructions for dealing with the allergy.

During 2004 only 11 cases of latex glove allergy were reported to the Compensation Commissioner in South Africa (Singh and Kgalamono, 2005). According to these authors

the small number of cases suggests that the recognition and diagnosis of latex allergy in South Africa lags far behind its true prevalence. They are of the opinion that a greater focus on preventative strategies in the workplace is needed as part of a national action programme that includes prevention, identification, management, and surveillance procedures.

4.7 Guidelines for appropriate use of PPE

PPE is the least effective way to protect workers because it does not eliminate or reduce the hazard; it only places a barrier between the worker and the hazard. If the PPE fails or is not used, the worker is not protected from the hazard. It is therefore of the utmost importance that any employee required to wear PPE receives training in the proper use and care of PPE before being allowed to perform work requiring its use. Periodic retraining should also be offered to PPE users as needed.

The training should include, but not necessarily be limited to, the following subjects:

- When PPE is needs to be worn;
- What PPE is necessary;
- How to properly don, doff, adjust, and wear PPE;
- The limitations of the PPE; and
- The proper care, maintenance, useful life, and disposal of PPE.

After the training, the employees need to demonstrate that they understand how to use PPE properly, or they will need further training. Retraining should be considered for an employee whose work habits or demonstrated knowledge indicate a lack of the necessary understanding, motivation, and skills required to use the PPE (i.e., uses PPE improperly). Further training is also required when changes in the workplace make previous training out of date, or when changes in the types of PPE to be used make previous training out of date.

It is further important to ensure that employees are using required PPE properly and are following the existing policies and procedures regarding PPE. This requires supervisors to regularly monitor, supervise, reinforce, and enforce the correct use and care of PPE by employees.

Without proper maintenance, the effectiveness of PPE cannot be assured. Maintenance should include inspection, care, cleaning, repair, and proper storage. Damaged or malfunctioning PPE should be identified timeously and replaced. **Wearing poorly maintained or malfunctioning PPE could be more dangerous than not wearing any form of protection at all.** Workers wearing such PPE think that they are protected when, in reality, they are not.

4.8 PPE matrix

Information on typical health and safety hazards associated with the mining of various commodities, occupations affected, and PPE issued to protect employees was obtained from occupational hygienists and safety practitioners at a number of mines. An example of a PPE matrix covering the hazard, occupation, and PPE required is given in Appendix 7.

In order to populate the 'electronic' PPE matrix, the information obtained from mines was 'condensed' into a more generic version (Appendix 8). Owing to the large number of occupations in the mining industry (as given in the South African Mines Occupational Hygiene Programme Codebook), an attempt was made to group the 'titles' used at various mines for the same occupation under a generic occupation title. For example, rock drill operators, drill machine operators, and pneumatic drill operators were all considered to be drillers/jack hammer operators.

A large number of items of PPE devices are available that are applicable to the broad spectrum of hazards associated with the diverse occupations involved in mining. Furthermore, each item may provide protection against one or more hazards and each mining occupation may be associated with one or more hazards. This results in a myriad possible permutations of associated PPE, hazards and mining occupations. If the available data on PPE, hazards and mining occupations are incorporated into a relational database, these permutations can be presented to and accessed by users via a simple software application for providing easily accessible and relevant information regarding PPE for mining occupations. The development of such a software application requires three basic elements:

- The design of an entity relationship diagram (ERD) to define the relationships between the data;
- An administrator interface to enter data and establish cross-referencing between the PPE, the hazard(s) and the occupations(s); and
- A user interface that is simple to use and provides easy access to the information contained in the database.

4.8.1 Database design

The primary tables in the database are those containing data on the hazards, occupations and PPE. The link tables Haz_PPE and Haz_Occ, as shown in Figure 4.8.1, accommodate the interrelationships of PPE to hazards and hazards to occupations respectively, with full referential integrity (to ensure that relationships between records in related tables are valid and maintained). To provide additional categorisation of PPE by body region a further table, 'BodyRegion', has been included.

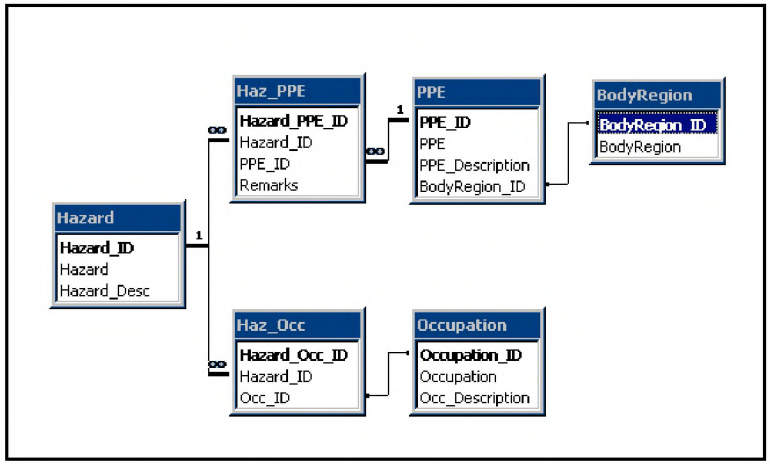

Figure 4.8.1: PPE database entity relationship diagram

It is evident from the ERD shown in Figure 4.8.1 that the PPE database, although very simple, can accommodate all the potential permutations of PPE hazard and occupation. As it is simple in nature and structure, the PPE database could be developed with the use of one of many available database systems. However, for reasons of simplicity of use and widespread availability, the PPE database was developed using Microsoft (MS) Access.

4.8.2 Data entry system

To maintain data integrity and obviate the need for different levels of user access security the data entry system and user interface were separated, with the standard MS Access interface being used for data entry purposes. Because the sequence in which data is entered is significant in relational databases (the relevant data entries must exist in the data tables before they can be linked in the link tables) an input interface was developed that made use of the standard features available within MS Access. A step-by-step description of data entry is presented in Appendix 9.

4.8.3 User interface

Guidelines for using the PPE matrix are given in Appendix 10.

To ensure that the end user cannot corrupt the data within the database a separate interface to the PPE database was developed in Visual Basic that allows the user to search and view the data only. To maintain simplicity of operation, a single combination search and view screen is used, as shown in Figure 4.8.3a. This approach obviates the requirement for the user to have any database searching skills, as all the searches are coded within the software.

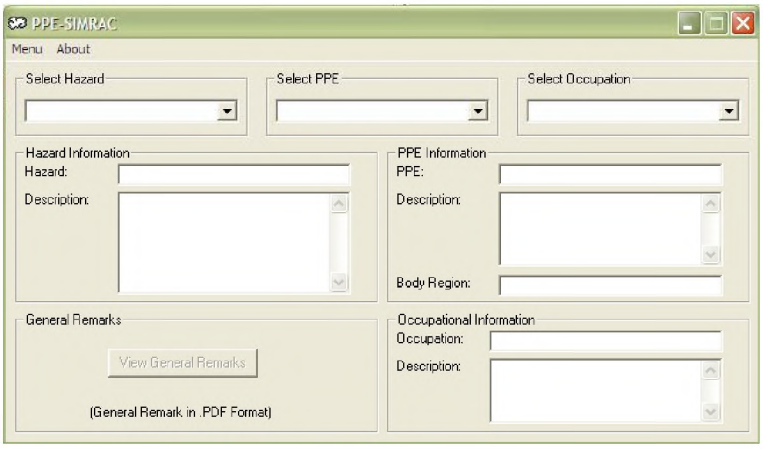

Figure 4.8.3a: Search and view screen

The user begins the query by first selecting a hazard. Once a hazard has been selected the screen is updated to reflect information on the selected hazard and a list of appropriate PPEs and affected occupations. Selection of one of the hazard-appropriate PPEs results in the screen being updated to provide additional information on the PPE. Similarly, selection of one of the occupations affected by the hazard results in the screen being updated with additional information related to the selected occupation. Should there be additional information available relevant to the particular combination of hazard and PPE, the 'View General Remarks' button will be enabled. Selecting this button will open the relevant documentation.

A screen shot of a final output of the programme is shown in Figure 4.8.3b.

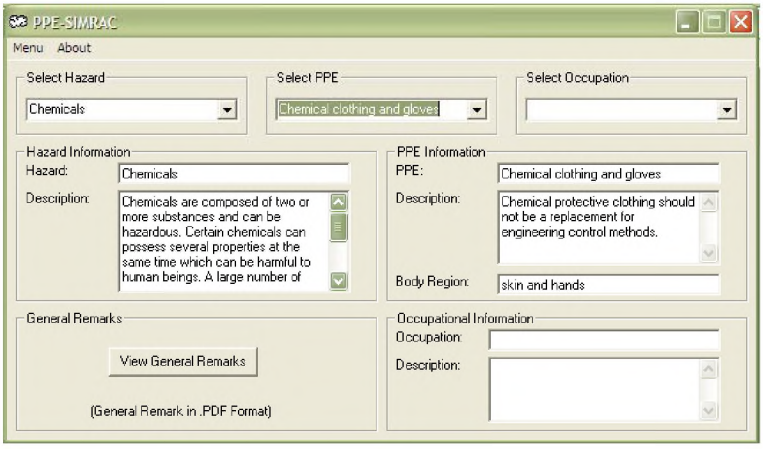

Figure 4.8.3b: Screen shot of a final output of the programme

4.8.4 Limitations

The original database design included provision for additional information on PPE, such as images, local availability and suppliers but these features were removed at the request of the client. The current system of an access database with a front-end viewer works well, and is simple to use, but has one major drawback in that the database is locally stored on the user's machine, with the result that additional entries to the database are not easily shared with other users. A preferable solution would be to host the database on a web server and develop web-based interfaces for data entry and viewing. Such an approach would provide a single, consistent, up-to-date database that could be assessed by everyone.

5 Conclusions

From statistics obtained during the study it is obvious that PPE plays a major role in health and safety initiatives on mines and that PPE is used on a regular basis. A conservative estimate is that at least R 333 million is spent annually on PPE for mines. Ideally PPE should only be used when engineering and administrative controls of hazards are not technically feasible, or when engineering controls are being installed or repaired, or when emergencies or other temporary hazardous situations arise.

Despite the extensive use of PPE in the mining industry, indications are that comprehensive PPE programmes are not implemented at many mines. A site-specific PPE programme is required to specify the selection, administration and maintenance of PPE. Successful PPE programmes require commitment from all levels: senior management, supervisors, and employees.

Findings in the literature suggest that PPE plays a role in the prevention of accidents and injuries. Shortcomings in the information available in the SAMRASS database prevented the retrieval of detailed information regarding the mechanism/events leading to injury or disease in order to establish the efficacy of PPE. However, it is evident from the database that the body parts or regions injured most are the fingers, the leg below the knee, and the metatarsal region of the foot. All of these body parts could be protected, at least potentially, by PPE (gloves, leg guards and protective footwear, for example).

Foot infections, corns, blisters and calluses were common ailments among mineworkers assessed as part of the project. Working in a hot environment, wearing gumboots, and the steel cap found in safety boots and gum boots were identified by these mineworkers as being significantly associated with these conditions. They also believed that the work place, especially the "dirty water" found underground caused recurring foot infections and that being away from work was the only solution to the problem. In general the foot hygiene among the workers assessed was satisfactory. They had a good knowledge of the importance of protective footwear. However, the associated medical complaints outweighed the benefits of protective footwear for many.

Most mineworkers claimed that, while they were on leave, their foot infections seemed to improve. The reasons for this were not apparent but while mineworkers are on leave they are no longer exposed to hot/wet underground working conditions or the use of PPE footwear. They might also practise better foot hygiene, or PPE-related problems (for example, occupational dermatitis) in susceptible individuals would also improve when they are away from work-related exposures. The importance of foot baths and socks in the prevention of infection and allergic reactions also requires further work to assist in the prevention of these two medical conditions.

The market place hosts a variety of PPE. Unfortunately, not all PPE is designed to fit the body dimensions of the user population in the local mining industry. Wearing PPE with poor fit characteristics could be dangerous. Measurements of the functional anthropometry of mineworkers that are being collected at present as part of SIM 04 09 01 at present could address this problem and will provide the designers of PPE with much needed information.

The selection of appropriate PPE is essential and should be preceded by a detailed hazard-identification process. This report and associated software endeavour to assist with the selection of PPE by providing general information for consideration in the selection process. It is by no means perfect but should be considered as the first step to assist mines in this regard. Further developments should be aimed at hosting the database on a web server and maintaining a single, consistent, up-to-date database that could be assessed by everyone.

6 Recommendations

The shortcomings in SAMRASS need serious consideration and should be addressed in a research project under the auspices of the Safety in Mines Research Advisory Committee (SIMRAC) planned for 2005/2006 (SIM 04 09 07: Recommendations for improvements in the reliability, accessibility and usefulness of OHS data and statistics). Provision should be made to provide inputs relating to the type of PPE used, the mechanism/events leading to injury or disease, and the efficacy of PPE.

When engineering, work practice, and/or administrative controls do not adequately protect employees and PPE is used, mines should consider the implementation of a carefully structured and comprehensive PPE programme as a matter of priority. The PPE programme should ideally be linked to existing health and safety programmes at mines. Selection of appropriate PPE is essential and should be preceded by a detailed hazard-identification process. This is also applicable for the selection of protective footwear.

As a second phase of the current project, and also to assist mines with PPE programmes, the Mine Health and Safety Council should consider the compilation of a Best Practice Document on the selection, use and management of PPE. Most of the mining countries in

the world have such documents, and these cover aspects of the use of PPE in mines. The document must comprehensively cover aspects of a PPE programme, including programme design criteria, management structure, promotional strategy, hazard identification, selection of appropriate PPE, fitting and wearing procedures, maintenance and inspection, training and education, and the auditing of a PPE programme.

The Best Practice Document must assist both employers and employees with the basics for conducting a hazard assessment of the workplace, the understanding of the limitations of PPE, and the training that is needed to ensure the proper use and care of PPE. Indices that could be used for the health and safety performance measurement of the effectiveness of PPE should also be included. The hosting of a regularly updated PPE database on a web server could assist in this regard.

Information on the functional anthropometry of mineworkers that is being collected as part of SIM 04 09 01 at present should be made available to the designers of PPE as a matter of priority. This much needed information will not only assist in the design of PPE but also enable informed decisions as far as the sizes of imported PPE are concerned.

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http://www.ccohs.ca/

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MINEsafe, Australia

http://www.minesafe.org/

MINEsafe provides an interactive framework for mineworkers' to have access to world's best practice on OH&S through the use of information communication technology. It draws on the extensive OH&S knowledge, expertise and data of the ILO, CFMEU, ICEM, Queensland Department of Natural Resources and Mines, New South Wales Department of Mineral Resources, Coal Services Pty Ltd, and the National Occupational Health and Safety Commission as a part of its comprehensive approach to OH&S information distribution.

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National Institute for Occupational Safety and Health (NIOSH) - USA

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NIOSH is a federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the Centres for Disease Control and Prevention (CDC) in the Department of Health and Human Services. The NIOSH objectives include the execution of research to reduce work-related illnesses and injuries, the promotion of safe and healthy workplaces through interventions, recommendations and capacity building, and enhancing global workplace safety and health through international collaborations.

Occupational Health and Safety Administration (OSHA) - USA

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Appendix 1: Evaluation of protective masks and safety eyewear

1. Background

In order to evaluate the dimensional fit of different types of face-fitting protective equipment for the South African (SA) population, facial forms and sizes representative of this population were used. This range of head models was developed by ERGOnomics TECHnologies (ERGOTECH) and is representative of at least 90 percent of the facial forms and sizes of the SA adult population. A dimensional fit of face-fitting headgear to this range of head models would therefore indicate that at least 90 percent of the SA population would be accommodated by the headgear type under investigation.

During the study conducted by ERGOTECH on facial forms and sizes, approximately 850 heads of South African subjects were scanned with a three dimensional (3D) laser scanner (see Figure 1 below) producing an accurate representation (point cloud) of each subject's head in 3D space.

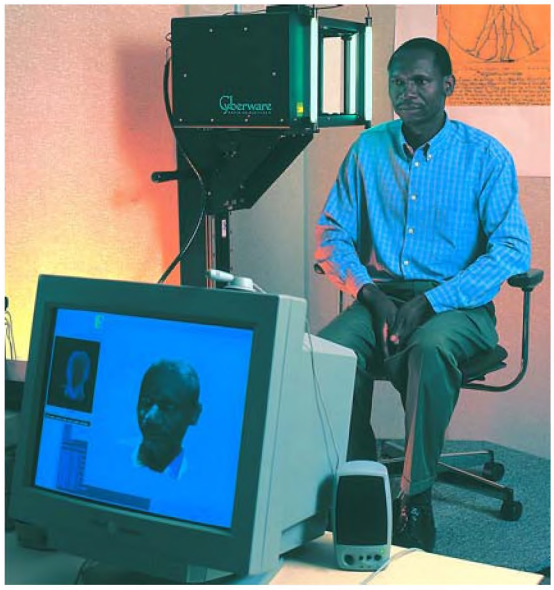

Figure 1: A scanning setup for scanning a person's head

From the 3D data, the coordinates of anatomical landmarks were extracted and used for the calculation of linear facial distances. The combination of these linear facial dimensions produces adequate information about each subject's face for characterising its form and size. A multivariate statistical analysis technique, cluster analysis, was used to determine characteristic facial forms and sizes of the SA population. Four characteristic groupings or clusters of facial forms and sizes were indicated.

Cluster 1:

Faces in cluster 1 are generally small faces (ranging from below to slightly above average of the total group) with narrow mid jawbone distances wider distances over the cheekbones and between average and small distances across the foreheads. The length of the faces, in comparison to the face width, is long but still ranges between shorter to

slightly longer than the average face length of the total sample group. The chin angles range between sharper to slightly more rounded than that of the average of the sample group. Grouping/cluster 1 faces are therefore overall small, narrow with prominent cheekbones and sharp chins: 1S-F (Figure 2) and 1L-F (Figure 3).

Cluster 2:

The faces in cluster 2 are small faces (ranging from below to slightly above average of the total group) that are generally wide over the forehead, cheekbones and mid-mandibles. The chin angles of subjects in this group/cluster range between slightly sharper than average to very rounded. The widths of faces in this group in relation to the face heights are much wider than those in cluster 1. Faces in this grouping/cluster are therefore overall small and wide with rounded chins: 2S-F (Figure 4) and 2L-F (Figure 5).

Cluster 3:

The facial forms in cluster 3 are large faces, ranging from slightly shorter to longer than the average of the total sample group. In relation to face length and when compared to the average of the total sample population, faces are narrow across the forehead, cheekbones and the mid-jawbone. Chin angles are sharp to approximately average in

comparison to the total sample population. Faces in cluster 3 are therefore large, narrow to average in width with sharp to average chin angles: 3S-F (Figure 6) and 3L-F (Figure 7).

Cluster 4:

The faces in cluster 4 are overall large. That is, these faces are longer and wider (over the foreheads, cheekbones and mid-mandibles with more rounded chin angles than the average of the total sample population: 4S-F (Figure 8) and 4L-F (Figure 9).

Eight head models were developed using 3D free-form modelling and deformation software. Each model was modelled according to the results obtained from the statistical analysis. The heads were then manufactured using Computer Numeric Control (CNC) machines. Figures 2 to 9 below illustrate the eight head models, with each characteristic form and size grouping indicated by a different colour.

Figure 2 : 1S-F

Figure 3 : IL-F

Figure 4 : 2S-F

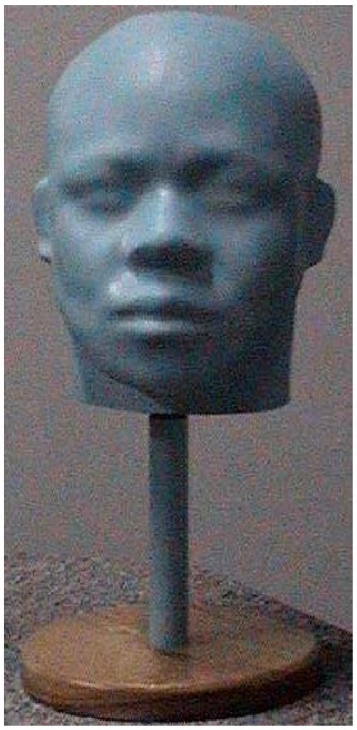

Figure 5 : 2L-F

Figure 6 : 3S-F

Figure 7 : 3L-F

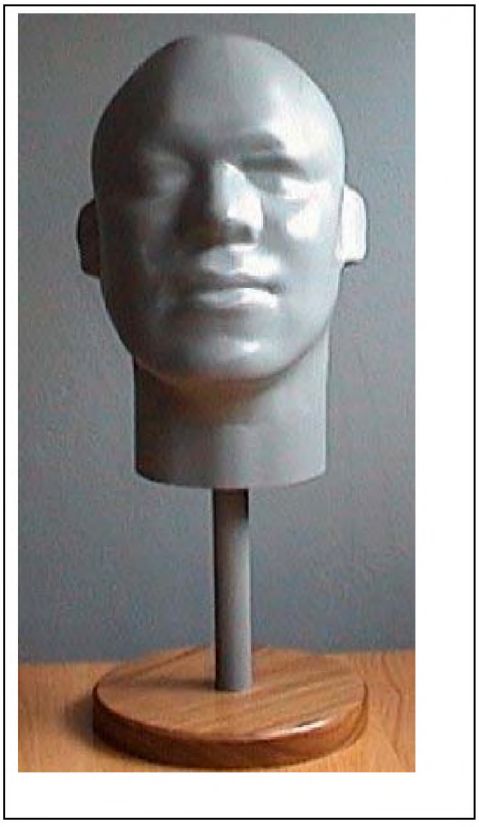

Figure 8 : 4S-F	Figure 9 : 4L-F

2. Method for evaluation of fit

In order to determine if a face-fitting protective item would be adequate to accommodate all ranges of people in a population, a dimensional evaluation of the placement of the protective item can be conducted. During a dimensional evaluation, factors such as the placement of, among other things, the chin, eyes and nose in relation to, for example, a protective mask are also visually assessed.

For the dimensional evaluation, a range of head models that are representative of at least 90 percent of the South African population is used. The application of the range of head models is to assess whether face-fitting protective items, in this case protective eyewear, half-masks and full-face masks, would fit this percentage of the population.

Dimensional evaluation provides a primary indication of fit to a prospective population. However, it does not take into account other factors that influence fit, such as the efficiency of the mask seal or user comfort. Only dimensional fit of the face-fitting protective items was investigated during this evaluation.

The overall rating for a mask size on a head model is the lowest rating obtained for all the aspects of fit evaluated. Therefore, if an acceptable fit was obtained for one aspect of the overall fit, but good fits for all the remaining aspects, the mask fit for that mask size to the head under investigation will be rated as an acceptable fit.

Where an acceptable to good fit is obtained on the entire range of head models, it is predicted that at least 90 percent of the SA population will be accommodated.

3. Procedures for the evaluation of half-mask respirator

The following donning procedure should be followed to ensure meaningful and repeatable results.

3.1 Donning of the mask

Hold the half-mask up to the face of the test head on which the mask is to be fitted, with the chin located in the chin cap. Pull the straps over the head. Tighten the straps while holding the mask in place on the face.

3.2 Fit procedure

The following procedure was used to evaluate the fit of a protective half-mask. The descriptions of area evaluated as well as the fit criteria are given below.

3.2.1 Facial contact and location of the mask

The mask seal is inspected to determine if the mask seals around the entire length of the seal. The location of the chin within the mask is inspected. The distance from where the mask rests on the nose to the nose root (sellion) is measured with a vernier calliper.

3.2.1.1. Face seal contact around the length of seal

A good fit was considered to be face-seal contact for the entire length of the seal. If there was no face-seal contact for the entire length of the seal it was considered to be a poor fit.

3.2.1.2 Location of chin

If the chin was in the cap of the mask it was considered to present a good fit. A poor fit was when there were gaps between the mask and the face under the chin or when the mask perched on the chin.

3.2.1.3 Location of top edge of mask

Good fit: 10 – 20 mm below sellion.

Acceptable fit: 0 – 10 or 20 – 25 mm below sellion.

Poor fit: < 0 mm or >25 mm from sellion.

3.2.2 Mask inner dimensions

3.2.2.1 (Mask nose height) – (head nose height)

Good fit: > 5 mm and < 10 mm

Acceptable fit: 0 – 5 mm or 10 – 40 mm

Poor fit: < 0 mm or > 40 mm

3.2.2.2 (Mask nose width) – (head nose width)

Good fit: 0 – 5 mm

Acceptable fit: 5 – 40 mm

Poor fit: < 0 mm or > 40 mm

3.2.2.3 (Mask inner widest width) – (head mouth width)

Good fit: > 10 mm and < 30 mm

Acceptable fit: 0 – 10 mm or 30 – 45 mm

Poor fit: < 5 mm and > 45 mm

4. Procedures for the evaluation of safety eyewear fit

In order to evaluate the fit of safety eyewear, the area assessed and criteria used for indication of a fit rating are described below.

4.1 Eye level

The centre of the pupils of the eyes in relation to the centre of the eyewear eyepiece was accessed. This variable is indicated in Figure 10.

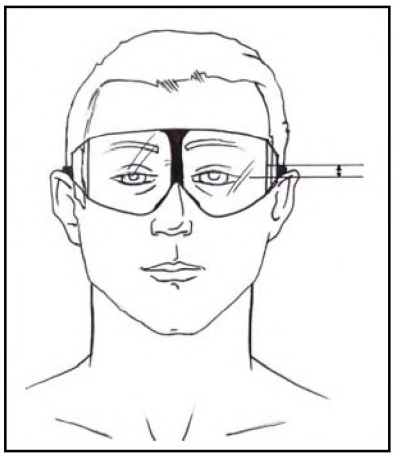

Figure 10: Measurement of eye level

4.1.1 Centre of pupil in relation to the eyewear eyepiece

Good fit: 0 - 10 mm above centre

Acceptable fit: <1/3 eye-piece height above/below eye-piece centre

Poor fit: >1/3 eye-piece height above/below eye-piece centre

4.1.2 Distance between endocanthus and eye-piece inner

Good fit: >10 mm and <15 mm

Acceptable fit: >5 mm and <10 mm or >15 mm and <20 mm

Poor fit: <5 mm or >20 mm

4.2 Protective coverage of eyepieces around eyes

The coverage provided by the eyepieces at the side and top and bottom of the eyes is investigated first. The clearance distance between the eyepieces and the face is then investigated.

4.2.1 Area at sides of eyes covered

Good fit: > 20 mm

Acceptable fit: > 10 mm and < 20 mm

Poor fit: < 10 mm

4.2.2 Area at top and bottom of eyes covered

Good fit: > 15 mm

Acceptable fit: > 10 mm and < 15 mm

Poor fit: < 10 mm

Maximum distance between eyewear and face (at any point along eyewear surface)

Good fit: < 10 mm

Acceptable fit: > 10 mm and < 15 mm

Poor fit: > 15 mm

4.3 Fit over nose bridge

Inspect how the eyewear fits over the nose and inspect the comfort features added at the nose bridge area provided on the eyewear.

4.3.1 Placement over nose bridge

Good fit: Fits loosely over nose bridge, but not sliding down onto nose.

Acceptable fit: Fits snugly over nose bridge, not sliding down onto nose or perching on nose bridge.

Poor fit: Slides down onto nose or perches on nose bridge.

4.3.2 Comfort features over nose bridge

Good fit: Comfort features, such as cushioning, provided over nose bridge.

Acceptable fit: No comfort features provided, but designed to accommodate facial contours.

Poor fit: No comfort features provided and not designed to accommodate facial contours.

4.4 Fit of eyewear temples

Measure and inspect the length of the temples, i.e. if they fit firmly behind the ears. Furthermore, measure and inspect the width between the temples, i.e. if it is too wide, fits snugly, or is too tight against the sides of the head.

4.4.1 Horizontal distance: tragion – start of bend on temples (positive = start of bend in front of tragion)

Good fit :> 0 mm and < 5 mm

Acceptable fit: > 5 mm and <25 mm or > -2 mm and <0 mm

Poor fit: <-2 mm or >25 mm

4.4.2 Width of temples: width of head where temples touch head - temple width

Good fit: > 5 mm and < 15 mm

Acceptable fit: >15 mm

Poor fit: <5 mm or pushes against sides of forehead

5. Procedures for the evaluation of protective full-face mask fit

The following donning procedure should be followed to ensure meaningful and repeatable results.

5.1 Donning of the mask

Loosen all harness straps until approximately 2 cm of the stop ends are loose.

Hold the respirator up to the face of the test head on which the mask is to be fitted, with the chin located in the chin cap.

Pull the harness over the head.

Pull the harness straps one at a time until lightly tensioned while holding the mask in place on the face.

Now tighten the straps in the following order, the left and right simultaneously: the bottom two, then the middle two, and then the top two. For harnesses with only two sets of straps, tighten bottom two and then top two.

5.2 Fit procedure

The following procedure was used to evaluate the fit of a protective full-face mask. The descriptions of area evaluated as well as the fit criteria are given below.

Eye level

Measure the centre of the pupil of the eyes in relation to the widest section of the protective mask eyepiece. This variable is indicated in Figure 11.

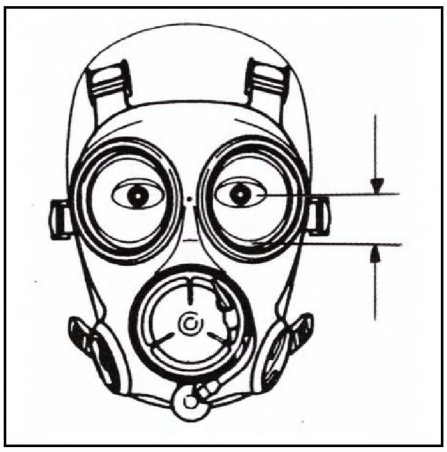

Figure 11: Eye level – distance between pupil height and bottom of eyepiece

5.2.1.1 Centre of pupil in relation to the mask glasses

Good fit: 0-10 mm above or below widest section

Acceptable fit: < 1/3 eyepiece above/below the widest section

Poor fit: > 1/3 eyepiece above/below the widest section

5.2.2. Facial contact with protective mask outer

Investigate the contact that the mask makes with the face around the entire length of the seal. Then investigate the location of the chin and the top edge of the mask. Measure the

distance between edge of the side of the mask and the ear. This variable is indicated in Figure 12.

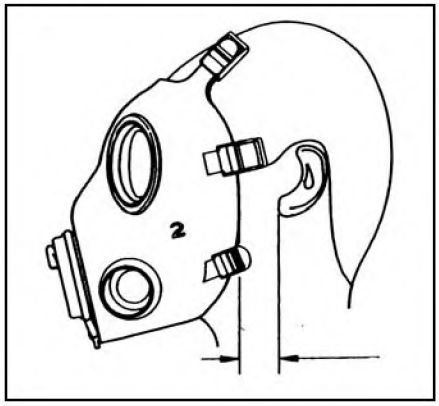

Figure 12: Distance between the side edge of the mask and subject's ear

5.2.2.1 Face seal contact around length of seal

Good fit: Entire length

Acceptable fit: >2/3 of length

Poor fit: 0 – 2/3 of length

5.2.2.2 Location of chin

Good fit: In cap

Acceptable fit: With chin in cap, just under hairline or just above eyebrows

Poor fit: Gaps under chin or mask perched on chin

5.2.2.3 Location of top edge of mask

Good fit: Between eyebrows and hairline

Acceptable fit: With chin in cap, just under hairline or just above eyebrows

Poor fit: On hairline on eyebrow

5.2.2.4 Distance between edge of side mask and ear

Good fit: 15 – 25mm

Acceptable fit: 5 - 15 mm or 25 – 35 mm

Poor fit: < 5 mm or > 35 mm

5.2.3. Facial contact of protective mask inner

Measure the distance from where the mask inner rests on the nose to the nose root (sellion) with a vernier calliper. Measure the closest distance between the mask inner and

the eyes. The distance should be measured with a vernier calliper between the edge of the mask inner and the edge of the eyelids and/or endocanthus (inner corner of eye), whichever is closest. Measure the vertical distance from where the mask inner rests on the nose to the nose point (pronasale) on the head model. Measure the mask inner width and depth, at that vertical distance from the top of the mask inner. Note: the mask inner width is measured with the inner at a comfortable stretch. Subtract the nose height and width from the measured mask inner width and height. Finally, measure on the head model the vertical distance from where the mask inner rests on the nose to the middle of the lips (stomion). Measure the mask inner width at that vertical distance from the top of the mask inner. Subtract the mouth width from the measured mask inner width.

5.2.3.1 Distance between sellion and where mask inner rests on nose

Good fit: 5 – 10 mm from nose root

Acceptable fit: 0-5 or 10-20 mm from nose root

Poor fit: <0 mm or >20 mm from nose root

5.2.3.2 Distance between mask inner and eyelids/endocanthus

Good fit: 5 – 10 mm

Acceptable fit: 2-5 or 10-15 mm

Poor fit: <0 mm or >15 mm

5.2.3.3 (Mask nose height) – (head nose height)

Good fit: 5 – 20 mm

Acceptable fit: 0- 5 mm or 20 – 40 mm

Poor fit: < 0 mm or > 40 mm

5.2.3.4 (Mask nose width) – (head nose width)

Good fit: > 5 mm

Acceptable fit: 0 – 5 mm or 5 – 40 mm

Poor fit: < 0 mm or >40 mm

5.2.3.5 (Mask inner widest width) – (head mouth width)

Good fit: > 10 mm and < 30 mm

Acceptable fit: 0 - 10 mm or 30 - 45 mm

Poor fit: < 0 mm and > 45 mm

Appendix 2: Foot Pathology Screening Form

Case No._____

Demographics

Date of Assessment: ___/____/2003

Age/Date of birth: _____

Current medication:_____

Height: _____m

Weight: _____Kg

Sex: _____

Medical History

Hypertension:	**Yes**		**No**	
Diabetes:	**Yes**		**No**	
Arthritis:	**Yes**		**No**	
Circulation:	**Yes**		**No**	
Overweight:	**Yes**		**No**	
Eyesight:	**Yes**		**No**	
Other:	**Yes**		**No**	

Surgical History

Major operation: ……

Foot surgery:……

Amputation: Type ……..

Reason: ……

Foot Complaints

Swelling:	**Yes**		**No**	
Pain:	**Yes**		**No**	
Stiffness:	**Yes**		**No**	
Corns:	**Yes**		**No**	
Calluses:	**Yes**		**No**	
Painful toenails:	**Yes**		**No**	
Bunions:	**Yes**		**No**	
Cold feet:	**Yes**		**No**	
Infections:	**Yes**		**No**	
Discolouration:	**Yes**		**No**	
Burning:	**Yes**		**No**	
Tingling:	**Yes**		**No**	
Hammer toes:	**Yes**		**No**	
Numbness:	**Yes**		**No**	

Dermatological Evaluation

Calluses: **Yes** ☐ **No** ☐ Describe _____

Corns: **Yes** ☐ **No** ☐ Describe _____

Fissures: **Yes** ☐ **No** ☐ Describe _____

Ulceration: **Yes** ☐ **No** ☐ Describe _____

History of ulceration: **Yes** ☐ **No** ☐ Describe _____

Infection: **Yes** ☐ **No** ☐ Describe _____

Nails

Thickened:	**Yes**	☐	**No**	☐ _____
Discoloured:	**Yes**	☐	**No**	☐ _____
Sores:	**Yes**	☐	**No**	☐ _____
Fungal infection:	**Yes**	☐	**No**	☐ _____
Plantar wart:	**Yes**	☐	**No**	☐ _____
Blister:	**Yes**	☐	**No**	☐ _____
Other:	**Yes**	☐	**No:**	☐ _____

Foot Shape/Function Evaluation

Limited range of motion:	**Yes**		**No**			
Ambulation aid:	**Yes**		**No**			
Posture:	**Symmetrical**		**Asymmetrical**			
Limb:	**Absent**		**Present**			
Feet:	**Flat**		**High instep**		**Normal**	
Bunion:	**Yes**		**No**			
Hammer toes:	**Yes**		**No**			
Bony outgrowth:	**Yes**		**No**			
General foot deformity:	**Yes**		**No**			
Other:						

General Observations:

History of previous foot treatment:							
Able to reach feet: **Yes**		**No**					
Able to remove socks/shoes: **Yes**		**No**					
Level of hygiene:							

Type of socks:	**Nylon/cotton**		**None**		**Other**			
Footwear:	**Shoe**		**Gumboots**		**Sandals**		**None**	
Shoe function:	**Adequate**		**Inadequate**					
Impression of PPE:	**Happy**		**Content**		**Disappointe**			

Why? .....

How long have you had the present PPE shoe? .....

How long does the footwear last?.....

Wash feet daily? .....

Clean pair of socks every day?.....

How do you cut your nails?.....

Ever treat corns with acid?.....

Do you smoke? .....

Measurements

Foot length: ……

Foot width over the five toes:……

Foot width over the ball of the foot:……

Foot width over the 'waist' of the foot……..

INCLUDE A FOOT TRACING OF BOTH FEET INDICATING CALLUSES ETc

Appendix 3: Foot Care Guidelines

The following guidelines were taken from different sources and only the relevant guidelines for the general mining industry are summarised below. Sources consulted include:

- Foot Care Guidelines From Merck Manual

(www.merck.com/pubs/mmanual_ha/sidebars/sb40_1.html)

- Diabetic Foot Care Guidelines From The Foot Physicians (www.footphysicians.com/info2.php?id=14)

- National Guideline On Foot Health At Primary Level. Department Of Health (www.DOH.gov.za/docs):

Mineworkers can avoid a great variety of skin and toenail disorders by simply:

- Washing their feet daily with soap, rinsing thoroughly and drying, especially between the toes;
- Trimming toenails straight across, not too short and not into the corners;
- Wearing clean socks/stockings and changing them daily;
- Having their feet examined during their annual periodical examination and being encouraged to discuss common and recurrent foot complaints/foot pathologies; and
- Never cutting/trimming corns or calluses or using corn plasters or other home remedies, as these preparations are acidic and often cause ulcers.

Mineworkers whose feet sweat a lot or who are more prone to foot infection should:

- Not ignore foot pain and inspect their feet daily to pick up any foot pathology early;
- Rotate shoes daily to allow them to air out;
- Wear non-coloured woollen or cotton socks as certain dyes may cause or aggravate skin allergies;
- Use foot powder; and
- Consult a doctor if a foot condition persists and does not respond to simple self-care measures

When protective footwear is selected the following should be considered:

- Making sure the shoes fits properly and are comfortable from the beginning, with no need to 'break them in";
- Selecting shoes later in the day when feet tend to be at their largest;

- Selecting shoes of the right length, width, and with enough room for the toes; and
- Replacing worn-out shoes and socks as soon as possible.

Appendix 4: Personal protective equipment (PPE) programme checklist

(Based on checklist compiled by Canadian Centre for Occupational Health and Safety)

The PPE programme coordinator should consider:

- Designing a PPE programme;
- Ensuring engineering controls are considered first, as PPE is the last line of defence;
- Securing the active participation of all parties;
- Ensuring that a programme coordinator has been appointed;
- Observing the gradual phasing in of the PPE programme on a pre-arranged time schedule; and
- Re-evaluating the programme on an ongoing basis.

Promotional strategy

- Publicise commitment to the programme;
- Ensure a clear, concise company policy has been formulated; and
- Examine the educational programme.

Workplace survey

- Review work practices, job procedures, equipment and plant layout; and
- Use job-hazard analysis techniques to integrate accepted safety and health principles and practice into specific operations

Selection

- Choose PPE to match the hazard;
- Obtain advice on proper selection;
- Institute workplace trials;
- Consider the physical comfort of PPE;
- Evaluate cost considerations of PPE usage; and
- Ensure PPE meets standards/certification.

Fitting and wearing

- Ensure programme includes the individual fitting of PPE; and
- Survey users to ensure PPE is worn properly.

Maintenance

- Ensure that workers know how to perform regular maintenance and inspection of their PPE.

Training

- Verify that all users, supervisors, selectors, buyers, and storekeepers are trained.

Support

- Ensure that education programmes are ongoing.

Auditing the programme

- Review the programme at least annually; and
- Review and compare production and safety performance records.

Worker responsibilities:

Use of proper PPE

- Make sure you are wearing the right PPE for the job. Check with your safety representative if you are not sure.

Maintenance and inspection

- Inspect PPE before and after each use;
- Take care of PPE at all times;
- Clean all PPE after use;
- Repair or replace damaged or broken PPE; and
- Store PPE in clean dry air - free from exposure to sunlight or contaminants.

Training

- Ensure you have been trained in how to fit, wear, and maintain PPE; and
- Ensure training programme includes information that explains when and what PPE should be worn, and why it should be worn.

Appendix 5: SABS standards for personal protective equipment

SABS Standard	Issue	Title
Eye Protection		
SABS EN 169	1992	Personal eye protection - Filters for welding and related techniques – Transmittance requirements and recommended utilisation
CKS 552	1980	Industrial safety spectacles for general use
SABS 1400	1993	Equipment (including oculars) for eye, face and neck protection against non-ionising radiation arising during welding and similar operations – Welding helmets, handshields, goggles and welding spectacles
SABS 1404	1993	Eye-protectors for industrial and non-industrial use
SABS 1644	1995	Lenses for sunglasses and fashion spectacles – Safety requirements
Hearing Protection		
SABS EN 458	1993	Hearing protectors - Recommendations for selection, use, care and maintenance – Guidance document
SABS 1451-1	1988	Hearing protectors Part 1: Ear-muffs
SABS 1451-2	1988	Hearing protectors Part 2: Ear-plugs
SABS 1451-3	1998	Hearing protectors Part 3: Ear-muffs attached to an industrial safety helmet
SABS SM 698	1969	Evaluation of ear protectors as skin irritants
Helmets		
SABS 0282	1997	Maintenance of helmet light assemblies
SABS 397	1983	Safety helmets for industrial use and for firemen
SABS EN 397	-	Industrial safety helmets
SABS 799	1983	Safety helmets for motor cyclists
SABS 1400	1993	Equipment (including oculars) for eye, face and neck protection against non-ionising radiation arising during welding and similar operations - Welding helmets, handshields, goggles and welding spectacles
SABS 1438-1	1987	Helmet light assemblies for miners Part 1: Incandescent lamps
SABS 1438-2	1987	Helmet light assemblies for miners Part 2: Lead-acid batteries
SABS 1438-3	1987	Helmet light assemblies for miners Part 3: Cables
SABS 1438-4	1987	Helmet light assemblies for miners Part 4: Helmet lights

		(headlights)
SABS 1438-5	1987	Helmet light assemblies for miners Part 5: Helmet light assemblies
SABS 1542	1991	Safety helmets for pedal cyclists
VC 8016	1984	Safety helmets for motor cyclists
Protective Clothing		
SABS 434	2001	Boiler suits and workwear suits
SABS 1068	1985	Coats and jackets (protective, unlined)
SABS 1276	1980	Protective suits for use when pesticides are handled
SABS 1557	1992	Sunscreen products
SABS 1585	1993	Coated fabrics for shelters and rainwear
SABS 1658	1996	Ballistic resistance of body armour
CKS 20	1985	Overalls, bib-and-brace
CKS 52	1974	Suits (servants)
CKS 124	1974	Leggings (waterproof)
CKS 125	1973	Capes (waterproof)
CKS 126	1973	Sou'westers
CKS 287	1971	Men's raincoats
CKS 288	1971	Women's raincoats
CKS 311	2001	Women's workwear
SABS EN 381-1	1993	Protective clothing for users of hand-held chain saws Part 1: Test rig for testing resistance to cutting by a chain saw
SABS EN 381-2	1995	Protective clothing for users of hand-held chain saws Part 2: Test methods for leg protectors
SABS EN 381-5	1995	Protective clothing for users of hand-held chain saws Part 5: Requirements for leg protectors
Fall Protection & Safety Belts		
SABS 0333-1	1999	Industrial rope access Part 1: Worksite procedures
SABS 0333-2	1999	Industrial rope access Part 2: Training and certification procedures
SABS 809	2000	Industrial restraint belts
SABS 1280	1980	Industrial safety belt webbing
SABS EN 353-1	1992	Personal protective equipment against falls from a height – Guided type fall arresters on a rigid anchorage line
SABS EN 353-2	1992	Personal protective equipment against falls from a height – Guided type fall arresters on a flexible anchorage line
SABS EN 355	1992	Personal protective equipment against falls from a height – Energy absorbers
SABS EN 358	1992	Personal equipment for work positioning and prevention of falls from a height - Work positioning systems
SABS EN 361	1992	Personal protective equipment against falls from a height – Full body harnesses

SABS EN 363	1992	Personal protective equipment against falls from a height – Fall arrest systems
Gloves		
SABS 316	1988	Industrial hand protectors (leather and fabric) and leather protective clothing
SABS 416	1973	Chemical resistant gloves
SABS 1155	1977	The manufacture of surgical rubber gloves (single use)
SABS 1228	1986	Abrasion-resistant PVC gloves
SABS 1297	1986	Leather gloves
SABS 1360-4	1982	Size designation of clothes Part 4: Gloves
SABS ISO 11193	1994	Single-use rubber examination gloves – Specification
SABS IEC 60903	1988	Specification for gloves and mitts of insulating material for live working
CKS 172	1972	Glove racks
Footwear		
SABS 320	1978	The production of men's heavy boots, service type (Goodyear welted)
SABS 321	1978	The production of men's boots (Goodyear welted, with stitched or stuck-on outer soles)
SABS 422	1988	Hospital nurses' shoes (Goodyear welted construction)
SABS 492-1	1982	Protective and safety gumboots Part 1: Handmade rubber gum boots
SABS 492-2	1982	Protective and safety gum boots Part 2: Moulded rubber gum boots
SABS 492-3	1983	Protective and safety gum boots Part 3: Handmade rubber ankle boots for men
SABS 492-4	1983	Protective and safety gum boots Part 4: Moulded rubber ankle boots for men
SABS 668	1975	The production of men's protective boots and shoes (Goodyear welted, with stitched or stuck-on outer soles)
SABS 669	1975	The production of men's protective shoes (Goodyear welted, with stitched or stuck-on outer soles)
SABS 741	2001	Industrial boots (including safety boots) with direct-vulcanised soles and heels
SABS 1114	2001	Industrial boots (including safety boots) with stuck-on pre-moulded or direct-injection-moulded soles and heels
SABS 1167	2001	Industrial shoes (including safety shoes) with stuck-on pre-moulded or direct-injection-moulded soles and heels
SABS 1168	2001	Industrial shoes (including safety shoes) with direct-vulcanized soles and heels
SABS 1320-1	2001	PVC gum boots Part 1: Injection-moulded gum boots
SABS 1320-2	1981	PVC gum boots Part 2: Dip-moulded gum boots with pre-moulded stuck-on outer soles and heels
SABS 1320-3	2001	PVC gum boots Part 3: Injection-moulded ankle boots for men
SABS SM 645	1994	Safety footwear - Impact resistance

SABS SM 1080	1994	Leather and other footwear materials - Resistance to to-and-fro rubbing
SABS SM 1111	1988	Accumulated impact strength of steel shanks
SABS SM 1112	1988	Bending modulus of steel shanks for footwear
SABS SM 1224	1994	Footwear – Electrical resistance properties
SABS SM 1225	1994	Safety footwear - Penetration resistance
SABS SM 1226	1994	Footwear – Compression resistance
SABS SM 1230	1994	Footwear – Corrosion resistance (metallic components)
SABS SM 1232	1994	Safety footwear - Penetration-resistant inserts – Flexing resistance
SABS SM 1235	1994	Footwear – Elastomeric material - Resistance to fuel oil
CKS 412	1974	Firemen's top boots
CKS 606	1990	Boots for firemen, direct-vulcanised construction

Appendix 6: Homologation database for respiratory protection from the SABS

HOMOLOGATION DATABASE: 2004

Homologation of products by SABS Consumer Health & Safety Department

SABS

Date	Type approval No.	Applicant	Product description	Homologation Report No.	VC No.
2004/01/28	AZ2004/01	HAZMAT Protective Systems (Pty) Ltd	HAZMAT HFP/C5004 B1P2 COMBINED FILTER	7158/1938308/CA0082	VC8072
2004/01/28	AZ2004/02	HAZMAT Protective Systems (Pty) Ltd	Hazmat HFP/C5006 P2 particle filter	7158/1938308/CA0085	VC8072
2004/02/04	AZ2004/03	Multifibres (Pty) Ltd.	Dasheng Mask DTC3W FFP1S filtering half mask	7158/1938308/CA275	VC8072
2004/03/23	AZ2004/04	HAZMAT Protective Systems (Pty) Ltd	HAZMAT HFP/C5003 A1P2 filter cartridge	7158/1938308/CA0083	VC8072
2004/04/08	AZ2004/05	Micron Filters	Microfil BL 70 P2 particle filter	7158/1938308/CA317	VC8072
2004/07/07	AZ2004/06	Zenith Safety Products Trust	Zenith Duad FFP2S filtering half mask	CA0072	VC8072
2004/07/07	AZ2004/07	Zenith Safety Products Trust	Zenith Monad FFP1S filtering half mask	7158/1938308/CA152	VC8072
2004/07/14	AZ2004/08	Dräger SA (Pty) Ltd.	DRÄGER X-PLORE 3300 HALF MASK EN 140:1998	VCM02201	VC8072
2004/07/23	AZ2004/09	Dräger SA (Pty) Ltd.	DRÄGER BG4 IP SELF-CONTAINED CLOSED-CIRCUIT BREATHING APPARATUS EN 145/O2/4P	7158/1938308/CA0101	VC8073
2004/08/05	AZ2004/10	MSA (Africa) (Pty) Ltd.	MSA/AUER AIRMAXX CABA WITH MSA AUTOMAXX-AS LUNG GOVERNED DEMAND VALVE	7158/1938308/CA0071/01	VC8073
2004/08/05	AZ2004/11	MSA (Africa) (Pty) Ltd.	MSA AUER ULTRA ELITE PS - MAXX FULL FACE MASK EN 136 CLASS 3	7158/1938308/CA0071/02	VC8072
2004/08/05	AZ2004/12	MSA (Africa) (Pty) Ltd.	MSA/AUER BD 96 AS SCBA CABA	7158/1938308/CA0065	VC8073
2004/08/06	AZ2004/13	MSA (Africa) (Pty) Ltd.	MSA AUER ULTRA ELITE PS FULL FACE MASK EN 136 CLASS 3	7158/1938308/CA0064/02	VC8072
2004/08/06	AZ2004/14	Industrial & Marine Sealing Systems	DRO-AIR 1131 FFP3SL FILTERING HALF MASK	VCM02393	VC8072
2004/08/12	AZ2004/15	Industrial & Marine Sealing Systems	DRO-AIR 1231 FFP3SL FILTERING HALF MASK	7158/1938308/CA310	VC8072
2004/08/17	AZ2004/16	Industrial & Marine Sealing Systems	DRO-AIR 1121 FFP2SL FILTERING HALF MASK	7158/1938308/CA311	VC8072
2004/08/17	AZ2004/17	Industrial & Marine Sealing Systems	DRO-AIR 1021 FFP2SL filtering half mask	VCM02394	VC8072
2004/08/17	AZ2004/18	Industrial & Marine Sealing Systems	DRO-AIR 1020 FFP2SL filtering half mask	VCM02395	VC8072
2004/09/07	AZ2004/19	Industrial & Marine Sealing Systems	DRO-AIR 1010 FFP1S filtering half mask	VCM02347	VC8072
2004/09/08	AZ2004/20	Industrial & Marine Sealing Systems	DRO-AIR 1121A FFP2SL filtering half mask	VCM02508	VC8072
2004/09/14	AZ2004/21	MSA (Africa) (Pty) Ltd.	MSA AUER Advantage 3121 medium full face mask EN 136 Class 3	VCM02480	VC8072
2004/09/29	AZ2004/22	MSA (Africa) (Pty) Ltd.	MSA AUER Advantage 3221 10027726 full face mask EN 136 Class 2	VCM02478	VC8072
2004/10/06	AZ2004/23	Dräger SA (Pty) Ltd.	Dräger Piccola FFP2-S filtering half mask	VCM02483	VC8072
2004/10/11	AZ2004/24	Industrial & Marine Sealing Systems	DRO-AIR 1121C FFP2SL filtering half mask	VCM02507	VC8072
2004/10/19	AZ2004/25	Dräger SA (Pty) Ltd.	Dräger Piccola FFP1 S filtering half mask	VCM02484	VC8072
2004/11/10	AZ2004/26	MSA (Africa) (Pty) Ltd.	MSA 20721 M6 FFP2S filtering half mask	VCM02471	VC8072

Appendix 7: Example of information used to populate electronic PPE matrix

	Potential hazards															PPE required																
Occupation	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Business manager		√	√	√					√	√						√	√	√	√		√	√	√				√	√			√
Business area manager		√	√	√					√	√						√	√	√	√		√	√	√				√	√			√
Project manager																					√										
OPS overseer		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			√
OPS supervisor		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			√
Miner/crew captain		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Developer		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			

	Potential hazards															PPE required													
Occupation	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Nightshift cleaner		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
General miner		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Team leader		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Crew captain		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Team stoping		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Team developing	√	√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Stope hand		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Developer hand	√	√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Machine operator	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√								√	√			√

	Potential hazards															PPE required													
Occupation	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Winch erector		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Winch operator		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√								√	√			
Mono winch operator		√	√	√			√	√	√	√		√	√	√	√	√	√	√	√								√	√			
Single Drum Winch Operator		√	√	√		√	√		√	√	√		√	√	√	√	√										√				
Skip attendant		√	√	√				√		√					√	√	√										√				
Loco driver	√	√	√	√	√	√	√	√		√		√	√		√	√	√										√				
Loco guard	√	√	√	√	√	√	√	√		√		√	√		√	√	√										√				
Maintenance worker		√								√			√		√	√	√										√				
PTV		√	√	√				√	√	√		√	√	√	√	√	√										√				

Occupation	Potential hazards															PPE required															
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Store man	√							√																							
Sanitation worker	√									√		√			√		√														
Loader operator		√	√	√	√	√	√					√	√	√	√	√	√										√				
L.H.D. operator		√			√	√	√						√	√	√	√	√										√				
Dump truck operator		√			√	√	√					√	√	√	√												√				
Logistics manager		√	√	√								√	√	√		√	√										√				
Engineer		√	√	√								√	√	√		√	√										√				
Logistics foreman		√	√	√								√	√			√	√										√				
Winding engine driver		√										√				√	√										√				

Occupation	Potential hazards															PPE required															
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Compressor operator	√	√														√											√				
Compressor assistant	√	√										√				√											√				
Boilermaker	√	√	√	√												√											√				
Boilermaker assistant	√	√	√	√																							√				
Boilermaker aide	√	√	√	√	√	√	√		√	√	√	√			√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Electrician		√		√	√	√	√		√	√	√	√			√			√	√	√	√	√	√	√	√	√	√	√	√	√	
Electrician assistant		√		√	√	√	√			√	√	√			√			√	√	√	√	√	√	√	√	√	√	√	√	√	
Electrician aide		√		√	√	√	√			√	√	√			√			√	√	√	√	√	√	√	√	√	√	√	√	√	
Fitter	√	√		√	√	√	√			√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required															
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Fitter assistant	√	√		√	√	√	√			√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
Fitter aide	√	√		√	√	√	√			√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√
Rigger						√				√	√	√						√		√	√	√	√	√	√	√	√	√	√		√
Rigger assistant						√				√	√	√						√		√	√	√	√	√	√	√	√	√	√		√
Pump attendant	√	√		√	√	√	√				√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√			√
Carpenter		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Carpenter assistant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Mason		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Mason assistant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Plumber	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Plumber assistant	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Painter	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Painter assistant	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
LDV Driver	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Crane driver	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Geologist		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Engineering Team	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Manager		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

	Potential hazards															PPE required														
Occupation	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Diesel Mechanic	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Assistant	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Change House Team	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Shaft Foreman		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Shaft Timber man		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Assistant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Banksman		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Onsetter		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Banksman/ONS Helper		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Conveyor Belt Supplier		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Conveyor Belt Attendant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Salv Y Labourer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Fork/Tract Driver		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Lampsman	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Lamp Repairer	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Tip Attendant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Planning Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Planning Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Surveyor		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Vent Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Safety Manager		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Chief Safety Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Safety Officer			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Safety Team Leader		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Full time H&S Stew		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
HRD Manager		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
ETD Co-ordinator		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

	Potential hazards															PPE required														
Occupation	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Training Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Training Instructor		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Asset Protector Man		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Asset Protector Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Man Accountant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Cost Accountant			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Tel. Exchange Op		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Secretary		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Personnel Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Personnel Officer		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Personnel Assistant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Personnel Clerk		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Hostel Assistant	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Controller	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Hostel Cook		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Barman			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Canteen Worker			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
T & A Terminal Operator		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Cleaner	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Handy Man		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Ass. Plant Operator	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Bagging Operator		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Belt Attendant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Chief Chemist	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Control Room Operator		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Crusher Attendant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Crusher Supervisors		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

	Potential hazards															PPE required														
Occupation	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Excavator Driver		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Filter Belt Operator	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Filter Press Operator	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Floatation Assistant	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
General Foreman		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Instrument Technician		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Leading Hand	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Loader Driver		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Mill Hand	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Plant Engineer	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Plant Foreman	√																														
Plant Manager		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Plant Metallurgist	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Plant Supervisors		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Principal Chemist	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Principal Lab Operator	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Process Clark	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Reagent Assistant	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Sampler		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Chemist	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Lab Operator	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Lab Technician	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Metallurgist	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Senior Sample Prep Attendant	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Shift Foreman		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Slimes Dam Attendant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Slimes Dam Supervisor		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Occupation	Potential hazards															PPE required														
	Chemicals	Noise	Heat	Cold	Vibration	Machinery	Equipment	Material	Environment	Water	Electricity	Gasses	Dust	Ventilation	Tools	Hard hat	Gumboots	Gloves	Overalls	Freezer suit	Boots	Rain wear	Vest	Apron	Respirator	Face shield	Hearing	Eye protection	Dust coat	Dust mask	PVC suit
Supervisor Lab Operator	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Typist		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Shift Foreman		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Slimes Dam Attendant		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Appendix 8: Generic occupation, hazard and PPE matrix

*N.B. SAMOHP Code according to South African Mines Occupational Hygiene Programme Codebook

HAV: Hand-arm vibration

WBV: Whole body vibration

UV: Ultraviolet (radiation)

Occupation	SAMOHP Code	Hazards	Appropriate PPE
Acid plant worker	30404	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Cold	Warm jacket/helmet liner/gloves
		Chemicals	Respirator/protective garment
		Eye/Face injury	Eye/face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		WBV	Engineering controls
Aqua jet operator	21406	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		Fall of ground	Hard hat/torso protection
		HAV	Anti-vibration gloves
Assay/chemistry/ laboratory worker	50499	Burns	Flameproof garment
		Chemicals	Eye/Face protection
		Eye/Face injury	
		Hand injury	Protective gloves
Backfill worker	20805	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/Face protection
		Dermatitis	Protective gloves
		Hand injury	
		Foot/Ankle injury	Protective footwear and metatarsal guards
		Fall of ground	Hard hat/torso protection

Occupation	SAMOHP Code	Hazards	Appropriate PPE
Banksman/ Onsetter	21304	Noise	Hearing protection
		Dust	Dust mask
		Cold	Pneumo jacket
		Hand injury	Protective gloves
		Eye/Face injury	Eye/face protection
		Foot/Ankle injury	Protective footwear and metatarsal guards
		UV radiation	Sun block cream
Beltsman	30205	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		Fall of ground	Hard hat/shoulder protection
Boilermaker	40450	Noise	Hearing protection
		Heat	Water bottle
		Cold	Warm jacket/helmet liner/gloves
		Welding arc	Welding mask/goggles
		Welding fumes	Respirator
		Eye/Face injury	Eye/face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		HAV	Anti-vibration gloves
Bulldozer operator	21103	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Cold	Warm jacket/helmet liner/gloves
		Diesel fumes	Respirator
		Eye/Face injury	Eye/face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		WBV	Anti-vibration seat
		UV radiation	Sun block cream

Occupation	SAMOHP Code	Hazards	Appropriate PPE
Carpenter	40621	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Cold	Warm jacket/helmet liner/gloves
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		HAV	Anti-vibration gloves
Cementation worker	21699	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/face protection
		Dermatitis	Protective gloves
		Hand injury	
		Foot/Ankle injury	Protective footwear and metatarsal guards
		Fall of ground	Hard hat/torso protection
Coal cutter operator	20601	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		Fall of ground	Hard hat/shoulder protection
		WBV	Anti-vibration seat
Coal preparation worker	30211	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Cold	Warm jacket/helmet liner/gloves
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		WBV	Engineering controls
Compressor attendant	40804	Noise	Hearing protection
		Heat	Water bottle
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards

Occupation	SAMOHP Code	Hazards	Appropriate PPE
Continuous Miner operator	20602	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		Fall of ground	Hard hat/shoulder protection
Conveyor belt attendant	21202	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		Fall of ground	Hard hat/shoulder protection
		WBV	Engineering controls
Crusher attendant	30207	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Cold	Warm jacket/helmet liner/gloves
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		WBV	Engineering controls
Cyanidation worker	30405	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Cold	Warm jacket/helmet liner/gloves
		Chemicals	Respirator/protective garment
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves
		Foot/Ankle injury	Protective footwear and metatarsal guards
		WBV	Engineering controls
Development team worker	20701	Noise	Hearing protection
		Dust	Dust mask
		Heat	Water bottle
		Eye/Face injury	Eye/Face protection
		Hand injury	Protective gloves