GUIDELINE FOR THE COMPILATION OF A MANDATORY CODE OF PRACTICE FOR AN OCCUPATIONAL HEALTH PROGRAMME (OCCUPATIONAL HYGIENE AND MEDICAL SURVEILLANCE) ON PERSONAL EXPOSURE TO AIRBORNE POLLUTANTS

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I, **MTHOKOZISI ZONDI**, Chief Inspector of Mines, under section 49(6) of the Mine Health and Safety Act, 1996 (Act 29 of 1996) and after consultation with the Council, hereby issues the guideline for the compilation of a mandatory code of practice for an occupational health program (occupational hygiene and medical surveillance) on personal exposure to airborne pollutants in terms of the Mine Health and Safety Act, as set out in the Schedule.

(Signed)

MTHOKOZISI ZONDI
Acting Chief Inspector of Mines

SCHEDULE

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DEPARTMENT OF MINERAL RESOURCES
MINE HEALTH AND SAFETY INSPECTORATE
GUIDELINE FOR THE COMPILATION OF A MANDATORY CODE OF PRACTICE FOR

AN OCCUPATIONAL HEALTH PROGRAMME

(OCCUPATIONAL HYGIENE AND MEDICAL SURVEILLANCE)

ON

PERSONAL EXPOSURE TO AIRBORNE POLLUTANTS

(Signed)
CHIEF INSPECTOR OF MINES (ACTING)

mineral resources
Department:
Mineral Resources
REPUBLIC OF SOUTH AFRICA

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Part A
The guideline

1 Foreword

1.1 The Commission of Inquiry into Safety and Health in the mining industry, chaired by the Honourable Mr Justice R N Leon, identified occupational health as one of the four major issues affecting occupational health and safety in the mining industry.

1.2 To address this issue, a tripartite sub-committee was established under the auspices of the Mining Occupational Health Advisory Committee (**MOHAC**). **MOHAC** found it necessary to address this issue a guideline for a mandatory code of practice (**COP**) for **airborne pollutants** be drafted.

1.3 Significant risks to health exist in mining. To protect, monitor and promote employees' health status, an occupational health program is required where **exposure** to such significant risks occur. **MOHAC** considered it appropriate to prepare a guideline covering both occupational hygiene and medical surveillance to ensure compliance and uniform standards.

1.4 Where the employer's risk assessment indicates a need to establish and maintain either a system of occupational hygiene measurements or a system of medical surveillance, or where either such system is required by regulation, the employer must prepare and implement a **COP** based on this guideline.

1.5 This guideline assists employers with the establishment of an occupational health programme, but does not stipulate specific requirements for specific circumstances. It sets out a basic system for managing risks to health. The first component of any management system is finding out what the situation is and the second is deciding what to do about it.

1.6 This guideline replaces the 'Guideline for the compilation of a mandatory **COP** for an occupational health programme on personal **exposure** to **airborne pollutants** with reference number DME 16/3/2/4-A1' published by the Department of Mineral Resources (**DMR**) in 2002.

2 Legal Status of the Guideline and Codes of Practice

2.1 In accordance with section 9(2) of the Mine Health and Safety Act, 1996 (Act 29 of 1996), as amended (**MHSA**), an employer must prepare and implement a **COP** on any matter affecting the health and safety of employees and other persons who may be directly affected by activities at the mine, if the **CIOM** requires it. These **COP**s must comply with any relevant guidelines issued by the **CIOM** [section 9(3) MHSA]. Failure by the employer to prepare or implement a **COP** in compliance with this guideline is a breach of the **MHSA.**

3 Objectives of the Guideline

3.1 The objective of this guideline is to enable the employer at every mine to compile a **COP**, which, if properly implemented and complied with, would protect and improve the health of employees at the mine, by **monitoring** and reducing their **exposure** to **airborne pollutants.**

3.2 This guideline provides guidance of a general nature on the required format and content for the **COP** and details sufficient technical background to enable the drafting committee at the mine to prepare a comprehensive and practical **COP** for the mine. It sets out the two components of an occupational health programme namely:

3.2.1 Occupational hygiene; and

3.2.2 Medical surveillance.

3.3 Where an employer is required, in terms of regulation 9.2(2) or in terms of its risk assessment, to establish and maintain a system of occupational hygiene measurements in respect of **airborne pollutants**, this guideline should assist the employer in doing so.

4 Definitions and Acronyms

In this guideline for a **COP**, unless the context otherwise indicates:

'Airborne pollutant' means any substance in the air that is harmful to health, including dust, fumes, aerosols, gases, fibres, vapours or mists.

'Analysis methodology' means analysis techniques used to quantify a pollutant collected on or in sampling media (eg gas chromatography/mass spectrometry).

'CIOM' means Chief Inspector of Mines.

'COP' means code of practice.

'DMR' means the Department of Mineral Resources.

'Exposure' means the subjection of a person to an **airborne pollutant** during employment through any route of entry (eg inhalation, ingestion, skin contact or absorption).

'Homogeneous exposure group (HEG)' means a group of employees whose **exposures** to a hazardous agent have been determined to be statistically similar enough that, by **monitoring** a small number of individuals in the group, the **exposures** of the remaining workers can be defined.

'MOHAC' means Mining Occupational Health Advisory Committee.

'Monitoring' means the repetitive and continued observation, measurement and evaluation of health and/or environmental, or technical data according to pre-arranged schedules, using nationally or internationally acceptable methodologies.

'MHSA' means the Mine Health and Safety Act, 1996 (Act 29 of 1996) as amended.

'NIOSH' means the United States National Institute for Occupational Safety and Health.

'Qualitative' means observations or information characterised by measurement on a categorical scale (ie dichotomous or nominal scale) or, if the categories are ordered, an ordinal scale eg 'low', 'medium', 'high'.

'Quantitative' means data in numerical quantities such as continuous measurements or counts eg percentile or rates.

'Occupational exposure limit (OEL)' means the **TWA** concentration for an 8-hour work day and a 40-hour work week to which nearly all workers may be repeatedly exposed to without adverse health effects.

'Sampling cycle' means the planned sampling program for the year, which must terminate at the end of each calendar year.

'TWA' means time weighted average.

'90th percentile' means the statistical value of **exposure** data which must be used to determine when **HEGs** need to be re-classified, calculated either by:

- Using Microsoft Excel programme (percentile function); or
- First placing all sample results in order from the lowest concentration to the highest concentration (ie concentration of specific contaminants). Next, assign each sample result a number, starting with the number one for the lowest concentration result up to the highest concentration being given the number equal to the total number of samples collected in that **HEG**. Multiply the total number of samples collected by 0.9. The sample result with the number corresponding to this calculated value is the **90th percentile**.

5 SCOPe

5.1 Regulation 9.2(2) requires that a system of occupational hygiene measurements on personal **exposure** to **airborne pollutants** must be prepared and implemented when the results of the risk assessment conducted has identified that the following hazard limits prevail:

5.1.1 Particulates ≥ 1/10 (10%) of the **OEL**.

5.1.2 Gasses ≥ ½ (50%) of the **OEL**.

5.2 Where there is no statutory determined **OEL** for a particular **airborne pollutant** the risk assessment conducted should determine how the pollutant must be addressed in the **COP**.

5.3 This guideline is aimed at assisting employers to draft a **COP** for an occupational health programme which measures occupational **exposures** to **airborne pollutants** aimed at ensuring compliance with **OELs**, protecting worker health and linking these **exposure** results to employee medical records.

6 Members of the Task Group

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Part B
Author's guide

1 The **COP** must, where possible, follow the sequence laid out in Part C: Format and content of the **COP**. The pages as well as the chapters and sections, must be numbered, where possible, to facilitate cross-referencing. Wording must be unambiguous and concise.

2 It should be indicated in the **COP** and on each annexure to the **COP** whether:

2.1 The annexure forms part of the **COP** and must be complied with or incorporated in the **COP** or whether aspects thereof must be complied with or incorporated in the **COP**; or

2.2 The annexure is merely attached as information for consideration in the preparation of the **COP** (ie compliance is discretionary).

3 When annexures are used, the numbering should be preceded by the letter allocated to that particular annexure and the numbering should start at one again. (eg 1, 2, 3 and A1, A2, A3).

4 Whenever possible illustrations, tables, graphs and the like, should be used to avoid long descriptions and/or explanations.

5 When reference has been made in the text to publications or reports, references to these sources must be included in the text as footnotes or side notes as well as in a separate bibliography.

Part C
Format and content of the mandatory COP

1 Title Page

The **COP** should have a title page reflecting at least the following:

1.1 The name of the mine;

1.2 The heading: 'Mandatory Code of Practice for the Assessment of Personal Exposure to Airborne Pollutants';

1.3 A statement to the effect that the **COP** was drawn up in accordance with guideline **DMR 16/3/2/4-A1** issued by the **CIOM**;

1.4 The mine reference number for the **COP**;

1.5 The effective date;

1.6 The revision dates (if applicable); and

1.7 The **DMR** mine code number.

2 Table of Contents

The **COP** must have a comprehensive table of contents.

3 Status of the Mandatory Code of Practice

This section must contain statements to the effect that:

3.1 The **COP** was drawn up in accordance with guideline **DMR 16/3/2/4-A1** issued by the **CIOM**;

3.2 This is a mandatory **COP** in terms of section 9(2) and 9(3) of the **MHSA**;

3.3 The **COP** may be used in an accident investigation/inquiry to ascertain compliance and to establish whether the **COP** is effective and fit for purpose;

3.4 The **COP** supersedes all previous relevant **COPs**; and

3.5 All managerial instructions, recommended procedures (voluntary **COPs**) and standards on the relevant topics must comply with the **COP** and must be reviewed to ensure compliance.

4 Members of the Drafting Committee

4.1 In terms of section 9(4) of the **MHSA** the employer must consult with the health and safety committee on the preparation, implementation or revision of any **COP**.

4.2 It is recommended that the employer should, after consultation with the employees in terms of the **MHSA**, appoint a committee responsible for the drafting of the **COP**.

4.3 The members of the drafting committee assisting the employer in drafting the **COP**, should be listed giving their full names, designations, affiliations and experience. This committee must include competent persons sufficient in number to effectively draft the **COP**.

5 General Information

General relevant information relating to the mine must be stated in this section of the **COP**, which must include at least the following:

5.1 A brief description of the mine and its location;

5.2 The commodities produced;

5.3 The mining method or combination of methods used at the mine must be listed. This section must discuss the degree of mechanisation, taking care to identify the potential sources of pollutants and possible pathways of **exposure**, and possible **exposure** scenarios;

5.4 The general controls in place to prevent **exposure** to **airborne pollutants** including ventilation arrangements;

5.5 Other related **COP**s and management standards must be reviewed concurrently to avoid conflict of requirements as laid down by the employer. The objective would be to have an integrated system; and

5.6 The unique features of the mine that have a bearing on this **COP** and cross-reference them to the risk assessment conducted.

6 Terms and Definitions

Any word, phrase or term of which the meaning is not absolutely clear, or which will have a specific meaning assigned to it in the **COP**, must be clearly defined. Existing and/or known definitions should be used as far as possible. The drafting committee should avoid jargon and abbreviations that are not in common use or that have not been defined. The definitions section should also include acronyms and technical terms used.

7 Risk Management

7.1 Section 11 of the **MHSA** requires the employer to identify hazards, assess the health and safety risks to which employees may be exposed while they are at work, record the significant hazards identified and risks assessed. The employer must determine how the significant risks identified in the risk assessment process must be dealt with, having regard to the requirement of section 11(2) and 11(3) that as far as reasonably practicable, attempts should first be made to eliminate the risk, thereafter to control the risk at source, thereafter to minimise the risk and thereafter, insofar as the risk remains, to provide personal protective equipment and to institute a programme to monitor the risk.

7.2 To assist the employer with the risk assessment with all possible relevant information such as accident statistics, ergonomic studies, research reports, manufacturers specifications, approvals, design and performance criteria for all relevant equipment should be obtained and considered.

7.3 in addition to the periodic review required by section 11(4) of the **MHSA**, the **COP** should be reviewed and updated after every serious incident relating to the topic covered in the **COP**, or if significant changes are introduced to procedures, mining and ventilation layouts, mining methods, plant or equipment and material

8 Key Elements to be addressed in the COP

8.1 Where the employer's risk assessment indicates a need to establish and maintain a system of occupational hygiene measurements and a system of medical surveillance, or where such systems are required by regulations, the following key elements must be addressed in the **COP**:

- Risk assessment and control
- Personal **exposure monitoring**.
- Hierarchy of controls.
- Medical surveillance.
- Reporting and reviewing.

These key elements are shown in Figure 1 below.

The occupational health programme to be implemented on the mine should be summarised in the **COP** in a flow chart similar to Figure 1.

8.2 Components of an occupational health programme

The occupational health programme has two components namely:

8.2.1 Occupational hygiene; and

8.2.2 Medical surveillance.

OCCUPATIONAL HEALTH PROGRAMME

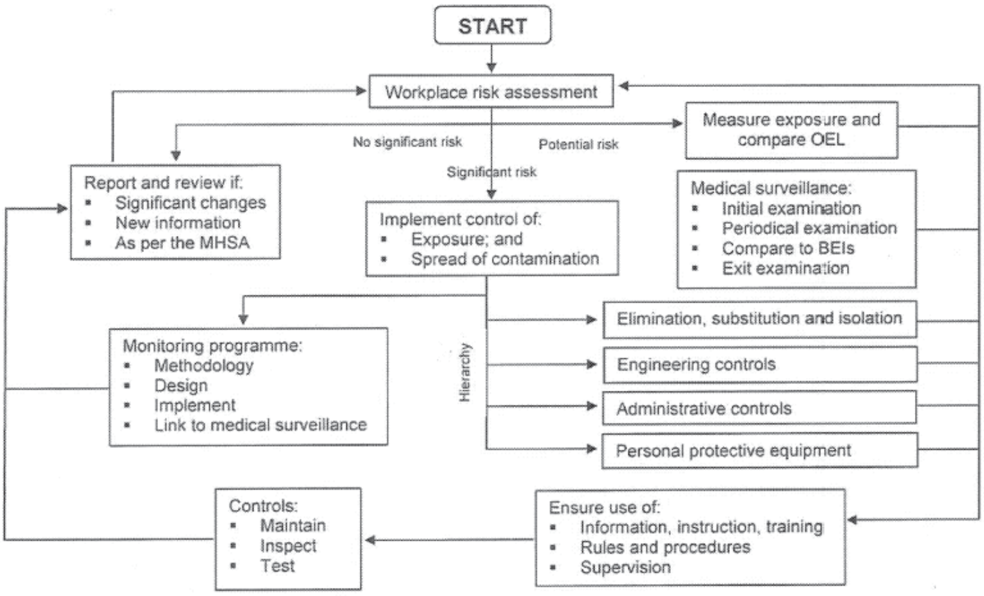


FIGURE 1: Occupational health programme

8.3 **Occupational hygiene programme**

In order to prepare the occupational hygiene programme for the mine, the **COP** should cover the following steps:

Step 1: Risk assessment.

Step 2: Determination of **HEG**.

Step 3: Sampling and **analysis methodology** and quality control.

Step 4: Personal **exposure monitoring**.

Step 5: Linking of occupational **exposure**.

Step 6: Hierarchy of control measures.

Step 7: Reporting and recording.

8.3.1 Risk assessment

The **COP** should set out measures to ensure that a **qualitative** and **quantitative** risk assessment process is followed and takes into account all the factors influencing the health of employees.

NOTE: Chapter 3 of the handbook published by the Safety in Mines Research Advisory Committee (SIMRAC): 'Handbook on Occupational Health Practice in the South African Mining Industry' could be consulted to assist in conducting a risk assessment.

The **COP** should address the following points:

8.3.1.1 Baseline risk assessment

At the initial commencement of a system of occupational hygiene measurements, as contemplated in section 12(2) of the **MHSA**, a baseline risk assessment is to be conducted to assess **exposure** to **airborne pollutants**.

8.3.1.2 The risk assessment must be described with reference to:

(a) Any **airborne pollutant(s)** to which employees are being exposed to (refer to Chapter 22 of the **MHSA airborne pollutants** occupational **exposure** limits);

(b) The route of entry (where applicable eg inhalation, absorption, ingestion, etc) and health effects that these individual **airborne pollutants** can have on employees;

(c) Where such pollutants may be present, eg welding bay, spray painting booth, battery charging stations, stope face, development end, etc;

(d) The airborne nature of those pollutants identified, eg gases, fumes, vapour mists, fibres, dusts etc;

(e) The nature of the key workplace operations and activities that pose the greatest potential for **exposure** with identified **airborne pollutants**;

(f) The occupations and number of employees who are being exposed to **airborne pollutants**;

(g) The pattern (eg intermittent, continuous, etc), duration and frequency of employee **exposure** to the airborne pollutants identified;

(h) The actual exposure levels measured compared to occupational **exposure** limits;

(i) The control measures in place, (eg substitution, engineering, administration, personal protective equipment etc), the additional control measures required to be instituted in order to reduce or maintain **exposures** to below the **OELs**, and if applicable, the planned programme of implementation;

(j) The frequency of any ongoing **monitoring** to assess the effectiveness of the controls mentioned above; and

(k) The relevant material safety data sheets as contemplated in section 21(4)(a), (b) and (c) of the **MHSA**.

NOTE: For the purpose of the risk assessment the commodity codes, activity codes, occupational codes and pollutant codes as set out in Annexure A should be used. Compliance with Annexure A is mandatory.

8.3.1.3 Review of risk assessment

The **COP** must address the review of the risk assessment whenever circumstances arise or change at the mine that could have an impact on the original assessments, and at least in the following instances:

(a) When outcomes of medical surveillance programs indicate the need for it;

(b) When a section 115 investigation indicates the need for it;

(c) When new or revised legislation is introduced;

(d) When new mining methods are introduced;

(e) When process changes are introduced (eg in process plants); and

(f) When new types of machinery are introduced.

8.3.1.4 Post risk assessment

The **COP** must address on an annual basis, the review of the risk assessment (continuous risk assessment and management) based on the personal **exposure monitoring** data of the previous cycle.

Historical data is to be maintained as provided for in section 15(2)(a).

8.3.2 Determination of **HEGs**

The **COP** should address the following points:

8.3.2.1 **HEGs** should be identified for purposes of personal **exposure** monitoring. The baseline risk assessment will enable the identification of **HEGs**, which will be established as follows:

Step 1

The sub-division of the mine into sampling areas (eg surface = sampling area 1, underground section A = sampling area 2, underground section B = sampling area 3, underground section C = sampling area 4, etc).

NOTE: Surface operations proceed to step 3, Underground operations proceed to step 2.

Step 2

At underground mines, sampling areas should be sub-divided into ventilation districts which are areas of a mine, ventilated independently from other areas with a common dedicated intake and return airways. Any airborne contaminants released in a ventilation district will only affect that particular district and does not circulate through other areas of the mine where people may be exposed.

In order for an area to be classified as a ventilation district it must comply with:

- Ventilated independently from other areas.
- Independent intake and return airways.
- Does not contaminate other areas.

Step 3

The sub-division of the sampling areas into activity areas as per the activity area code list found in Annexure A (mandatory codes). Annexure A must be complied with.

Step 4

To ensure that adequate measurements of personal **exposures** (refer also to paragraph 8.3.4 below) are taken in line with the identified **airborne pollutants** for each activity area. If insufficient historical personal **exposure** data is not available regarding the extent of the risk, a personal **monitoring** survey must be undertaken for each identified **airborne pollutant**

NOTE: Acceptable methodologies on personal **monitoring** as stipulated by **NIOSH** should be used for this assessment.

Step 5

A statistical analysis should be conducted. Annexure B could be consulted in this regard. The results of the identified **airborne pollutants** present, either from historical data or from measured data, during the personal sampling strategy, in that particular activity area should be compared to their respective **OEL** values. These **OEL** values and pollutant codes are contained as Schedule 22.9(2)(a) in Chapter 22 of the **MHSA** regulations.

NOTE: Annexure B is attached for information purposes only.

Plot past data over time to determine whether the **exposure** trends are higher or lower. If the **exposure** trends exist, the section 12(1) appointee should use only the most recent **exposure** data in the initial assessment.

In order to ensure that **HEGs** are correctly allocated a statistical analysis of the results is to be done. An example of such an approach is shown in Annexure B.

NOTE: Annexure B is attached for information purposes only.

Once the personal **exposures** within each activity area have been compared to their respective **OEL** values, each activity area can now be categorised into classification bands to determine the various **HEGs** within that activity area. The classification bands for **airborne pollutants** are tabled in Annexure C. Annexure C forms part of this guideline and must be compiled with.

NOTE: An activity area eg stoping, is not a **HEG**. This activity area eg stoping, must be subdivided into the classification bands as shown above. These classification bands are the **HEGs** within that particular activity area.

Repeat step 4 for every pollutant identified in the risk assessment process.

Step 6

In this step were a single pollutant acting independently has been identified in an activity area the following process must be followed:

(a) Once the personal **exposures** within each activity area has been compared to the respective **OEL** values of the single pollutant, that activity area can now be categorised into classification bands determined by the various **HEGs** within that activity area. The classification bands for **airborne pollutants** are depicted in Annexure C. Annexure C is mandatory and must be complied with.

(b) If an employee is exposed to a number of identified pollutants, which have an additive effect, step 7 must be followed.

(c) Repeat step 5 for every such identified pollutant.

NOTE: (1) Single pollutant - where no additive effects are known or considered likely, the constituents can be regarded as acting 'independently'. It is then sufficient to ensure compliance with each of the individual OELs.

(2) Refer to Annexure D with reference to identified pollutant acting independently.

NOTE: Annexure D is attached for information purposes only.

Step 7

When pollutants that have an additive effect have been identified in an activity area where these effects are additive, their combined effects must be used when classifying the activity area into their respective **HEGs**. The following formula must be used to assess the combined effect.

C1/L1 + C2/L2 + C3/L3 .... **for compliance, the combined effect should be < 1** where **C1, C2** etc, are the concentrations of constituents in air and L1, L2 etc, are the corresponding **OELs**.

NOTE: The **OELs** for pollutants listed in Schedule 22.9(2)(a) of the **MHSA** are for single compounds or for pollutants containing a common entity. Workers are however frequently subjected to mixed **exposures**. It is therefore necessary to take into account the possible additive or synergistic effects of these pollutants. Due to the difficulty in assessing, if the effects of a mixture of pollutants are either additive or synergistic, the requirements of this **COP** will be to treat all such cases as if they are additive. With all types of mixed **exposures**, it is essential that the classification band category assessment should be based on the concentrations of each of the constituents in air to which workers are exposed.

Table C1 in Annexure C depicts exposures to the various hazards that can be considered as being additive or synergistic. Annexure C is mandatory and must be complied with.

NOTE: Refer to Annexure D with reference to identified pollutants that have an additive effect. Annexure D is for information purposes only.

8.3.2.2 At the end of each cycle (annually; end of calendar year) sampling results for each **HEG** must be statistically analysed and re-classified when required. Reclassification of **HEGs** should be done by means of statistically recognised principles. 90% confidence limits are to be used to test the homogeneity of **HEGs**. Refer to Annexure B for an example.

NOTE: Annexure B is attached for information purposes only.

The total number of exposed employees will be determined at the beginning of annual reporting cycle and would only change if there is an increase in employees during the quarterly reporting cycle (exposed individuals are only counted once in an annual reporting cycle to prevent duplicate counting).

Reduction in employees would not reduce the total number of exposed employees during the reporting cycle.

NOTE: The total number of exposed employees will be determined at the start of annual **sampling cycle** based on the previous year's results in accordance with the **HEG** classification based on the various **exposure** bands.

8.3.2.3 **HEGs** must be re-assessed whenever circumstances arise or change at the mine when the following occurs:

(a) **Exposure** levels change due to controls being initiated and likewise, when controls deteriorate.

(b) Employee complaints are received.

(c) Processes are changed (eg, change in procedures, mining and ventilation layouts, mining methods, plant, equipment or material).

(d) Occupational illness occurs.

(e) A change in **exposure** category occurs.

(f) Other events warranting re-evaluation occurs:

(i) New technological data; and

(ii) New regulatory initiatives.

(g) Should the review of the baseline assessment warrants it.

8.3.3 Sampling, **analysis methodology** and quality control

The **COP** must address the following points:

8.3.3.1 Continuing sampling strategy

Continuing sampling must be conducted to assess whether significant changes in trends have occurred and should be added to accumulated data during statistical analysis re-classification of **HEGs**.

(a) Determining sample size

The total number of samples should be evenly spread out over a twelve-month period for all categories, that is A, B and C, as below.

A minimum of 5% or five samples (whichever is the greater) per HEG should be taken as per classification bands in Annexure C as per the following:

(i) Category A - 5% or five samples per quarter;

(ii) Category B - 5% or five samples six-monthly to be evenly spread bi-annually;

(iii) Category C - 5% or five samples per annum to be evenly spread annually; and

(iv) Category D - no sampling plan for this category. Measurement results that are below 10% of the **OEL** will be reported under this category.

NOTE: Annexure C is mandatory and must be complied with.

(b) Section 12(1) appointees must use their professional judgment to decide whether additional samples need to be taken in order to increase the confidence that **HEGs** are appropriately categorised.

8.3.3.2 Sampling strategy and schedules

The **COP** should address a sampling strategy that includes a monitoring schedule for each **HEG**. The **sampling cycle** and records thereof should be kept as required by law (see for example sections 12(3) and 15(2)(b) of the **MHSA**).

8.3.3.3 Sampling methodology

(a) The **COP** should address, for each pollutant identified, an appropriate sampling methodology selected and implemented (refer to Annexure E: Background information on particulates; sampling and **analysis methodology**. Annexure E is for information purposes only).

(b) The **COP** should put measures in place to ensure that a quality control program for the sampling methodology is developed and implemented.

NOTE: (1) Refer to Annexure F: Quality assurance. Annexure F is for information purposes only.

(2) The relevant methodology chosen for each pollutant identified must be stated in the **COP**.

8.3.3.4 Chemical **analysis methodology**

The **COP** should address the following points:

(a) For each pollutant identified, an appropriate chemical **analysis methodology**, which complies with internationally accepted good practice, should be selected and implemented. All the selected chemical analytical methods should be listed in the **COP** eg **NIOSH** methods for silica crystalline respirable: **NIOSH** 7500 (XRD); **NIOSH** 7602 (IR).

(b) The sample analysis should be done either by a laboratory that is accredited (accredited to chemically analyse the specific pollutants) in terms of South African bureau of Standards (SABS) ISO/IEC 17025 of the South African National Accreditation System (SANAS), or a laboratory that is participating in a proficiency testing program and is in a process of obtaining SANAS accreditation, which latter laboratory must produce a proficiency test certificate to the client before doing any sample analysis.

(c) A minimum number of samples taken as determined in accordance with 8.3.3.1(a) of this guideline must each be individually analysed.

NOTE: The results from the analysis obtained in a **HEG** will be averaged and allocated to the specific **HEG** in which the samples were taken.

8.3.3.5 Gravimetric weighing facilities

The **COP** should contain measures to ensure that gravimetric weighing facilities have a quality control program in place (refer to Annexure E for information on the requirements for a weighing facility and to Annexure F for a quality control program. Annexures E and F are for information purposes only).

8.3.4 Personal exposure monitoring

The **COP** should set out measures to ensure that personal **exposure** monitoring is conducted to obtain reliable estimates of employee shift **exposures** in a workplace. Samples taken should be:

(a) Representative of all full working shifts;

(b) Measured and compared to occupational **exposure** limits per working shift eg day shift and night shift;

(c) Randomly spread over the full **sampling cycle** period for each **HEG**; and

(d) Randomly spread across all occupations within the **HEG**.

8.3.4.1 Training

The **COP** should set out the training programme in place for:

(a) Storage and maintenance of equipment;

(b) Issuing of the sampling equipment;

(c) Wearer of the sampling equipment;

(d) Handling of the sampling equipment;

(e) Transportation of equipment; and

(f) Pre- and post-calibration of the sampling train checks.

8.3.5 Hierarchy of control

The **COP** should address the hierarchy of controls which are going to be implemented to mitigate the risk(s). The following hierarchy of controls should be taken into consideration:

- Elimination;
- Engineering controls;
- Administrative controls;
- Minimising (the risk); and
- Personal protective equipment.

8.3.6 Recording and reporting

The **COP** should address the following:

8.3.6.1 Record keeping system

A record keeping system, which records the **exposure** history of each **HEG** at the mine, should be kept and be readily available at the mine, including any reasons for deviation on sample results such as:

(a) Controls not operating effectively; and

(b) Events or factors which have influenced the results, eg air sampling at surface operations after high rainfall or during excessive winds.

8.3.6.2 Mandatory reports

Reporting to the DMR must be done on a quarterly basis for all categories, that is A, B, C and D (refer to Annexure C: Classification bands and reporting forms. Annexure C is mandatory and must be complied with).

NOTE: (1) For all categories A, B and C, the measurement results on the samples taken at that time must be reported at the end of each quarter. The rolling average results must be reported at the end of each sampling cycle.

(2) The results in a **HEG** of which **90th percentile** equates to less than 10% of the **OEL** will be classified under D category.

(3) Pollutant(s) that do not have an additive effect on the target organ(s) must be separately reported.

8.4 Occupational medical surveillance

8.4.1 Occupational medical surveillance programme

The **COP** should describe:

8.4.1.1 The medical surveillance program at the mine as required in terms of section 13 and regulations 11.5, 11.6 and 11.7 of the **MHSA** and any additional medical surveillance required in terms of the employer's risk assessment.

8.4.1.2 The method used to link the occupational hygiene measurements (eg **exposures** to individual pollutants as well as additive or synergistic mixtures) to each employee's record of medical surveillance as contemplated in section 12(3) of the **MHSA**.

NOTE: A manual or computerised system could be utilised to link this information. This system may have to be customised in accordance with the employer's specific needs or commercial programs. Effective communication between the section 12(1) appointee and the occupational medical practitioner is recommended to ensure that the linkages between occupational hygiene **exposures**' history and medical conditions are identified.

8.4.1.3 The procedure on how the following categories of medical surveillance in terms of the **MHSA**, will be conducted:

(a) Initial examination - in terms of section 13(2)(c);

(b) Periodic examination - in terms of section 13(2)(c); and

(c) Exit examination - in terms of sections 17 and 19(2).

8.4.2 Methodological standards for test techniques forming part of medical surveillance

8.4.2.1 The **COP** should set out measures to ensure that chest x-rays:

(a) Are at least 35x43 cm in size, even when digital;

(b) Are of a suitable quality for proper identification and classification of pneumoconiosis; and

(c) Show the date, name of individual and any unique form of personal identification used by the mine (eg identity number, personnel number, passport number, company number, etc).

8.4.2.2 The **COP** must set out how lung function testing will be conducted.

NOTE: The occupational medical practitioners Guidance Note for Lung Function Testing (DMR 25/5/P) and the Guidance Note for Occupational Medical Practitioners: Tuberculosis Control Programs (DMR 25/5/P) could be consulted.

8.4.3 Inclusive medical surveillance system

8.4.3.1 The **COP** should set out measures to ensure that the system of medical surveillance is designed in consultation with the occupational medical practitioner to avoid duplication where employees are exposed to more than one hazard. A single, similar test could suffice for the medical surveillance of more than one hazard. It could therefore be possible to use the same examination or test for the medical surveillance of more than one hazard, provided that the requirements of medical surveillance for each hazard are achieved.

Implementation

1 Implementation Plan

1.1 The employer must prepare an implementation plan for its **COP** that makes provision for issues such as organisational structures, responsibilities of functionaries and programmes and schedules for the **COP**, that will enable proper implementation of the **COP** (a summary of and a reference to, a comprehensive implementation plan may be included).

1.2 Information may be graphically represented to facilitate easy interpretation of the data and to highlight trends for the purposes of risk assessment.

2 Compliance with the Code of Practice

The employer must institute measures for monitoring and ensuring compliance with the **COP**.

3 Access to the Code of Practice and Related Documents

3.1 The employer must ensure that a complete **COP** and related documents are kept readily available at the mine for examination by any affected person.

3.2 A registered trade union with members at the mine or where there is no such union, a health and safety representative on the mine, or, if there is no health and safety representative, an employee representing the employees on the mine, must be provided with a **COP**y on written request to the manager. A register must be kept of such persons or institutions with **COP**ies to facilitate updating of such **COP**ies.

3.3 The employer must ensure that all employees are fully conversant with those sections of the **COP** relevant to their respective areas of responsibilities.

ANNEXURE A
Mandatory codes

(This annexure forms part of the guideline and must be complied with)

1 MAIN COMMODITY CODE LIST

The main commodity being produced by the mine.

AS	Asbestos	**MH**	Malmesbury hornfels
AP	Attapulgite	**MN**	Manganese
BT	Bentonite	**MB**	Marble
CA	Calcrete	**MC**	Mica
CE	Cement	**MP**	Mineral-pigments
CL	Coal	**MM**	Montmorillonite
Co	Cobalt	**NA**	Salt
CR	Chrome	**Ni**	Nickel
CY	Clay	**NP**	Nepheline
CU	**COP**per	**NR**	Norite
DI	Diamonds	**PB**	Lead
DR	Dolerite	**PL**	Perlite
DM	Dolomite	**PH**	Phosphates
DK	Dwyka	**PT**	Platinum group metals
EM	Emeralds	**PR**	Prospecting (unspecified minerals)
FD	Feldspar	**PY**	Pyrophyllite
FI	Fireclay	**QZ**	Quartzite

FS	Fluorspar	**QD**	Quartzite dimension stone
FT	Felsite	**SA**	Sand
FU	Fullers-earth	**SH**	Shale
FY	Flintclay	**SI**	Silica
GC	Gas and condensate (MOSSGAS)	**SM**	Silicon-metal
AU	Gold	**ST**	Sillimanite
GT	Granite	**SG**	Slag
GD	Granite dimension stone	**SD**	Slate dimension stone
GV	Gravel	**SL**	Soil
GS	Gypsum	**TC**	Talc
HG	Mercury	**TE**	Tigers-eye
IL	Ilmenite	**SN**	Tin
FE	Iron-ore	**TN**	Titanium
JP	Jasper	**UR**	Uranium
KA	Kaolin	**VA**	Vanadium
KG	Kieselguhr	**WS**	Wollastonite
LS	Limestone	**ZN**	Zinc
MA	Magnesite		

2 ACTIVITY AREA CODE LIST

ACTIVITY	**CODE**
Conventional mining (coal)	01
Continuous miner (coal)	02
Longwall mining (coal)	03
Handgot (coal)	04
Stoping/pillar extraction (coal)	05
Rock mining (coal)	06
Opencast	07
Stoping	08
Development (single shift)	09
Development (multiblast)	10
Shaft sinking	11
Raise boring/dry drilling	12
Trackless mining	13
Scraper block caving	14
Ground handling (conveyor/loco's)	15
Shafts and services	16
Roving underground	17
Underground workshops	18
Raw material	19
Crushing	20
Milling/pulverising	21

Screening/grading	22
Separation processes	23
Concentrating	24
Heat process	25
Smelting	26
Chemical process	27
Refining	28
Final products	29
Roving plant	30
Roving surface	31
Assay/laboratory	32
Surface workshops	33
Dumps/dump recycling	34

NOTE: Where the above broad descriptions do not define an activity area exactly, select the 'best fit'.

3 OCCUPATION CODE LIST

Alphabetical index

CODE	OCCUPATION
70301	Acclimatisation supervisor
70302	Acclimatisation worker
80699	Accommodation worker (other accommodation, n.e.c.)
80599	Accommodation worker (residential, n.e.c.)
10206	Accountant (n.e.c.)
10200	Accounting/financial management
10299	Accounting/financial worker (n.e.c.)

CODE	OCCUPATION
30402	Acid plant official
30404	Acid plant worker
10900	Administration/secretarial management
10903	Administrative officer
10000	Administrative/financial management (multi-disciplinary)
10099	Administrative/financial management (n.e.c.)
19999	Administrative/financial/business worker (n.e.c.)
60601	Advocate/barrister
90000	Agricultural management (multi-disciplinary)
90099	Agricultural management (n.e.c)
99999	Agricultural worker (n.e.c)
40412	Air conditioning/refrigeration engineer
40413	Air conditioning/refrigeration mechanic
81100	Air transport management
81101	Air transport officer
81199	Air transport worker (n.e.c.)
21507	Air and water services team leader/supervisor

CODE	OCCUPATION
21508	Air and water services worker
81102	Airport controller
30110	Amalgamator
70803	Ambulance officer
70101	Anaesthetist
80106	Aptitude tester
60105	Aptitude testing supervisor
21406	Aquajet operator
50901	Architect
50902	Architectural assistant
50900	Architectural management
50999	Architectural worker (n.e.c.)
40320	Armature winder
50403	Assay technician
50401	Assayer
50499	Assay/chemistry/laboratory worker (n.e.c.)
29909	Assistant driller (Ocean)
10511	Assessor
35910	Assopulp worker
60602	Attorney/solicitor/conveyancer
70303	Audio visual tester
70322	Audiologlst/speech therapist
70323	Audiometrist
10100	Auditing management
10199	Auditing worker (n.e.c.)
10102	Auditor (computer/systems)
10101	Auditor (internal and external)
40319	Auto electrician
20805	Backfill worker
35020	Baker
11114	Banking officer
11100	Banking/investment management
11199	Banking/investment worker (n.e.c.)
21304	Banksman/onsetter
81202	Bargemaster (Ocean)
80803	Barber/hairdresser
80706	Barman
60601	Barrister/advocate
35110	Beer maker
80705	Beerhall supervisor
21305	Bell signaller
30205	Beltsman
70304	Bio-medical engineer
70102	Biokineticist

40422	Blacksmith
40424	Blacksmith: apprentice
40421	Blacksmith: chargehand
40420	Blacksmith: foreman
40423	Blacksmith: operative
40425	Blacksmith: worker (n.e.c.)
20306	Blaster (supervisory)
20502	Blaster: opencast/quarry (non-supervisory)
20503	Blaster: surface works (eg smelter) (non-supervisory)
20501	Blaster: underground metal (non-supervisory)
20599	Blasting worker (n.e.c.)
40803	Boiler attendant
40450	Boilermaker: operative (gr 1)
40451	Boilermaker: operative (aide) (gr 2)
36015	Book binder
81202	Bosun (Ocean)
10208	Bookkeeper
21404	Box/orepass controller
36710	Brick maker
40614	Bricklayer
40617	Bricklayer: aide
40615	Builder
80499	Building service worker (n.e.c.)
80400	Building services management
40618	Building worker (n.e.c.)
40618	Building worker: operative
50503	Business analyst (computers)
10001	Business management
35010	Butcher
10312	Buyer/purchaser
40343	Cable joiner
30508	Calcinating worker
80701	Canteen supervisor
80703	Canteen worker
80501	Caretaker/housekeeper

CODE	OCCUPATION
40621	Carpenter
40622	Carpenter and joiner
40823	Carpenter and joiner: apprentice
40620	Carpenter and joiner: chargehand
40619	Carpenter and joiner: foreman
40624	Carpenter: aide
40625	Carpenter: worker (n.e.c.)
10209	Cashier
30507	Caster

80700	Catering management
21699	Cementer (Ocean)
80799	Catering worker (n.e.c.)
21602	Cementation driller/injector
21601	Cementation supervisor
21699	Cementation worker (n.e.c)
21307	Chairlift operator
00000	Chairman (group)
80604	Change house team leader/supervisor
80605	Change house worker
10395	Checker
80702	Chef/cook
40701	Chemical engineer
40700	Chemical engineering management
40799	Chemical engineering worker (n.e.c)
30499	Chemical process worker (n.e.c.)
50402	Chemist
50404	Chemist technician
00000	Chief executive
80802	Child minder
70320	Chiropodist/podiatrist
60805	Cinema/video operator
40601	Civil engineer
40600	Civil engineering management
40610	Civil engineering technician
40699	Civil engineering worker (n.e.c.)
40651	Civil/building chargehand (other, n.e.c.)
40650	Civil/building foreman (other, n.e.c.)
40652	Civil/building tradesman (other, n.e.c.)
80402	Cleaner (office)/tea maker
40611	Clerk of works
10295	Clerk (accounts/finance)
99995	Clerk (agriculture, n.e.c.)
81195	Clerk (air transport)
50995	Clerk (architectural)
10195	Clerk (auditing)
11195	Clerk (banking/investment)
80795	Clerk (catering)
80695	Clerk (club)

CODE	**OCCUPATION**
60995	Clerk (creative arts)
10795	Clerk (economics)
40195	Clerk (engineering planning)
49995	Clerk (engineering)
51095	Clerk (environmental)

80395	Clerk (estate/township)
70895	Clerk (first aid)
10995	Clerk (general eg filing n.e.c.)
50195	Clerk (geology)
80595	Clerk (hostel/quarters)
50795	Clerk (industrial engineering)
60295	Clerk (industrial relations)
10595	Clerk (insurance)
60695	Clerk (legal)
60795	Clerk (library)
10895	Clerk (marketing/sales)
79995	Clerk (medical)
39995	Clerk (metallurgical plant)
20195	Clerk (mining planning)
29995	Clerk (mining) (n.e.c.)
10495	Clerk (payroll/timekeeping)
60195	Clerk (personnel)
36095	Clerk (printing)
10695	Clerk (property/mining rights)
60895	Clerk (public relations)
81095	Clerk (rail transport)
80995	Clerk (road transport)
50395	Clerk (rock mechanics)
50895	Clerk (safety/loss control)
60495	Clerk (school)
80195	Clerk (security)
61095	Clerk (sports/recreation)
50695	Clerk (statistics)
10395	Clerk (stores)
00295	Clerk (strategic planning)
50295	Clerk (survey)
11295	Clerk (tax)
60395	Clerk (training)
60595	Clerk (welfare)
70202	Clinical assistant
80600	Club management
80601	Club secretary
80602	Club team leader
80603	Club worker
20604	Coal auger operator
20601	Coal cutter operator
20605	Coal plough operator
30211	Coal preparation worker

CODE	**OCCUPATION**
30509	Coking plant attendant

36014	Collator
80401	Commissionaire (offices)
80502	Commissionaire (residential accommodation)
10900	Company secretary (administrative)
40804	Compressor attendant
50508	Computer operator
50505	Computer programmer
30399	Concentration/flotation worker (n.e.c.)
19996	Consultant (administrative/financial n.e.c.)
99996	Consultant (agriculture, n.e.c.)
49996	Consultant (engineering, n.e.c.)
09996	Consultant (general management, n.e.c.)
69996	Consultant (humanities, n.e.c.)
79996	Consultant (medical, n.e.c.)
39996	Consultant (metaliurgy/beneficiation/manufacturing, n.e.c.)
29996	Consultant (mining production, n.e.c.)
59996	Consultant (scientific/technical, n.e.c.)
89996	Consultant (service occupation, n.e.c.)
11296	Consultant (tax)
40000	Consulting engineer (engineering support)
20000	Consulting engineer (mining)
30003	Consulting metallurgist
20602	Continuous miner driver
49902	Contractor (outside)
30202	Control room operator
60602	Conveyancer/attorney/solicitor
20299	Conveyer worker (n.e.c.)
21202	Conveyer belt attendant
21201	Conveyer belt team leader/supervisor
80702	Cook/chef
10901	Corporate secretary (admin)
10205	Cost accountant
10205	Cost controller
81301	Crane driver
81398	Crane driver trainer
60999	Creative worker (n.e.c.)
10207	Credit controller
20103	Critical path scheduler
90499	Crop worker
81009	Crossing attendant
30207	Crusher attendant
30505	Cupolaman
49903	Cutter
30403	Cyanidation team leader/supervisor
30405	Cyanidation worker
50513	Data base administrator

50514	Data base technician

CODE	OCCUPATION
50510	Data capture supervisor
50511	Data capture typist
29908	Day pusher (Ocean)
29910	Deck attendant (Ocean)
20313	Deck leader (Ocean)
50509	Data controller (computers)
70504	Dental assistant
70503	Dental mechanic
70499	Dental specialist eg oral pathologist (n.e.c.)
70401	Dental surgeon/dentist
70502	Dental therapist
70599	Dental worker (n.e.c.)
70103	Dermatologist
40102	Designer (engineering)
80104	Detective
20303	Developer
50501	Development management (hardware)
50502	Development management (software)
20310	Development team leader/supervisor
20701	Development team worker
50111	Diamond drill team leader/supervisor
50112	Diamond drill worker
50110	Diamond driller
40501	Diecaster
40477	Diesel mechanic
40478	Diesel mechanic: apprentice
40476	Diesel mechanic: chargehand
40475	Diesel mechanic: foreman
70305	Dietician
60802	Diplomatic/political liaison officer
29911	Diver (Ocean)
40905	Disinfestation worker
80105	Dog handler
80801	Domestic servant
21102	Dragline operator
21101	Dragline supervisor
29906	Drains cleaner
49994	Draughting technician
50994	Draughtsperson (architectural)
40794	Draughtsperson (chemical engineering)
40694	Draughtsperson (civil engineering)
40394	Draughtsperson (electrical engineering)
50194	Draughtsperson (geological)

40594	Draughtsperson (mechanical engineering)
29994	Draughtsperson (mining production, n.e.c.)
49994	Draughtsperson (n.e.c.)
50294	Draughtsperson (survey)
59994	Draughtsperson (technical services)

CODE	OCCUPATION
20401	Drill rig operator (jumbo)
40528	Drill sharpener
20402	Drier: hand percussion/jackhammer
20403	Driller: hand (coal)
20404	Driller: opencast/large diameter
20499	Drilling worker (n.e.c.)
40527	Drillsmith
80908	Driver: ambulance (code 08)
21103	Driver: bulldozer
80905	Driver: forklift
21109	Driver: haul truck (underground and opencast)
80911	Driver: heavy articulated motor vehicle (code 13)
80909	Driver: heavy motor vehicle eg bus/ambulance (code 10)
80907	Driver: light motor vehicle/car (code 08)
80906	Driver: mobile industrial/agricultural equipment (code 07)
80903	Driver: motorcycle (code 01-04)
80904	Driver: tractor (code 05)
80998	Driving instructor
30406	Dryerman
30702	Dump team leader/supervisor
30703	Dump worker
30701	Dumpsman
10907	Duplicator
70104	Ear, nose and throat specialist
10703	Economics assistant
10700	Economics management
10799	Economics worker (n.e.c.)
10702	Economist (n.e.c.)
10205	Economy controller
60901	Editor
60400	Educational management
60499	Educational/school worker (n.e.c.)
70306	EEG technician
40341	Electrical chargehand (other n.e.c.)
40301	Electrical engineer
40300	Electrical engineering management
40399	Electrical engineering worker (n.e.c.)
40340	Electrical foreman (other n.e c.)
40310	Electrical technician

40342	Electrical tradesman (other n.e.c.)
40314	Electrician
40317	Electrician: aide
40315	Electrician: apprentice
40313	Electrician: chargehand
40312	Electrician: foreman
40316	Electrician: underground section
40318	Electrician: worker (n.e.c.)
40802	Electricity generator worker

CODE	OCCUPATION
40437	Electro mechanic/millwright/minewright
40311	Electronic technician
60500	Employee assistance program management
19910	Encoder
40800	Energy systems management
40805	Energy systems officer
40801	Energy systems team leader/supervisor
40899	Energy systems worker (n.e.c.)
40201	Engineer (n.e.c.)
40205	Engineering assistant (n.e.c.)
40004	Engineering foreman (n.e.c.)
40202	Engineering inspector
40001	Engineering management (multi-disciplinary)
40099	Engineering management (n.e.c.)
49901	Engineering team leader (n.e.c.)
40299	Engineering technical worker (n.e.c.)
40203	Engineering technician (n.e.c.)
60905	Entertainer
51004	Environmental assistant
51007	Environmental construction supervisor
51008	Environmental construction worker
51001	Environmental engineer
51000	Environmental engineering management
51005	Environmental observer
51003	Environmental officer
51002	Environmental superintendent
51099	Environmental worker (n.e.c.)
21504	Equipper
80300	Estate/township management
80301	Estate/township officer
80302	Estate/township team leader/supervisor
80399	Estate/township worker (n.e.c.)
40104	Estimator/calculator
00000	Executive director (n.e.c.)
10317	Explosives issuer

50506	Facilities management (computers)
40344	Fan attendant
90001	Farm manager
10904	Filing/records officer
30302	Filter operator/worker
30301	Filter team leader/supervisor
10204	Financial accountant
10201	Financial analyst
10701	Financial economist
10202	Financial engineer
10200	Financial/accounting management
10000	Financial/admin management (multi-disciplinary)
80202	Firefighting/rescue officer

CODE	OCCUPATION
80203	Firefighling/rescue team leader/supervisor
80298	Firefighting/rescue trainer
80299	Firefighting/rescue worker (n.e.c.)
81005	Fireman/stoker
80201	Firemaster
70802	First aid attendant
70800	First aid management/medical station superintendent
70801	First aid team leader/supervisor
70898	First aid trainer
70898	First aid training superintendent
70899	First aid worker (n.e.c.)
40428	Fitter and turner
40429	Fitter and turner: apprentice
40427	Fitter and turner: chargehand
40426	Fitter and turner: foreman
40433	Fitter (including machining): apprentice
40432	Fitter (including machining)
40431	Fitter (including machining): chargehand
40430	Fitter (including machining): foreman
40434	Fitter: operative (grade 1)
40435	Fitter: operative aide (grade 2)
40436	Fitter: worker (n.e.c.)
90301	Forester
90300	Forestry engineer
90399	Forestry worker
40502	Forger
40505	Founder
30599	Furnace worker (n.e.c.)
90501	Game ranger
40656	Ganger/plate/tracklayer (main line)
40480	Garage mechanic: aide

40481	Garage serviceman
40482	Garage worker (n.e.c.)
90102	Garden supervisor/groundsman
90199	Garden worker
40002	General engineering supervisor
49999	General engineering worker (n.e.c.)
00199	General management (n.e.c.)
00102	General manager (company)
00101	General manager (mine)
20305	General miner
70201	General practitioner
50103	Geochemist
50100	Geological management
50109	Geological observer/field assistant
50199	Geological worker (n.e.c.)
50101	Geologist
50108	Geology technician

CODE	**OCCUPATION**
50102	Geophysicist
21401	Grab operator
50408	Grade officer
60904	Graphic artist
30210	Grinderman/pulveriser
90102	Groundsman/garden supervisor
80500	Guest house/quarters management
36013	Guillotine operator
70105	Gynaecologist
80803	Hairdresser/barber
40654	Handyman (maintenance)
21504	Handyman (mining)
21001	Haulage team leader/supervisor
21099	Haulage/underground rail transport worker (n.e.c.)
70307	Health/food inspector
90502	Herdsman/stable hand
21302	Hoist driver
21399	Hoisting worker (n.e.c.)
90101	Horticulturist
79901	Hospital cleaner
10902	Hospital secretary
70002	Hospital superintendent
70324	Hospital worker/orderly
80505	Hostel management
80506	Hostel official
80507	Hostel team leader/supervisor
80501	Housekeeper/caretaker

60000	Humanities management (multi-disciplinary)
60099	Humanities management (n.e.c.)
69999	Humanities worker (n.e.c.)
20801	Hydraulic prop team leader/supervisor
20802	Hydraulic prop worker
40411	Hydraulic technician
40999	Hygiene services worker (n.e.c.)
60203	Induna/tribal representative
50701	Industrial engineer
50700	Industrial engineering management
50704	Industrial engineering officer
50702	Industrial engineering technician
50799	Industrial engineering worker (n.e.c.)
70106	Industrial physician
60202	Industrial relations assistant
60200	Industrial relations management
60201	Industrial relations practitioner
60299	Industrial relations worker (n.e.c.)
50599	Info services/computer worker (n.e.c.)
50516	Information centre management (computers)
50500	Information services management

CODE	OCCUPATION
40321	Instrument engineer
40325	Instrument mechanician (industrial)
40326	Instrument mechanician apprentice (industrial)
40324	Instrument mechanician chargehand (industrial)
40323	Instrument mechanician foreman (industrial)
40322	Instrument technician
10596	Insurance adviser
10500	Insurance management
10599	Insurance worker (n.e.c.)
70107	Internist/specialist physician
10315	Inventory controller
90400	Irrigation engineer
10317	Issuer (explosives)
10316	Issuer (stores, non-explosive)
60902	Journalist/writer
40602	Junior engineer (civil engineering)
40302	Junior engineer (electrical engineering)
40402	Junior engineer (mechanical engineering)
40207	Junior engineer (n.e.c)
90503	Kennel worker
30504	Kilnman
80703	Kitchen worker
50406	Laboratory assistant

50400	Laboratory manager/superintendent
50405	Laboratory technician
60103	Labour controller
30506	Ladleman
40346	Lamp room team leader/supervisor
40347	Lamp room worker
40345	Lampsman
90200	Land rehabilitation engineer
90201	Land rehabilitation supervisor
90299	Land rehabilitation worker
29905	Lasher/loader (n.e.c.)
80503	Laundry supervisor
80504	Laundry worker
30407	Leaching worker
20309	Learner miner
50409	Learner official (assay/chemistry)
40303	Learner official (electrical engineering)
40206	Learner official (engineering, n.e.c.)
50113	Learner official (geology)
40403	Learner official (mechanical engineering)
30105	Learner official (metallurgy)
20202	Learner official (mining)
40208	Learner operative
60603	Legal assistant
60600	Legal management

CODE	OCCUPATION
60699	Legal worker (n.e.c.)
60701	Librarian
60702	Library assistant
60700	Library management
60799	Library worker (n.e.c.)
21306	Lift operator
80705	Liquor outlet supervisor
36010	Lithographer
90599	Livestock worker (n.e.c.)
21106	Load haul dump driver
21004	Loader driver (rail)
21104	Loader driver (trackless)
81003	Loco driver (main line - SPOORNET)
81004	Loco driver (not main line)
21002	Loco driver (underground)
21003	Loco guard (underground)
20603	Longwall sheerer operator
10317	Magazine master
50106	Magnetometer specialist

40653	Maintenance supervisor
10203	Management accountant
10812	Marketing assistant
10810	Marketing officer
10800	Marketing and sales management
10899	Marketing/sales worker (n.e.c.)
40626	Mason
40627	Mason aide
70308	Masseur/masseuse
70600	Matron/nursing services management
40414	Mechanic (ocean)
70402	Maxillo-facial and oral surgeon
40521	Mechanical charge hand
40401	Mechanical engineer
40400	Mechanical engineering management
40599	Mechanical engineering worker (n.e.c.)
40520	Mechanical foreman (n.e.c.)
20699	Mechanical rockbreaking worker (n.e.c.)
40410	Mechanical technician
40522	Mechanical tradesman (other, n.e.c.)
60908	Media technician
70001	Medical advisor
79901	Medical labourer
70201	Medical officer
70309	Medical orthotist/prosthetist
70310	Medical physicist
70199	Medical specialist (n.e.c.)
70800	Medical station superintendent/first aid management
70311	Medical technician

CODE	**OCCUPATION**
70312	Medical technologist
79999	Medical worker (n.e.c.)
70000	Medical/health care management (multi-disdplinary)
70099	Medical/health care management (n.e.c.)
20803	Meshing and lacing team leader/supervisor
20804	Meshing and lacing worker
11010	Messenger/postal worker
30103	Metallurgical official (n.e.c.)
30199	Metallurgical worker (n.e.c.)
30000	Metallurgical/plant management
30001	Metallurgical/plant superintendent
30002	Metallurgical/plant supervisor
30101	Metallurgist
30102	Metallurgy technician (extractive)
51006	Micros**COP**ist

30208	Milling worker
40437	Millwright/electro mechanic/minewright
21510	Mine construction team leader/supervisor (n.e.c.)
21599	Mine construction worker (n.e.c.)
00101	Mine manager
20002	Mine overseer
20101	Mine planning/valuation engineer
80103	Mine police/security guard
20099	Mine production management (n.e.c.)
20399	Mine production supervisor (n.e.c.)
29999	Mine production worker (n.e.c.)
10900	Mine secretary (administration)
21499	Mine transport worker (n.e.c.)
20305	Miner (general)
50104	Mineralogist
20504	Miner's assistant (cheesa)
20201	Mining engineer (n.e.c.)
20299	Mining technical worker (n.e.c.)
20210	Mining technician (n.e.c.)
90699	Mixed farming worker (n.e.c.)
40103	Model maker
50205	Model maker (survey)
11113	Money market dealer
21308	Monorail winch operator
21309	Monorope winch operator
40543	Motorman (ocean)
70313	Mortuary attendant
40473	Motor mechanic
40474	Motor mechanic apprentice
40472	Motor mechanic chargehand
40471	Motor mechanic foreman
40479	Motor/diesel mechanic operative
40504	Moulder

CODE	**OCCUPATION**
20704	Multi task worker Underground production
20705	Multi task worker Opencast production
60905	Musician
50515	Network technician (computers)
70108	Neurologist
29908	Night pusher (ocean)
70109	Neurosurgeon
20308	Night shift cleaner
70601	Nurse (charge/senior sister)
70603	Nurse (enrolled/staff)
70602	Nurse (registered) all categories n.e.c.

70604	Nursing assistant
70698	Nursing instructor
70600	Nursing services management/matron
70099	Nursing worker (n.e.c.)
70314	Occupational therapist
70120	Occupational health physician
70121	Occupational hygienist
00101	Offshore installation manager (ocean)
21304	Onsetter/banksman
50703	Operations research officer
50507	Operations/network operator (computers)
70110	Ophthalmologist
70316	Optical dispenser
70315	Optician/optometrist
70501	Oral hygienist
70324	Orderly/hospital worker
21404	Ore pass/box controller
70403	Orthodontist
70111	Orthopaedic surgeon
70317	Orthoptist
70113	Paediatrician
40637	Painter and decorator/maintenance hand
40638	Painter and decorator (worker n.e.c.)
40470	Panel beater
35911	Paper maker
35900	Paper manufacturing management
35912	Paper tester
70112	Pathologist (medical)
40503	Patternmaker
40629	Paver
10404	Paymaster
10402	Payroll administrator
10401	Payroll controller
10400	Payroll management
10499	Payroll worker (n.e.c)
50517	PC programmer/product specialist
60905	Performing artist

CODE	**OCCUPATION**
70404	Peridontist
10905	Personal assistant/secretary
80899	Personal care worker (n.e.c.)
60102	Personnel assistant/masiza
60100	Personnel management
60101	Personnel officer/practitioner
60199	Personnel worker (n.e.c.)

70799	Pharmaceutical worker (n.e.c.)
70701	Pharmacist
60906	Photographer
70318	Physiologist
70319	Physiotherapist
81103	Pilot (aircraft)
21505	Pipes and tracks team leader/supervisor
21506	Pipes and tracks worker
20703	Pit worker
40003	Planned maintenance foreman
40100	Planning management (engineering)
20100	Planning management (mining)
20104	Planning observer
20102	Planning officer
40101	Planning officer (engineering)
40199	Planning worker (engineering n.e.c.)
20199	Planning worker (mining n.e.c.)
30204	Plant team leader/supervisor
30299	Plant worker (n.e.c.)
30201	Plant/reduction official
40628	Plasterer
70114	Plastic surgeon
40448	Plater
40447	Plater/boilermaker
40449	Plater/boilermaker apprentice
40446	Plater/boilermaker chargehand
40445	Plater/boilermaker foreman
40452	Plater/boilermaker worker (n.e.c.)
40455	Plater/welder
40457	Plater/welder apprentice
40454	Plater/welder chargehand
40453	Plater/welder foreman
40458	Plater/welder worker (n.e.c.)
40656	Plate/track layer/ganger (main line)
60404	Play school supervisor
40632	Plumber
40635	Plumber aide
40633	Plumber apprentice
40631	Plumber chargehand
40630	Plumber foreman
40634	Plumber operative

CODE	**OCCUPATION**
40636	Plumber worker (n.e.c.)
70320	Podiatrist/chiropodist
09801	Pool gang worker

11010	Postal worker/messenger
40530	Power hammer operator
40529	Press operator
60405	Pre-primary school assistant
36011	Printer (n.e.c.)
36012	Printing machine operator
36000	Printing management
36001	Printing supervisor
36099	Printing worker (n.e.c.)
30203	Process controller
60900	Producer/director (creative arts)
20001	Production/section/underground manager
50705	Productivity officer
19992	Project manager (admin/financial n.e.c.)
99992	Project manager/officer (agriculture n.e.c.)
49992	Project manager/officer (engineering n.e.c.)
09992	Project manager/officer (general management n.e.c.)
69992	Project manager/officer (humanities n.e.c.)
79992	Project manager/officer (medical/health n.e.c.)
29992	Project manager/officer (mining n.e.c.)
39992	Project manager/officer (reduction/beneficiation/manufacturing)
59992	Project manager/officer (scientific/technical n.e.a)
89992	Project manager/officer (services n.e.c.)
10601	Property broker
10600	Property/mining rights management
10602	Property/mining rights officer
10699	Property/mining rights worker (n.e.c.)
50107	Prospector
70309	Prosthetist/medical orthotist
70405	Prosthodontist
70115	Psychiatrist
60501	Psychologist (clinical)
60104	Psychologist (industrial)
60803	Public relations assistant
60800	Public relations management
60801	Public relations officer
60899	Public relations worker (n.e.c.)
30210	Pulveriser/grinderman
40531	Pump team leader/supervisor
40532	Pump worker
30104	Pupil metallurgist
10312	Purchaser/buyer
10300	Purchasing/stores management
40613	Quantity surveyor
20307	Quarryman

CODE	OCCUPATION
79999	Radio/medic (ocean)
40327	Radio mechanician
11012	Radio operator
70321	Radiographer
70116	Radiologist
81000	Rail transport management
81001	Rail transport officer
81002	Rail transport team leader
81099	Rail transport worker (n.e.c.)
20607	Raise/tunnel borer operator
20606	Raise/tunnel borer supervisor
10313	Receiver (stores)
10906	Receptionist/typisi/word processor operator
10904	Records/filing officer
30099	Reduction/beneficiation/manufacturing management (n.e.c.)
39999	Reduction/beneficiation/manufacturing worker (n.e.c)
30201	Reduction/plant official
21403	Reeler
30601	Refiner
30699	Refining worker (n.e.c.)
40415	Refrigeration plant operator
40414	Refrigeration plant team leader/supervisor
40412	Refrigeration/air conditioning engineer
40413	Refrigeration/air conditioning mechanic
40906	Refuse collector
70202	Registrar (medical)
80200	Rescue training service management
80202	Rescue/firefighting officer
80203	Rescue/firefighting team leader/supervisor
80298	Rescue/firefighting trainer
80299	Rescue/firefighting worker (n.e.c)
99997	Researcher (agriculture n.e.c)
49997	Researcher (engineering n.e.c.)
09997	Researcher (general management n.e.c)
69997	Researcher (humanities n.e.c.)
79997	Researcher (medical n.e.c)
39997	Researcher (metallurgy/beneficiation/manufacturing n.e.c)
29997	Researcher (mining production n.e.c)
50397	Researcher (rock mechanics)
59997	Researcher (scientific/technical n.e.c)
89997	Researcher (service occupation n.e.c.)
40508	Rigger and ropeman
40509	Rigger and ropeman apprentice
40507	Rigger and ropeman chargehand
40506	Rigger and ropeman foreman

40511	Rigger and ropeman worker (n.e.c.)
40510	Rigger aide
40655	Road builder

CODE	OCCUPATION
80900	Road transport management
80901	Road transport officer
80902	Road transport team leader
80999	Road transport worker (n.e.c.)
20799	Rock breaking worker (n.e.c.)
50301	Rock mechanics engineer
50300	Rock mechanics management
50302	Rock mechanics officer
50399	Rock mechanics worker (n.e.c.)
20899	Rock support worker (n.e.c.)
20806	Roof bolt machine operator
20807	Roof bolt worker
29909	Roughneck (ocean)
81201	Roustabout (ocean)
40523	Rubber reliner
50802	Safety/loss control auditor
50800	Safety/loss control management
50803	Safety/loss control observer assistant
50801	Safety/loss control officer
50899	Safety/loss control worker (n.e.c.)
10811	Sales representative
10319	Salvage yard aide
10320	Salvage and reclamation worker (surface)
29907	Salvage and reclamation worker (underground)
50204	Sample worker
50203	Sampler
40904	Sanitation worker
40540	Saw doctor
40542	Saw sharpener
40541	Sawmill mechanic
35710	Sawyer
60401	School principal
50000	Scientific/technical management (multi-disciplinary)
50099	Scientific/technical management (n.e.c.)
59999	Scientific/technical worker (n.e.c.)
20902	Scraper winch bell operator
20901	Scraper winch driver
20999	Scraping worker (n.e.c)
30209	Screensman
81299	Sea transport worker (n.e.c)
10999	Secretarial/administrative worker (n.e.c.)

10900	Secretarial/administration management
10905	Secretary/personal assistant
29901	Section leader
20001	Section/production/underground manager
11112	Securities officer
80103	Security guard/mine police
80101	Security inspector/officer

CODE	OCCUPATION
80100	Security management
80102	Security supervisor (eg sergeant)
80199	Security worker (n.e.c.)
50105	Sedimentologist
50306	Seismic network technician
50305	Seismologist
21107	Self-propelled machine driver (n.e.c.)
89999	Service worker (n.e.c.)
80000	Services management (multi-disciplinary)
80099	Services management (n.e.c.)
40903	Sewage plant operator
20301	Shaft foreman
21501	Shaft sinker
21503	Shaft timberman worker
21502	Shaft timberman/timberman
29909	Shakerhand (ocean)
11111	Share transfer officer
40459	Sheetmetal worker
20302	Shift boss
40526	Shot blast operator
20804	Shotcrete worker
21105	Shovel operator
81007	Shunter
21108	Shuttle car driver
81008	Signaller
40639	Signwriter
21303	Skipman
30704	Slimes dam team leader/supervisor
30705	Slimes dam worker
30799	Slimes dam/dump worker (n.e.c.)
30501	Smelter
30502	Smelter team leader/supervisor
30503	Smelter worker
60502	Social worker
60602	Solicitor/attorney/conveyancer
30206	Sorter
20405	Spannerman/driller's assistant

50407	Spectrographer
70322	Speech therapist/audiologist
61099	Sports worker (n.e.c.)
61002	Sports/recreation assistant
61000	Sports/recreation management
61001	Sports/recreation officer
90502	Stable hand/herdsman
21402	Stacker operator
21509	Stage worker
10311	Standards officer
50602	Statistical officer

CODE	OCCUPATION
50699	Statistical worker (n.e.c.)
50601	Statistician
50600	Statistics management
81201	Stevedore
11110	Stockbroker
81005	Stoker/fireman
29904	Stone packer
20311	Stope team leader/supervisor
20702	Stope team worker
20304	Stoper
10314	Storekeeper
10310	Stores controller
10316	Stores issuer (non-explosive)
10313	Stores receiver
10399	Stores worker (n.e.c.)
10300	Stores/purchasing management
50304	Strata control observer
50303	Strata control officer
00201	Strategic planning analyst
00200	Strategic planning management
00299	Strategic planning worker (n.e.c.)
30408	Stripper operator
19993	Student (administrative/financial n.e.c.)
99993	Student (agriculture n.e.c.)
49993	Student (engineering n.e.c.)
50193	Student (geology)
69993	Student (humanities n.e.c.)
79993	Student (medical)
39993	Student (metallurgy/beneficiation/manufacturing n.e.c.)
29993	Student (mining production n.e.c.)
59993	Student (scientific/technical n.e.c.)
89993	Student (service occupation n.e.c.)
29902	Supervisors assistant (underground)

70399	Supplementary medical worker (n.e.c.)
70117	Surgeon (general)
50200	Survey management
50299	Survey worker (n.e.c.)
50201	Surveyor (land)
50202	Surveyor (mine)
29903	Sweeper/vamper
10203	Systems accountant
50504	Systems analyst
50512	Systems/network programmer
34510	Tailor
80402	Tea maker/office cleaner
60404	Teacher (nursery education)
60403	Teacher (primary education)
60402	Teacher (secondary education)

CODE	OCCUPATION
20312	Team leader/supervisor (other mining production work)
40204	Technical assistant engineering (n.e.c.)
20211	Technical assistant mining (n.e.c.)
50001	Technical services management
59901	Technical services department (TSD) officer (n.e.c.)
11099	Telecommunications worker (n.e.c.)
11011	Telephonist
60907	Television cameraman
70118	Thoracic surgeon
35999	Timber, pulp and paper worker (n.e.c.)
10403	Timekeeper
21405	Tip team leader/supervisor
21406	Tip worker
40512	Toolmaker
20312	Toolpusher (ocean)
60804	Tour guide
40612	Town planner
49994	Tracer (n.e.c.)
21101	Trackless machine team leader/supervisor
21198	Trackless machine trainer (eg dragline)
21199	Trackless machine worker (n.e.c.)
40656	Track/plate layer/ganger (main line)
81006	Train guard
19998	Trainer (administrative/financial n.e.c.)
99998	Trainer (agriculture n.e.c.)
40798	Trainer (chemical engineering)
40698	Trainer (civil engineering)
50598	Trainer (computers)
81398	Trainer (crane driving)

40398	Trainer (electrical engineering)
80298	Trainer (firefighting/rescue)
70898	Trainer (first aid)
49998	Trainer (general engineering n.e.c.)
09998	Trainer (general management n.e.c.)
69998	Trainer (humanities, n.e.c.)
40598	Trainer (mechanical engineering)
79998	Trainer (medical n.e.c.)
39998	Trainer (metallurgy/beneficiation/manufacturing n.e.c.)
29998	Trainer (mining production n.e.c.)
70698	Trainer (nursing)
80998	Trainer (road driving)
50898	Trainer (safety/loss control)
59998	Trainer (scientific/technical n.e.c.)
80198	Trainer (security)
89998	Trainer (service occupation n.e.c.)
60398	Trainer/instructor (n.e.c.)
60302	Training assistant
60300	Training management

CODE	OCCUPATION
60301	Training officer (n.e.c.)
60399	Training worker (n.e.c.)
60903	Translator
81399	Transport worker (n.e.c.)
60203	Tribal representative/induna
10906	Typist/word processor operator/receptionist
09999	Unclassified occupation (unknown/no specific skill)
10906	Typist/word processor operator/receptionist
20001	Underground/production/section manager
30401	Uranium plant official
70119	Urologist
50518	User support (computers)
10510	Valuator
80704	Waiter/waitress
40900	Water, effluent and sanitation management
40907	Water, effluent and sanitation officer
40901	Water, effluent and sanitation team leader/supervisor
40902	Water treatment operator
10395	Weighbridge attendant
40456	Welder
60504	Welfare assistant
60503	Welfare officer
60599	Welfare worker (n.e.c.)
40526	Winch Operator\Driver
40525	Winch transporter team leader

40524	Winch transporter/erector
21301	Winding engine driver (licensed)
20406	Wireline operators (ocean)
10906	Word processor operator/typist/receptionist
50707	Work study observer/assistant
50706	Work study officer
35913	Wrapper
60902	Writer/journalist
10318	Yard supervisor
10321	Yard worker (n.e.c.)

4 POLLUTANT CODE LIST

SUBSTANCE	CODE	SUBSTANCE	CODE
Acetaldehyde	1	*Acrylamide	8
Acetic acid	2	Acrylic acid	9
Acetic anhydride	3	*Acrylonitrile	10
Acetone	4	Aldrin	11
Acetonitrile	5	Allyl alcohol	12
Acetylsalicylic acid [aspirin]	6	Allyl chloride	13
Acrolein	7	Allyl-2,3-epoxypropyl ether	14
Acrylaldehyde	7	Allyl glycidyl ether [AGE]	14

SUBSTANCE	CODE	SUBSTANCE	CODE
Aluminium alkyl compounds	15	Selenium-doped	57
Aluminium metal		Borates, tetra sodium salts	
inhalable particulate	16	Anhydrous	58
respirable particulate	17	Decahydrate	59
Aluminium oxides		Pentahydrate	60
inhalable particulate	18	Bornan-2-one	61
respirable particulate	19	Boron oxide	62
Aluminium salts, soluble	20	Boron tribromide	63
Aminodimethylbenzene	21	Boron trifluoride	64
2-Aminoethanol	22	Bromacil	65
2-Aminopyridine	23	Bromine	66
Ammonia	24	Bromine pentafluoride	67
Ammonium chloride, fume	25	Bromochloromethane	68
Ammonium sulphamate	26	Bromoethane	69
n-Amyl acetate	27	Bromoethylene	70
sec-Amyl acetate	28	Bromoform	71
Aniline	29	Bromomethane	72
Anisidines, o- and p-isomers	30	Bromotrifluoromethane	73
Antimony & compounds [as Sb] except	31	*Buta-1,3-diene	74
antimony trisulphide and antimony trioxide		n-Butane	75

*Arsenic and compounds, except arsine [as As]	32	Butan-1-ol	76
Arsine	33	Butan-2-ol	77
*Asbestos, all forms	34	Butan-2-one	78
Asphalt, petroleum fumes	35	trans-But-2-enal	79
Atrazine	36	*2-Butoxyethanol [EGBE]	80
Azinphos-methyl	37	n-Butyl acetate	81
Aziridine	38	sec-Butyl acetate	82
gamma-BHC	39	tert-Butyl acetate	83
Barium compounds, soluble [as Ba]	40	Butyl acrylate	84
Barium sulphate, respirable particulate	41	n-Butyl alcohol	76
Benomyl	42	sec-Butyl alcohol	77
*Benzene	43	tert-Butyl alcohol	85
Benzenethiol	44	n-Butylamine	86
Benzene-1,2,4-tricarboxylic acid 1,2-	45	Butyl benzyl phthalate	87
anhydride		n-Butyl chloroformate	88
p-Benzoquinone	46	n-Butyl glycidyl ether [BGE]	89
Benzoyl peroxide	47	n-Butyl lactate	90
Benzyl butyl phthalate	48	2-sec-Butylphenol	91
Benzyl chloride	49	*Cadmium & cadmium compounds, except cadmium oxide fume, cadmium	
*Beryllium and beryllium compounds [as Be]	50	sulphide and cadmium sulphide pigments	92
Biphenyl	51	[as Cd]	
*Bis (chloromethyl) ether [BCME]	52	*Cadmium oxide fume [as Cd]	93
Bis (2,3-epoxypropyl) ether	53	*Cadmium sulphide and cadmium sulphide pigments respirable particulate [as Cd]	94
Bis (2-ethylhexyl) phthalate	54	Caesium hydroxide	95
2,2-Bis(p-Methoxyphenyl)-1,1,1-trichloroethane (DMDT)	55	Calcium carbonate	
Bismuth telluride [as Bi2Te3)		inhalable particulate	96
Undoped	56	respirable particulate	97

SUBSTANCE	CODE	SUBSTANCE	CODE
Calcium cyanamide	98	1-Chloro-4-nitrobenzene	141
Calcium cyanide	335	Chloropentafluoroethane	142
Calcium hydroxide	99	Chloropicrin	143
Calcium oxide	100	beta-Chloroprene	133
Calcium silicate		3-Chloropropylene	13
inhalable particulate	101	Chlorosulphonic acid	144
respirable particulate	102	alpha-Chlorotoluene	49
Camphor, synthetic	103	2-Chlorotoluene	145

Caprolactam	
inhalable particulate	104
vapour	105
Captafol	106
Captan	107
Carbaryl	108
Carbofuran	109
Carbon black	110
Carbon dioxide	111
*Carbon disulphide	112
Carbon monoxide	113
Carbon tetrabromide	114
Carbon tetrachloride	115
Carbonyl chloride	116
Catechol	117
Cellulose	
inhalable particulate	118
respirable particulate	119
Cement	
inhalable particulate	120
respirable particulate	121
Chlordane	122
Chlorine	123
Chlorodiphenyl (42% chlorine)	124
Chlorodiphenyl (54% chlorine)	125
Chlorine dioxide	126
Chlorine trifluoride	127
Chloroacetaldehyde	128
2-Chloroacetophenone	129
Chloroacetyl chloride	130
Chlorobenzene	131
Chlorobromomethane	132
2-Chlorobuta-1,3-diene	133
Chlorodifluoromethane	134
*1-Chloro-2,3-epoxy propane	135
Chloroethane	136
2-Chloroethanol	137
*Chloroethylene (VCM)	138
Chloroform	139
Chloromethane	140

2-Chloro-6-(trichloromethyl) pyridine	146
Chlorpyrifos	147
Chromium, metal and inorganic compounds [as Cr]	
Cr [II] compounds	148
Metal and Cr (III) compounds	149
*Cr [VI] compounds	150
Coal dust [respirable particulate]	
<5% crystalline quartz/silica	151
>5% crystalline quartz/silica	522
Coal tar pitch volatiles [as cyclohexane solu]	152
*Cobalt & cobalt compounds [as Co]	153
COPper	
fume	154
Dusts & mists [as Cu]	155
Cotton dust	156
Cresols, all isomers	151
Cristobalite	521 – 524
Crotonaldehyde	79
Cryofluorane [INN]	158
Cumene	159
Cyanamide	160
Cyanides, except hydrogen cyanide, cyanogen & cyanogen chloride	334–337
Cyanogen	161
Cyanogen chloride	162
Cychlohexane	163
Cyclohexanol	164
Cyclohexanone	165
Cyclohexene	166
Cyclohexylamine	167
Cyclonite [RDX]	168
Cyhexatin	169
2,4-D	170
DDT	171
DDVP	172
2,4-DES	173
DMDT	174
Derris, commercial	175
Diacetone alcohol	176

SUBSTANCE	CODE	SUBSTANCE	CODE
Dialkyl 79 phthalate	177	Diethyl ether	214
Diallyl phthalate	178	Di-(2-ethylhexyl) phthalate [DEHP]	215
2.2'-Diaminodiethylamine	179	Diethyl ketone	216
*4.4' - Diaminodiphenylmethane [DADPM,	180	Diethyl phthalate	217
DDM]		Diflurochloromethane	134
1,2-Diaminoethane	181	Diglycidyl ether [DGE]	218
Diammonium peroxodisulphate [as S2O8]	182	o-Dihydroxybenzene	117
Diatomaceous earth, natural [respirable particulate]	183	m-Dihydroxybenzene	219
Diazinon	184	p-Dihydroxybenzene	220
Diazomethane	185	1,2 Dihydroxyethane	283–284
Dibenzoyl peroxide	47	Diisobutyl ketone	221
Dibismuth tritelluride	56-57	Diisobutyl phthalate	222
Diborane	186	Diisodecyl phthalate	223
Diboron trioxide	62	Diisononyl phthalate	224
Dibrom	187	Diisooctyl phthalate	225
*1,2-Dibromo-2,2-dichloroethyl dimethyl	187	Diisopropylarnine	226
phosphate		Diisopropyl ether	227
Dibromodifluoromethane	188	Di-linear 79 phthalate	177
*1,2-Dibromoethane	189	Dimethoxymethane	228
Dibutyl hydrogen phosphate	190	N,N-Dimethylacetamide	229
Dibutyl phosphate	190	Dimethylamine	230
Dibutyl phthalate	191	N,N-Dimethylaniline	231
Dichloroacetylene	192	1,3-Dimethylbutyl acetate	232
1,2-Dichlorobenzene	193	Dimethyl ether	233
1,4-Dichlorobenzene	194	N,N-Dimethylethyfamine [DMEA]	234
Dichlorodifluoromethane	195	Dimethylformamide	235
1,3-Dichloro-5,5-dimethyl hydantoin	196	2,6-Dimethyltheptan-4-one	221
Dichlorodiphenyltrichloroethane	171	Dimethyl phthalate	236
1,1-Dichloroethane	197	Dimethyl sulphate	237
*1,2-Dichloroethane	198	Dinitrobenzene, all isomers	238
*1,1 -Dichloroethylene	199	Dinitro-o-cresol	239
1,2 Dichloroethylene. cis & trans isomers	200	Dinitrotoluene	240
*Dichlorofluorornethane	201	Dinonyl phthalate	241
*Dichloromethane	202	Di-sec-octyl phthalate	215
*2,2'-Dichloro-4,4'-methylene dianiline	203	1,4-Dioxane, tech grade	242
2.4-Dichlorophenoxyacetrc acid	170	Dioxathion	243
1,3-Dichloropropene, cis & trans isomers	204	Diphenyl	51

1,2-Dichlorotetrafluoroethane	205	Diphenylamine	244
Dichlorvos	172	Diphenyl ether [vapour]	245
Dicyclohexyl phthalate	206	Diphosphorus pentasulphide	246
Dicyclopentadiene	207	Diphospborus pentoxide	247
Dicyclopentadienyl iron	208	Dipotassium peroxodisulphate [as S2O8]	248
Dieldrin	209	Diquat dibromide	249
Diethanolamine	210	Disodium disuiphite	250
Diethylamine	211	Disodium peroxodisulphate [as S2O8]	251
2-Diethyiaminoethanol	212	Disodium tetraborate	58-60
Diethylene glycol	213		
Diethylene triamine	179	Disulfoton	252

SUBSTANCE	CODE	SUBSTANCE	CODE
Disulphur decafluoride	253	*Ethylene glycol monomethyl ether acetate	286
Disulphur dichloride	254	[EGMEA]	
2,6-Di-tert-butyl-p-cresol	255	Ethyleneimine	287
6,6-Di-tert-butyl-4,4-thiodi-m-cresol	256	*Ethylene oxide	288
Diuron	257	Ethyl ether	214
	592 -	Ethyl formate	289
Divanadium pentoxide	593	2-Ethylhexyl chloroformate	290
Divinyl benzene [DVB]	258	Ethylidene dichloride	197
Emery		Ethyl mercaptan	267
inhalable particulate	259	4-Ethylmorpholine	291
respirable particulate	260	Ethyl silicate	292
Endosulfan	261	Fenchlorphos	293
Endrin	262	Ferbam	294
Enflurane	263	Ferrocene	208
*Epichlorohydrin	264	Ferrovanadiurn dust	295
1,2-Epoxy-4-epoxyethyl-cyclo-hexane	265	Flammable gas (methane/hydrogen)	296
2,3-Epoxypropyl isopropyl ether	266	Fluorides [as F]	297
Ethane-1,2-diol	283-	Fluorine	298
	284	Fluorodichloromethane	201
Ethanethiol	267	Fluorotrichloromethane	299
Ethanol	268	*Formaldehyde	300
Ethanolamine	269	Formamide	301
Ether	214	Formic acid	302
*2-Ethoxyethanol [EGEE]	270	2-Furaldehyde	303
*2-Ethoxyethyl acetate [EGEEA]	271	Furfural	303
Ethyl acetate	272	Furfuryl alcohol	304
Ethyl acrylate	273	Gasoline	305
Ethyl alcohol	268	Germane	306
Ethylamine	274	Germanium tetrahydride	306

Ethyl amyl ketone	275	Gtutaraldehyde	307
Ethyl benzene	276	Glycerol, mist	308
Ethyl bromide	277	Glycerol trinitrate	309
Ethyl butyl ketone	278	Glycol monoethyl ether	270
Ethyl chloride	279	Graphite, natural & synthetic	
Ethyl chloroformate	280	inhalable particulate	310
Ethylene chlorohydrin	281	respirable particulate	311
Ethylene diamine	181	*Grain dust (oat, wheat, barley)	312
*Ethylene dibromide	189	Guthion	37
*Ethylene dichloride	198	Gypsum	
Ethylene dinitrate	282	inhalable particulate	313
Ethylene glycol		respirable particulate	314
inhalable particulate	283	gamma-HCH	315
vapour	284	Hafnium	316
Ethylene glycol dinitrate [EGDN]	282	Halothane	317
*Ethylene glycol monobutyl ether [EGBE]	80	Heptachlor	318
*Ethylene glycol monoethyl ether [EGEE]	270	n-Heptane	319
*Ethylene glycol monoethyl ether acetate [EGEEA]	271	Heptan-2-one	320
*Ethylene glycol monomethyl ether [EGME]	285	Heptan-3-one	278

SUBSTANCE	CODE	SUBSTANCE	CODE
gamma-Hexachlorocyclohexane	315	Isoflurane	357
Hexachloroethane		Isooctyl alcohol [mixed isomers]	358
Vapour	321	Isopentyl acetate	351
inhalable particulate	322	Isophorone	359
respirable particulate	323	Isophorone-diisocyanate [IPDI]	360
Hexahydro-1,3,5-trinitro-1,3,5-triazine	186	Isopropyl acetate	361
Hexane, all isomers except n-Hexane	324	Isopropyl alcohol	362
n-Hexane	325	Isopropyl benzene	159
1,6-Hexanolactam	104-105	Isopropyl chloroformate	363
Hexan-2-one	326	Isopropyl ether	227
Hexone	327	Isopropyl glycidyl ether [IGE]	266
sec-Hexyl acetate	232	Kaolin, respirable particulate	364
Hexylene glycol	328	Ketene	365
Hydrazine	329	*Lead, elemental, and inorganic compounds [as Pb]	366
Hydrazoic acid [as vapour]	330	*Lead tetra-ethyl [as Pb]	367
Hydrogen	331	Lead tetra-methyl [as Pb]	368
Hydrogen bromide	332	Limestone	96-97
Hydrogen chloride	333	Lindane	315

Hydrogen cyanide and cyanide salts [as CN]		Liquified petroleum gas [LPG]	369
*Hydrogen cyanide	334	Lithium hydride	370
Calcium cyanide	335	Lithium hydroxide	371
Potassium cyanide	336	*MBOCA	203
Sodium Cyanide	337	*MDA	180
Hydrogen fluoride [as F]	338	*MDI	360
Hydrogen peroxide	339	Magnesite	
Hydrogen selenide [as Se]	340	inhalable particulate	372
Hydrogen sulphide	341	respirable particulate	373
Hydroquinone	220	Magnesium oxide [as Mg]	
4-Hydroxy-4-methyi-pentan-2-one	176	inhalable particulate	374
2-Hydroxypropyl acrylate	342	fume and respirable particulate	375
2,2'- Iminodiethanol	210	Malathion	376
2,2'-lminodi(ethylamine)	179	Maleic anhydride	377
Indene	343	Manganese, elemental, and inorganic	378
Indium and compounds [as In]	344	compounds [as Mn]	
Iodine	345	Manganese, fume [as Mn]	379
Iodoform	346	Manganese cyclopentadienyl tricarbonyl [as Mn]	380
lodomethane	347	Manganese tetroxide	381
Iron oxide, dust & fume [as Fe]	348	Man-made mineral fibres [Glass, slag and	382
Iron pentacarbonyl	349	rock wool fibres]	
Iron salts [as Fe|	350	Marble	96-97
Isoamyl acetate	351	Mequinol [INN]	383
Isoamyl alcohol	352	Mercaptoacetic acid	384
Isoamyl methyl ketone	353	Mercury alkyls [as Hg]	385
Isobutyl acetate	354	Mercury and compounds, except Mercury alkyls, [as Hg]	386
Isobutyl alcohol	355		
Isobutyl methyl ketone	327	Mesityl oxide	387
*Isocyanates, all [as –NCO]	356	Methacrylic acid	388

SUBSTANCE	CODE	SUBSTANCE	CODE
Methacrylonitrile	389	4-Methylpentan-2-ol	410
Methane	390	4-Methylpentan-2-one	327
Methanethiol	391	4-Methyl-3-penten-2-one	387
Methanol	392	*4-Methyl-m-phenylene diisocyanate	360
Methomyl	393	2-Methylpropao-1-ol	355
Methoxychlor	174	2-Methylpropan-2-ol	85
*2-Methoxyethanol [EGME]	285	Methyl propyl ketone	413
*2-Methoxyethyl acetate [EGMEA]	286	1-Methyl-2-pyrrolidone	414

SUBSTANCE	CODE	SUBSTANCE	CODE
Oil mist, mineral	450	Piperidine	483
Orthophosphoric acid	451	Plaster of Paris	
Osmium tetraoxide [as Os]	452	inhalable particulate	484
Oxalic acid	453	respirable particulate	485
Oxalonitrile	161	Platinum metal	486
2,2'-Oxydiethanol	213	Platinum mine dust respirable particulate	
Ozone	454	<5% crystalline quartz/silica	487
Paraffin wax, fume	455	>5% crystalline quartz/silica	522
Paraquate dichloride respirable particulate	456	Platinum salts, soluble [as Pt]	488
Parathion	457	Polychlorinated biphenyls [PCBs]	124-125
Parathion-methyl	412		
Particles not otherwise classified [PNOC]:		Polyvinyl chloride [PVC]	
<5% crystalline quartz/ silica		inhalable particulate	489
inhalable particulate	458	respirable particulate	490
respirable particulate	459	Portland cement	
Pentacarbonyliron [as Fe]	349	inhalable particulate	491
Pentachlorophenol	460	respirable particulate	492
Pentaerythritol		Potassium cyanide	336
inhalable particulate	461	Potassium hydroxide	493
respirable particulate	462	Propane-1,2-diol	502-503
Pentane, all isomers	463		
Pentan-2-one	413	n-Propanol	494
Pentan-3-one	216	Propan-1-ol	494
Pentyl acetate	27	Propan-2-ol	362
Perchloroethylene	464	Propane	495
Perchloryl fluoride	465	Propargyl alcohol	496
Phenacyl chloride	129	Propionic acid	497
Phenol	466	Propoxur	498
p-Phenylenediamine	467	Propranolol	499
Phenyl-2,3-epoxypropyl ether	468	n-Propyl acetate	500
Phenyl ether, vapour	245	Propylene dinitrate	501
*Phenylethylene	469	Propylene glycol	
Phenylhydrazine	470	total (particulate & vapour)	502
2-Phenylpropene	416	particulate	503
Phorate	471	Propylene glycol dinitatre [PGDN]	501
Phosdrin	419	Propylene glycol monomethyl ether	394
Phosgene	472	2-Propyn-1-ol	496
Phosphine	473	Pulverised fuel ash	
Phosphoric acid	474	inhalable particulate	504
Phosphorus, yellow	475	respirable particulate	505

Phosphorus pentachloride	476	Pyrethrins	506
Phosphorus pentasulphide	246	Pyridine	507
Phosphorus trichloride	477	2-Pyridylamine	508
Phosphoryl trichloride	478	Pyrocatechol	117
Phthalic anhydride	479	Quartz, crystalline	521 - 524
Picloram	480	Quinone	509
Picric acid	481	RDX	168
Piperazine dihydrochloride	482	Resorcinol	219

SUBSTANCE	**CODE**	**SUBSTANCE**	**CODE**
Rhodium [as Rh]		Sucrose	541
metal fume & dust	510	Sulfotep	542
soluble sails	511	Sulphur dioxide	543
Ronnel	293	Sulphur hexafluoride	544
Rosin core solder pyrolysis products [as	512	Sulphuric acid	545
formaldehyde]		Sulphur monochloride	254
Rotenone	175	Sulphur pentafluoride	253
Rouge		Sulphur tetrafluoride	546
inhalable particulate	513	SuLphuryl difluoride	547
respirable particulate	514	2,4,5-T	548
*Rubber fume	515	*TDI	360
*Rubber process dust	516	TEDP	542
Selenium & compounds, except hydrogen selenide [as Se]	517	TEPP	549
Silane	518	TNT	550
Silica, amorphous		Talc	
inhalable particulate	519	inhalable particulate	551
respirable particulate	520	respirable particulate	552
Silica, crystalline [respirable particulate]		Tantalum metal and oxide dusts [as Ta]	553
Cristobalite	521	Tellurium & compounds, except hydrogen telluride [as Te]	554
Quartz	522	Terphenyls, all isomers	555
Tridymite	523	1,1,2,2-Tetrabromoethane	556
Tripoli	524	Tetrabromomethane	114
Silica, fused [respirable particulate]	525	Tetracarbonyl nickel	430
Silicon		1,1,1,2-Tetrachloro-1,2-difluoroethane	557
inhalable particulate	526	1.1,1,2-Tetrachloro-2,2-difluoroethane	558
respirable particulate	527	Tetrachloroethylene	463
Silicon carbide		Tetrachloromethane	115
inhalable particulate	528	Tetrachloronaphthalenes, all isomers	559

respirable particulate	529	Tetraethyl dithiopyrophosphate	542
Silicon tetrahydride	518	Tetraethyl orthosilicate	292
Silver	530	Tetraethyl pyrophosphate	549
Silver compounds [as Ag]	531	Tetrafluorodichloroethane	202
Sodium azide	532	1,1,1,2-Tetrafluoroethane [HFC 134a]	560
Sodium cyanide	337	Tetrahydrofuran	561
Sodium 2,4-dichlorophenoxy	173	Tetramethyl orthosilicate	415
Ethyl sulphate		Tetramethyl succinonitrile	562
Sodium fluoroacetate	533	Tetrasodium pyrophosphate	563
Sodium hydrogen sulphite	534	Tetryl	418
Sodium hydroxide	535	Thallium, soluble compounds [as TI]	564
Sodium metabisulphate	250	4,4-Thiobis(6-tert-butyl-m-cresol)	256
Starch		Thioglycolic acid	384
inhalable particulate	536	Thionyl chloride	565
respirable particulate	537	Thiram	566
Stibine	538	Tin compounds, inorganic except SnH4 [as Sn]	567
Strychnine	539		
*Styrene	469	Tin compounds, organic except cyhexatin [as Sn]	568
Subtilisins [Proteolytic enzymes as 100% pure crystalline enzyme]	540	Titanium dioxide	

SUBSTANCE	CODE	SUBSTANCE	CODE
inhalable particulate	569	Tripoli	522
respirable particulate	570	Tri-o-tolyl phosphate	580
Toluene	571	Tungsten & compounds [as W]	
*2,4-Toluene diisocyanate [TDI]	360	soluble	588
p-Toluenesulphonyl chloride	572	Insoluble	589
Tribromomethane	71	Turpentine	590
Tributyl phosphate, all isomers	573	Uranium compounds, natural soluble [as U]	591
Tricarbonyl(eta-cyclopentadienyl) manganese	380	Vanadium pentoxide	
		inhalable particulate	592
Tricarbonyl(methylcyclopenta-dienyl) manganese	406	fume & respirable particulate	593
Trichloroacetic acid	574	Vinyl acetate	594
1,2,4-Trichlorobenzene	575	*Vinyl benzene	469
1,1,1-Trichlorobis-2,2-bis(pchlorophenyl)ethane	171	Vinyl bromide	595
		*Vinyl chloride	596
*1,1,1-Trichloroethane	401	4-Vinyl cyclohexene dioxide	265
1,1,2-Trichloroethane	576	*Vinylidene chloride	199

* Trichloroethylene	577
Trichlorofluoromethane	299
Trichloromethane	139
Trichloronitromethane	143
2,4,5-Trichlorophenoxyacetic acid	548
1,2,3-Trichloropropane	578
1,1,2-Trichlorotrifluoroethane	579
Tri-o-cresyl phosphate	580
Tricyclohexyltin hydroxide	169
Tridymite	522
Triethylamine	581
Trifluorobromomethane	285
Trimanganese tetraoxide	381
Trimellitic anhydride	583
Trimethylamine	584
Trimethylbenzene, all isomers or mixtures	585
3,5,5-Trimethylcyclohex-2-enone	359
Trimethyl phosphite	586
2,4,6-Trinitrophenol	481
2,4,6-Trinitrotoluene	550
Triphenyl phosphate	587
Vinyl toluenes, all isomers	417
Warfarin	597
Welding fumes	598
White spirit [Stoddard Solvent]	599
Wood dust	
*Hard wood	600
Soft wood	601
Xylene, o-, m-, p- or mixed isomers	602
Xylidine, all isomers	603
Yttrium	604
Zinc chloride, fume	605
Zinc distearate	606-607
Zinc oxide, fume	606
Zinc stearate	
inhalable particulate	607
respirable particulate	608
Zirconium compounds [as Zr]	609

NOTE: Certain substances will have the same code number as they have the same case number, they are therefore the same substance with a different name.

ANNEXURE B
HEG determination, example of statistical approach

(This annexure is attached for information purposes only)

Introductory information:

*In statistics, a **confidence interval** is a particular kind of interval estimate of a population parameter. Instead of estimating the parameter by a single value, an interval likely to include the parameter is given. Thus, confidence intervals are used to indicate the reliability of an estimate. How likely the interval is to contain the parameter is determined by the confidence level or confidence coefficient. Increasing the desired **confidence level** will widen the confidence interval.

A confidence interval is always qualified by a particular **confidence level**, usually expressed as a percentage. The end points of the confidence interval are referred to as **confidence limits**.

Step 1

Action to be performed:

1 Capture sampling data in Microsoft Excel.

2 Determine the descriptive statistics for the data by utilising Microsoft Excel Analysis ToolPak.

---

* Interval estimation [online] available from https://en.wikipedia.org/wiki/Interval_estimation

To install the Analysis ToolPak:

- On the **Tools** menu, select **Add-Ins**.
- If **Analysis ToolPak** is not listed in the **Add-Ins** dialog box, click **Browse** and locate the drive, folder name and file name for the Analysis ToolPak Add-Ins, Analys32.xll usually located in the Library/Analysis folder, or run the Setup program if it is not installed.
- Select the **Analysis ToolPak** check box.

To use the Analysis ToolPak:

- Before using the Analysis ToolPak, you must first arrange the data you want to analyse in one column (eg A1 to A40 - if you have 40 values that you want to analyse).
- On the **Tools** menu, click **Data Analysis**.
- In the **Analysis Tools** box, select the **Descriptive Statistics** tool.
- Enter the input range (eg A1 to A40).
- Select the **Grouped by Columns** option.
- Select the output range (eg B1 to B40).
- Select the **Summary Statistics** option.
- Select the **Confidence Level of Mean** option and enter this value as being **95%.**
- Select **OK**.

Expected result:

Example of data entered into Microsoft Excel	Expected result after completing actions as indicated under STEP 1	
DATA	DESCRIPTIVE STATISTICS	
1.78	Mean	1.963
1.87	Standard error	0.148
2.15	Median	2.150
2.29	Mode	#N/A
2.54	Standard deviation	0.535
1.51	Sample variance	0.286
2.47	Kurtosis	-0.665
2.45	Skewness	-0.689
1.32	Range	1.65
2.32	Minimum	0.89
2.48	Maximum	2.54
1.45	Sum	25.52
0.89	Count	13
	Confidence level (95.0%)	0.323

Step 2

Action to be performed:

From the descriptive statistics calculate the following:

(A)	2SD	= 2 x Standard Deviation	eg	2 x 0.535 = 1.071
(B)	Mean - 2SD	= Mean - 2SD	eg	1.963 - 1.071 = 0.892

(C)	Mean + 2SD	= Mean + 2SD	eg	1.983 + 1.071 = 3.034

(D) **90th Percentile** value by utilising the following Microsoft Excel formulae:

= PERCENTILE (A1:A40,0.9) = 2.478 (for the data used in this example)

where:

'A1:A40' = Range where data is entered in Microsoft Excel spread sheet

'0.9' = The percentile to be calculated, in this case the 90th percentile

Interpretation:

From the calculation performed above it can already be estimated that this HEG is NOT statistically correct defined, as:

- The mean value fails within the 'B Category' and the **90th percentile** value falls within the 'A Category', For a **HEG** to be statistically correctly defined its mean and **90th percentile** values will almost always fall within the same classification band.

Step 3

Action to be performed:

Determine if 95% of the samples taken falls within two standard deviations (2SD) from the mean value.

Example:

- 95% of the samples must be between 'Mean - 2SD' (0.892) and 'Mean + 2SD' (3.034).
- from the data 1 sample (0.89) is smaller than 'Mean - 2SD and 0 samples are larger than 'Mean + 2SD'.

Interpretation:

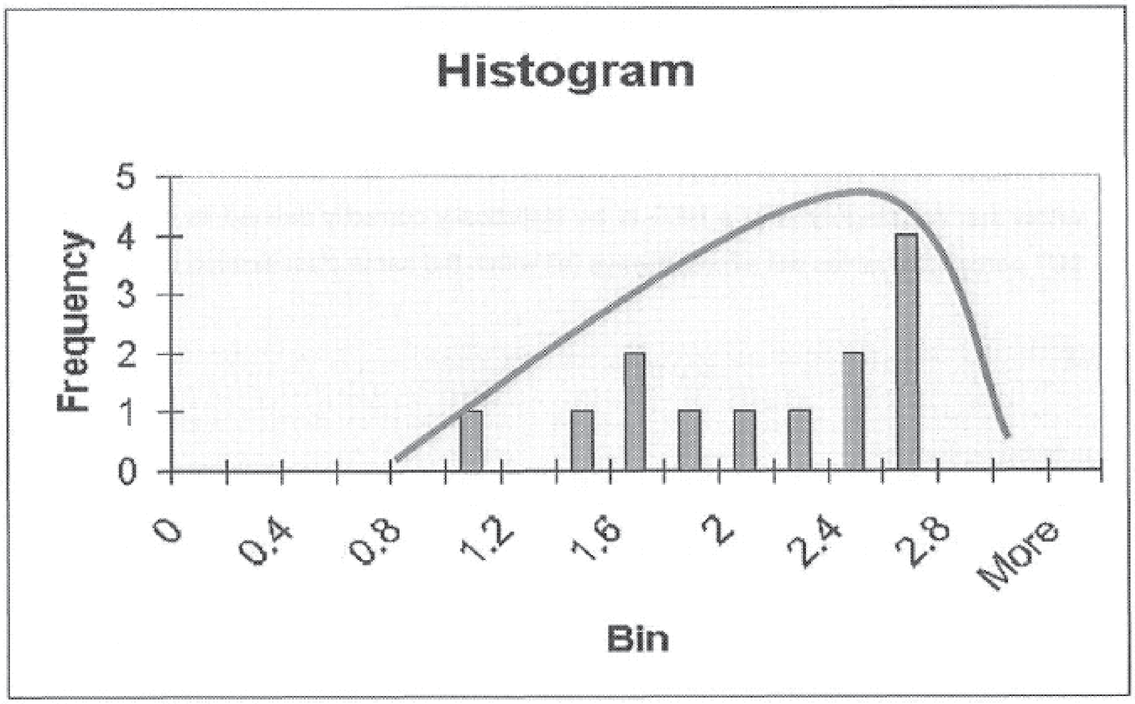
One out of 13 samples represent 7.69 % of the sample group (eg 1/13 x 100 = 7.69%). This is more than the allowable 5% and therefore the **HEG** cannot be seen as statistically correctly defined.

Step 4

Action to be performed:

Draw a histogram to graphically indicate the data.

Expected result:



Interpretation:

From the histogram, it is also clear that the HEG is NOT statistically correctly defined (no bell curve). Only two things can be done to correct this situation:

- Obtain more samples to determine the correct distribution of samples within the **HEG**. This is currently being forced by the legislated sampling strategy as the 'mean' value reported for dose (concentration of airborne pollutant(s) to which a person is exposed) allocations, (for an OEL of two in this example) falls within a 'B Category' (5% sampled over six months) but the 90th percentile value is reported as an 'A Category' thus forcing more samples to be taken (5% over three MTh's).
- Conduct an investigation to determine if more than one **HEG** is being represented by the data.

Step 5

Action to be performed:

Conduct an investigation to determine if more than one **HEG** is being represented by the data. This can be done by investigation and following the methodology as explained, up to this point (for example):

After investigation, the **HEG** was divided into two separate **HEGs** (intake-side **HEG** and return-side **HEG**).

The data collected was then allocated to the two **HEGs** and the statistical analysis revealed the following:

DATA ALLOCATED TO THE INTAKE SIDE HEG	**DESCRIPTIVE STATISTICS**	
0.89	Mean	1.47
1.32	Standard error	0.14
1.78	Median	1.48
1.87	Mode	#N/A
1.51	Standard deviation	0.35
1.45	Sample variance	0.12
	Kurtosis	0.57

Skewness	-0.72
Range	0.98
Minimum	0.89
Maximum	1.87
Sum	8.82
Count	6
Confidence level (95.0%)	0.36

CALCULATIONS

2 X SD = 0.702
Mean - 2SD = 0.767
Mean + 2SD = 2.172
90th percentile = 1.825

Interpretation:

From the above it can already be estimated that this HEG is statistically correctly defined, as the mean value (1.47) falls within the 'B Category' and the 90th percentile value (1.825) also falls within the 'B Category'.

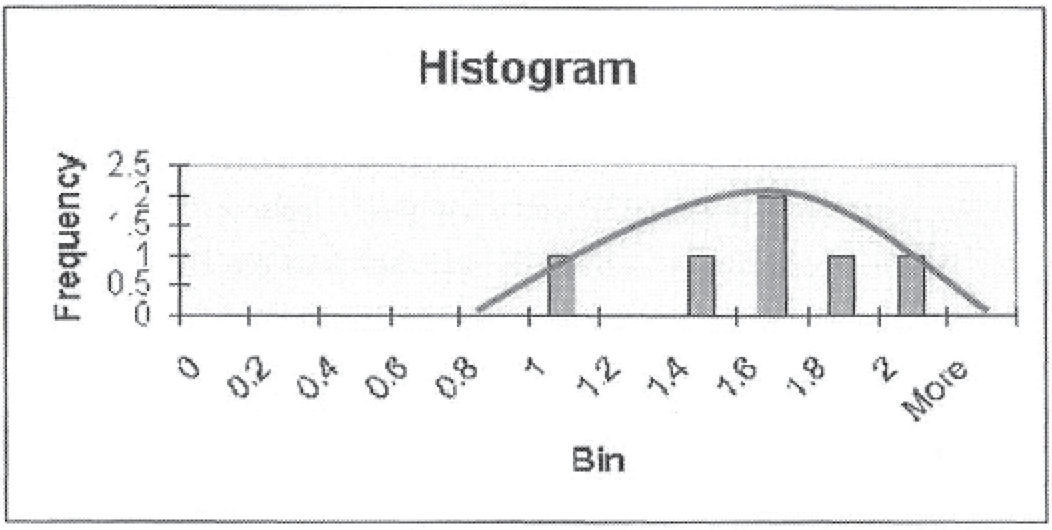
DOES 95% OF THE SAMPLES FALL WITHIN TWO STANDARD DEVIATIONS (SD) FROM THE MEAN?

(A) 95% of the samples must be between mean - 2SD (0.7674) and mean + 2SD (2.173)

(B) From 'DATA': 0 sample < mean - 2SD0 samples > Mean + 2SD

(C) 0/6 = 0%

This is within the allowable 5% and therefore the **HEG** is statistically correctly defined.



DATA ALLOCATED TO THE RETURN SIDE HEG	DESCRIPTIVE STATISTICS	
2.15	Mean	2.38
2.29	Standard error	0.05
2.32	Median	2.45
2.54	Mode	#N/A
2.47	Standard deviation	0.13

2.45	Sample variance	0.01
2.48	Kurtosis	-0.26
	Skewness	-0.80
	Range	0.39
	Minimum	2.15
	Maximum	2.54
	Sum	16.7
	Count	7
	Confidence level (95.0%)	0.12

CALCULATIONS

2 X SD = 0.274434
Mean - 2SD = -2.11128
Mean + 2SD = 2.660149
90th Percentage = 2.504

Interpretation:

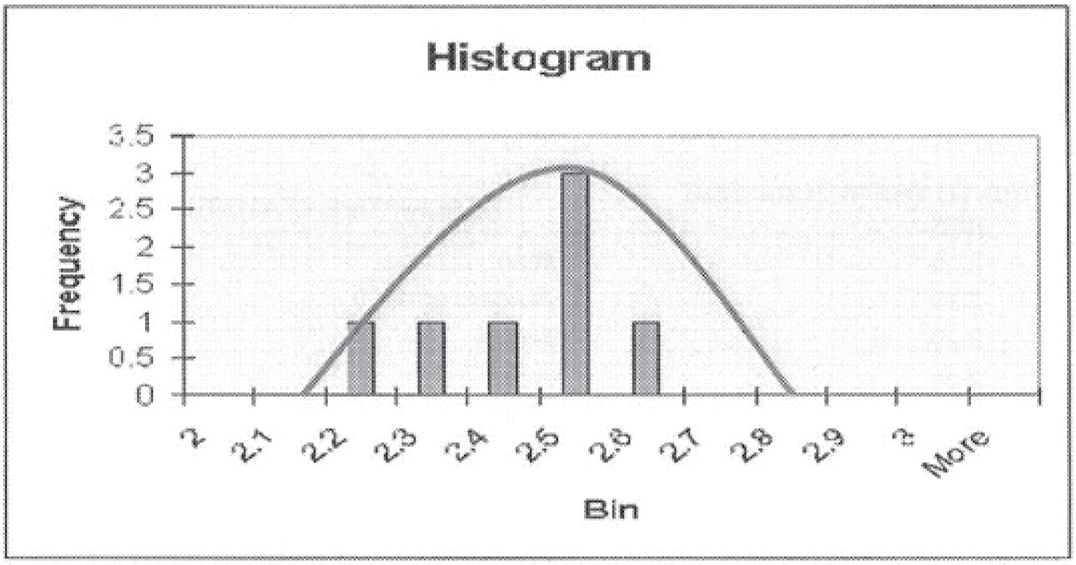
From the above it can already be estimated that this **HEG** is statistically correctly defined, as the mean value (2.39) falls within the 'A Category' and the **90th percentile** value (2.504) also falls within the 'A Category'.

DOES 95% OF THE SAMPLES FALL WITHIN TWO STANDARD DEVIATIONS (SD) FROM THE MEAN?

(A) 95% of the samples must be between mean - 2SD (-2.514) and mean + 2SD (7.286)

(B) From 'DATA': 0 sample < mean - 2SD and 0 samples > mean + 2SD

(C) 0/7 = 0%. This is within the allowable 5% and therefore the **HEG** is statistically correctly defined.



Step 6 - Paired T-test

ANNEXURE C
Mandatory classification bands

(Annexure C forms part of this guideline and must be complied with)

	CLASSIFICATION BANDS
CATEGORY	**PERSONAL EXPOSURE LEVEL**
A	**Exposures** ≥ the **OEL**
B	**Exposures** ≥ 50% of the **OEL** and < of the **OEL**
C	**Exposures** ≥ 10% of the **OEL** and < 50% of the **OEL**
D	**Exposures** < 10% of the **OEL**

Pollutants (excluding toxic gasses and vapours)

Toxic gasses and vapours

	CLASSIFICATION BANDS
CATEGORY	**PERSONAL EXPOSURE LEVEL**
A	**Exposures** ≥ the **OEL**
B	**Exposures** ≥ 50% of the **OEL** and < of the **OEL**
C	**Exposures** ≥ 10% of the **OEL** and < 50% of the **OEL**
D	**Exposures** < 10% of the **OEL**

NOTE: An activity area eg stoping is not a **HEG**, this activity area eg stoping, must be sub-divided into the classification bands as shown above. These classification bands are the **HEGs** within that particular activity area.

ANNEX C

Mandatory forms: Personal exposure reporting form 21.9(2)(a): Reporting single pollutant for category A, C and D

MINE
QUARTERLY AIRBORNE POLLUTANTS EXPOSURE REPORT FORM 21.9(2)(a) IN TERMS OF REGULATION 9.2.7

MAIN COMMODITY CODE: **DMR MINE CODE:**

SAMPLE AREA: **SUB MINE CODE:**

ACTIVITY AREA CODE: **REPORTING PERIOD:**

HEG RECLASSIFICATION BAND:

(based on previous annual 90th percentile results)

NUMBER OF SAMPLES

PLANNED FOR THE CURRENT SAMPLING CYCLE:	**Q1**	**Q2**	**Q3**	**Q4**	**ANNUAL RESULTS**
Number of samples taken					
Quarterly HEG classification (based on 90th percentile measurement results)					

HEG								
Occupations codes in HEG	**Occupations in HEG**	**Number of persons per occupation**	**Pollutant code**	**Sample concentration per occupation (TWA - 8hr) mg/m3**	**Analysis %**	**Mean pollutants concentration dose allocated to medical records** **(Tick appropriate block)** **mg/m3** **f/ml** **ppm**	**90th percentile HEG classification**	**OEL** **(Tick appropriate block)** **mg/m3** **f/ml** **ppm**
TOTAL								

COMMENTS ON:

Reasons for over-exposures

Corrective measures that will be implemented to prevent/mitigate over-exposures

ANNEX C

Mandatory forms: Personal exposure reporting form 21.9(2)(a): Reporting single pollutant for category B

MINE

QUARTERLY AIRBORNE POLLUTANTS EXPOSURE REPORT FORM 21.9(2)(a) IN TERMS OF REGULATION 9.2.7

MAIN COMMODITY CODE:	**DMR MINE CODE:**
SAMPLE AREA:	**SUB MINE CODE:**
ACTIVITY AREA CODE:	**REPORTING PERIOD:**
HEG RECLASSIFICATION BAND:	
(based on previous annual 90th percentile results)	

NUMBER OF SAMPLES

PLANNED FOR THE CURRENT SAMPLING CYCLE:	**Q1**	**Q2**	**BI-ANNUAL RESULTS**	**Q3**	**Q4**	**ANNUAL RESULTS**
Number of samples taken						
Quarterly HEG classification **(based on 90th percentile measurement results)**						

HEG						**Mean pollutants concentration dose allocated to medical records**		**OEL**
						(Tick appropriate block)		**(Tick appropriate block)**
Occupations codes in HEG	**Occupations in HEG**	**Number of persons per occupation**	**Pollutant code**	**Sample concentration per occupation (TWA - 8hr) mg/m3**	**Analysis %**	**mg/m3** **f/ml** **ppm**	**90th percentile HEG classification**	**mg/m3** **f/ml** **ppm**
TOTAL								

COMMENTS ON:

Reasons for over-exposures

Corrective measures that will be implemented to prevent/mitigate over-exposures

ANNEX C:

Mandatory forms: Personal exposure reporting form 21.9(2)(a): Reporting additive effects

MINE

QUARTERLY AIRBORNE POLLUTANTS EXPOSURE REPORT FORM 21.9(2)(a) IN TERMS OF REGULATION 9.2.7

MAIN COMMODITY CODE:	**DMR MINE CODE:**
SAMPLE AREA:	**SUB MINE CODE:**
ACTIVITY AREA CODE:	**REPORTING PERIOD:**
HEG RECLASSIFICATION BAND:	
(based on previous annual 90th percentile results)	
NUMBER OF SAMPLES	

PLANNED FOR THE CURRENT SAMPLING CYCLE:	**Q1**	**Q2**	**BI-ANNUAL RESULTS**	**Q3**	**Q4**	**ANNUAL RESULTS**
Number of samples taken						
Quarterly HEG classification						
(based on 90th percentile measurement results)						

HEG	**Sample concentration**	**Mean polluta**	**OEL**

Occupations codes in HEG	Occupations in HEG	Number of persons per occupation	Pollutant code	per occupation (TWA- 8hr) mg/m3	Analysis %	nts concentration dose allocated to medical records (Tick appropriate block) mg/m3 f/ml ppm	90th percentile HEG classification	(Tick appropriate block) mg/m3 f/ml ppm	Pollutant Index	AQI
TOTAL										

COMMENTS ON:

Reasons for over-exposures

Corrective measures that will be implemented to prevent/mitigate over-exposures

ANNEXURE D
Supplementary information for determination of HEGS

(For information purposes only)

1 Definitions

'Occupational exposure limit (OEL)' means the time weighted average concentration for an eight-hour work day and a 40-hour work week to which nearly all workers may be repeatedly exposed without adverse health effects.

'Occupational exposure limit - ceiling limit (OEL-C)' means an instantaneous value, which must never be exceeded during any part of the working **exposure**.

'Occupational exposure limit - short term exposure limit (OEL-STEL)' means a 15-minute **TWA exposure** that should not be exceeded at any time during a workday even if the eight-hour **TWA** is within the **OEL-TWA**. Exposures above the **OEL-TWA** up to the **STEL** should not be longer than 15 minutes and should not occur more than four times per day. There should be at least 60 minutes between successive **exposures** in this range. An averaging period other than 15 minutes may be recommended when observed biological effects warrant this.

For those substances for which no **OEL-STEL** have been specified, excluding airborne particulates, a figure of three times the occupational **exposure** limit is to be used when controlling short-term excursions in **exposure**.

'Respirable particulates' means the respirable fraction of airborne particulates.

'Inhalable particulates' means the inhalable fraction of airborne particulates.

2 Exposure Standards for Particulates not otherwise Classified (PNOC)

Not all dusts have assigned **exposure** standards. However, it should not be assumed that this indicates that these unlisted particulates do not represent a hazard to health.

In addition to any specific physiological effect related to the unique properties of an individual particulate, high concentrations of particulates in the workplace may cause unpleasant deposition of dust in the ears, eyes and upper respiratory tract, and reduce visibility in the workplace. In addition, the mechanical action of these dusts, or the cleaning procedures necessary for their removal, may cause injury to the skin or mucous membranes.

Where no specific **exposure** standard has been assigned and the substance is both of inherently low toxicity and free from toxic impurities, the recommended **exposure** standard for **PNOC** in general should be 10 mg/m3 for inhalable particulates and 3 mg/m3 for respirable particulates. However, this general **exposure** standard should not be applied where the particulate material contains other substances, which may in themselves be toxic or cause physiological impairment at lower concentrations. In such circumstances, the **exposure** standard for the more toxic components should be applied. For example, where a dust contains asbestos or more than one per cent crystalline silica, such as quartz, cristobalite or tridymite, the **exposure** to these materials should not exceed the appropriate value for these substances.

Providing the airborne particulate does not contain other hazardous components, compliance with the **exposure** standard for dusts in general should prevent impairment of respiratory function even over many years of **exposure**.

3 Mixtures of Substances

The **exposure** standards listed in this document are applicable to airborne concentrations of single pure substances. In practice, however, a working environment may contain a number of **airborne pollutants** and **exposure** to these additional substances, either simultaneously or sequentially, could give rise to an increased hazard to health.

Although the following proposals have been made to deal with mixtures, in several specific cases, the application of **exposure** standards to environments containing mixtures of pollutants requires considerable caution. The interaction of any particular mixture of substances should be assessed by either toxicologists, occupational hygienists or physicians after specific toxicological consideration of ail substances involved:

- Independent effects.
- Additive effects.
- Synergism and potentiation.

3.1 Independent effects

Where there is clear toxicological evidence to indicate that two or more pollutants have totally distinct mechanisms of effect on the body, each substance may be separately evaluated against its appropriate **exposure** standard, For example, since crystalline silica affects the lungs, and inhaled ethanol vapour acts upon the liver and central nervous system, each of these substances may be assessed individually against its appropriate **exposure** standard. If neither standard is exceeded, the atmosphere within the working environment is deemed to be satisfactory.

3.2 Additive effects

When the body is exposed to two or more contaminants, an additive effect is obtained when pollutants have the same target organ or the same mechanism of action. In this situation, the total effect upon the body equals the sum of effects from the individual substances.

When assessing the hazard from a mixture of airborne contaminants, it is important to identify and quantify all components in the airborne mixture as a number of factors, such as particle size distribution or solvent vapour pressure, can give rise to substantial variations between the concentration of each component in the parent mixture and that which occurs in air.

Although an example of an additive effect is the general effect of organic solvents on the central nervous system (narcotic or anaesthetic effect), the **exposure** standard for a number of solvents, such as benzene and carbon tetrachloride, have been assigned on the basis of effects other than those on the central nervous system.

Therefore, it is essential to refer to the documentation for the specific substances to ascertain the basis of the standard and any potential interactions.

3.3 Synergism and potentiation

Sometimes the combined effect of multiple **exposures** is considerably greater than the sum of the effects from the individual components. This phenomenon can be one of synergism or potentiation. Synergism occurs when both chemicals have an effect individually and a more than additive effect when together. Potentiation is when one chemical has an effect, but the second chemical does not, but enhances the effect of the former chemical on combined **exposure**.

An example of a synergistic effect is the combined effect of solvents such as n-hexane and methyl ethyl ketone (MEK) on the nervous system. In combination, the damage caused by simultaneous high concentrations of both these solvents is far greater than the sum of either of these substances acting alone.

Interaction can also arise from **exposures** via routes other than inhalation. For example, imbibed alcohol increases the narcotic effects of inhaled trichloroethylene. Interaction effects may also occur in connection with **exposure** to entirely different environmental factors such as simultaneous **exposure** to chemical agents and physical factors, such as light, heat and noise. Smoking of tobacco is known to have a synergistic effect in combination with, for example, inhaled particulates.

At present the understanding of interaction effects is incomplete. The knowledge that such effects can occur is reason to maintain the concentrations of individual substances as low as is practicable under complex **exposure** conditions.

TABLE C1: Substances which are considered to have additive or synergistic effects

IRRITATION		ORGAN DAMAGE				SYSTEMIC EFFECT			OTHERS		
Respiratory	Eye	Skin	Dermal	Lung	Liver	Kidney	Blood	CNS	Fume fever:	Dyspnoea	Pneumoconiosis
Aluminium	Aluminium	Aluminium	Aluminium	Aluminium	Arsenic	Arsenic	Cadmium	Lead	Aluminium	Cadmium	Aluminium
Antimony	Antimony	Antimony	Arsenic	Arsenic	Boron	Boron	**COP**per	Lithium	Antimony	Cobalt	Beryllium
Arsenic	Beryllium	Arsenic	Boron	Beryllium	**COP**per	Cadmium	Lead	Manganese	Beryllium	Manganese	Cobalt
Beryllium	Boron	Beryllium	Chromium	Cadmium	Manganese	Chromium	Manganese	Mercury	Cadmium	Selenium	Iron
Boron	Calcium	Boron	Cobalt	Chromium	Mercury	**COP**per	Phosphorus	Tin	Cobalt	Vanadium	Silica
Cadmium	Chromium	Calcium	Lithium	Cobalt	Molybdenum	Manganese	Selenium		**COP**per	Zinc	Tin
Calcium	**COP**per	Chromium	Nickel	**COP**per	Phosphorus	Mercury	Tin		Iron		
Cobalt	Lithium	Lithium	Potassium	Manganese	Selenium	Nickel			Magnesium		
COPper	Magnesium	Mercury	Silver	Nickel		Phosphorus			Manganese		
Lithium	Mercury	Nickel	Sodium	Potassium		Selenium			Mercury		
Magnesium	Molybdenum	Phosphorus	Tin	Silica					Nickel		
Molybdenum	Phosphorus	Potassium	Zinc	Titanium					Selenium		
Phosphorus	Potassium	Selenium							Tin		

Potassium	Selenium	Sodium	Zinc
Selenium	Sodium	Tin	
Sodium	Tin		
Tin	Vanadium		
Titanium			
Vanadium			
Zinc			

ANNEXURE E

Background information, sampling and analysis on particulates

(For information purposes only)

This annexure provides background information on particulates, details sampling and analysis methodologies.

1 Sampling Methodology and Analysis for Airborne Particulates

1.1 Gravimetric sampling of airborne particulates will be used as a basis for measuring environmental conditions and expressing the results as a concentration in milligrams per cubic metre of air (mg/m3).

1.2 Instruments shall make use of a constant volume pump or other means for the constant aspiration of air. Volume flow rates are to be calibrated before and checked after each sample with the sampling train in line, using the volume displacement method (soap bubble method) as the primary standard; the required flow rate will be dependent on the sampling methodology. Samples are to be discarded if the flow rates vary by more than 5% (elutriator or cyclone efficiency for particle size selection is dependent on flow rate).

1.3 Filter media suitable for the various applications will depend on the sampling methodology adopted.

1.4 Mass determination of filters is to be done by using micro-balances capable of reading to the nearest 10 micrograms.

1.5 Samples, once taken, are to be transported in such a manner that any possible particulate loss resulting from bumping, vibration or being transported is minimised. Filters should be transported with the dust deposit side facing upwards.

NOTE: The use of the public postal system or other public transport services does not satisfy the above requirements.

2 Standard Procedure for the Assembly of the Sampling Train

2.1 Introduction

Filters are used to sample airborne chemical hazards in particulate form. Particulate samples are collected using a small, porous filter typically 25 mm or 37 mm in diameter. A cyclone is used when the measurement of respirable dust is required. Respirable dust particles are those particles small enough to reach the alveoli of the lung. When using a cyclone, the larger particles will be removed from the air by centrifugal force and fall into the bottom of the cyclone, while the smaller particles (respirable) will pass through the cyclone and be collected on the filter.

2.2 Equipment required

(a) Air sampling pump capable of sampling at the recommended flow rate with the sampling medium in line.

(b) Air flow calibrator, such as an electronic calibrator.

(c) Filters, support pad or, screen and cassette blanks as specified in the method.

(d) Cyclone, size as specified in the method.

(e) Filter cassette holder.

(f) Optional equipment, such as cassette sealing bands.

(g) To determine the correct flow rate for the chemical being sampled, refer to the appropriate analytical method.

2.3 Preparing the filter cassette

The filter cassette is used to hold the filter securely in place during sampling. The cassette consists of an inlet, an outlet and possibly a middle ring or extension cowl.

The cassette with all three sections can be used with the inlet in place (closed face) or with the inlet removed (open face) depending on the method.

2.3.1 Without cyclone - see Figure D1

To load the cassette, place a cellulose support pad or stainless-steel screen in the outlet of the cassette and add the appropriate filter. Add the extension cowl or middle ring if required then close the cassette firmly with the inlet. Insert the plugs into the inlet and outlet.

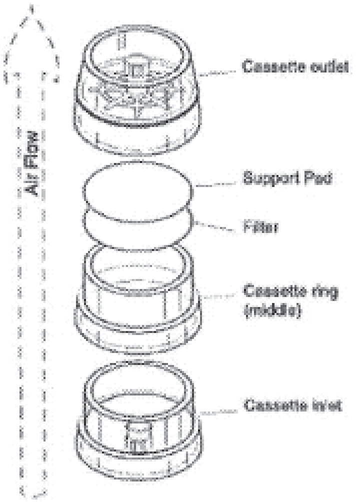


Figure D1: Filter assembly

2.3.2 With cyclone - see Figure D2

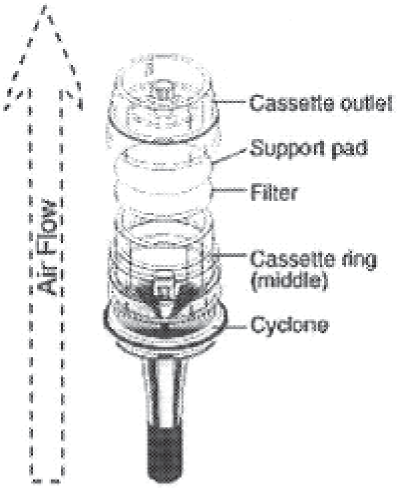


Figure D2: Filter assembly with cyclone attached

Place a cellulose support pad in the outlet of the cassette and add the appropriate filter. Add the middle ring and place the cyclone securely into this ring. Insert the plug into the cassette outlet. The cyclone must meet the ISO/CEN/ACGIH size selective curve.

2.4 Setting up the sampling train

2.4.1 Without a cyclone

Ensure that the pump is in the correct flow mode. When calibrating the flow use the sampling train that is to be used in the field. Remove the plugs from the cassette and use flexible tubing to connect the filter outlet to the pump intake and the filter inlet to the external flow meter.

2.4.2 With a cyclone

Ensure that the pump is in the correct flow mode. When calibrating the flow, use the sampling train that is to be used in the field. Insert the cyclone calibration chamber over the cyclone and ensure that it fits securely to avoid leaks. Remove the plug from the cassette and use flexible tubing to connect the filter outlet to the pump intake and the calibration chamber to the external flow meter. The cap on the stem of the cyclone (grit pot) should remain in place during calibration and use. The cyclone must meet the ISO/CEN/ACGIH convention for respirable particulate sampling.

3 Sampling

Prior to sampling commencing you may want to seal the cassette with a cellulose band to prevent leakage from occurring. Secure the cassette and attach the adapter on the end of the short piece of rubber tubing to the outlet of the cassette. Then connect the long piece of flexible tubing to the inlet of the pump. Attach the filter holder in the worker's breathing zone and the pump to the worker's belt (pumps are sometimes placed in a protective leather pouch and the whole harness strapped to the chest or back of the person being sampled, with the filter assembly in the worker's breathing zone). The inlet of the cassette should be facing down. If a cyclone is being used, it should be placed in a vertical (downwards) position. Remove the plug from the cassette inlet if applicable and turn the pump on. Note the start time and any other pertinent sampling information.

4 After Sampling

At the end of the sampling period, turn the pump off and note the stop time. Using a calibrated flow meter, check the flow rate to verify that the flow has not changed by more than 5%.

Remove the filter cassette from the holder and cap the inlet and outlet of the cassette with the plugs provided. If a cyclone was used, remove the cyclone and discard the dust in the grit pot. Close the cassette firmly with the inlet, and cap the inlet and outlet with the plugs. When removing cassettes from the sampling train, handle carefully to avoid losing the sample.

Pack the sample filter and all pertinent sampling information securely for transportation to the weighing facility for post-weighing.

The main problem associated with the assembly of filter cassettes and cyclones (sampling train) is that of possible particulate mass loss due to internal leakages (airflow past the filter paper) and/or external leakages (through connections, faulty cyclones or damaged filter cassettes).

5 Visual Examination

Visual examinations necessary to minimise leakage are as follows:

5.1 External leakages

(i) Grit pots at the bottom of cyclones must be tight fitting and with no cracks or cuts. Cable ties or clamps may be necessary in some instances.

(ii) Check that rubber 'O'-rings, where fitted, are in good order.

(iii) Check each segment of the filter cassette for cracks. The various segments most be firmly pressed together to ensure that the filter media and support pad are well nipped. Wrap the joints with a good quality insulation tape or shrink seal.

(iv) Cyclones must be critically examined for loose screws, missing gaskets, perished or oversized rubber 'O'-rings, broken or cracked parts etc.

(v) Good quality transparent tubing, in good condition (no cracks or weak areas), must be used. All connections must be fitted with cassette adaptors, cable ties or clamps. Tube connections must be made over outlet parts. Insert-type connections must be avoided.

5.2 Infernal leakages

(i) Check that the rubber 'O'-rings are good order where fitted.

(ii) Fit the pre-weighed filter paper precisely on top of a new support pad (a metal support grid is not recommended) inside the filter cassette. Ensure that the filter media faces the intake airside of the assembly.

(iii) For a proper seal check that the filter cassette rides on the small rubber 'O'-ring inside the cyclone before assembly. Secure the threaded plastic ring firmly.

5.3 General

(i) All instruments must be cleaned after use with a damp cloth, which has been submerged in a mild solution of detergent and water.

(ii) Cyclones and plastic cassettes must be washed in a mild solution of detergent and water. Rinsing with water should be followed up with a final rinse in methyl alcohol after which they should be allowed to dry.

(iii) The use of an ultra-sonic bath is also recommended for the cleaning of cyclones and cassettes.

(iv) Due to the possible contamination of filters, Vaseline or silicone grease is not recommended for sealing purposes.

(v) A good seal is indicated when the edge around a used filter paper, where the two interlocking segments of the cassette make contact with the filter paper, is free of particulate matter.

(vi) The removal of the cyclone body from the cassette must be done slowly and with great care so as not to dislodge any collected particulate matter from the filter.

NOTE: Filter holders should be removed from the cyclone at the end of sampling for transport to the weighing facility with the dust deposit side facing upwards. Unnecessary movement or handling before transportation is undesirable.

6 Sampling Methodology

6.1 Introduction

As small quantities of particulates are collected in personal gravimetric sampling, the most practical method of assessing such quantities of particulates is to establish the mass of the clean filter before sampling, and then to observe the increase in filter mass due to the particulates collected on the filter. In principle, the difference between the 'before sampling' mass and the 'after sampling' mass represents the mass of particulates collected.

There are, however, factors which could affect the particulate mass measurements. These include:

(i) Variation in filter mass due to absorption or desorption of moisture between the 'before'- and 'after' sampling mass determinations.

(ii) The basic limitations of instrumentation, weighing procedure and competency of staff.

This standard weighing procedure incorporates practical means for alleviating these problems.

6.2 Requirements of sampling pump

A portable battery powered pump must be used for personal sampling. The capacity of the battery must be sufficient to operate continuously over the chosen sampling time. The pump should be capable of maintaining the required flow rate with a variation within ±5% for the entire sampling duration, allowing for increasing filter loads. Pumps with automatic flow control facilities are recommended. The performance characteristics of field sampling pumps vary considerably and reference should be made to experienced laboratories for selection of pumps for specific sampling applications.

The flow must be sufficiently free from pulsation. As a minimum and tentative criterion, there must be no visible vibration of a rotameter float, if such a flow meter is connected to the filter holder with the filter inserted. It may be necessary to install a pulsation damper between the pump and the filter if an internal pulsation damper has not been included or if the pump shows significant pulsation.

Connecting tubing must be constriction-proof and the connections leak proof.

CAUTION: When sampling in explosive gas or dust atmospheres, ensure that the sampling pump is intrinsically safe.

6.3 Calibrating a pump with an electronic calibrator

Personal sampling pumps are essential tools for sampling airborne contaminants. However, the determination of airborne concentrations requires accurate knowledge of the volume of air sampled. This value depends upon the constancy of the flow rate of the pump, and upon the reliability of the means of measuring that rate.

Built-in rotameters on sample pumps are not precision instruments and cannot be used to determine a pump's flow rate. These devices provide only an approximation. Flow rates should be measured with an instrument such as an electronic calibrator, which bases measurement on the unchanging physical dimensions of an enclosed volume. A precision rotameter can also be used, but only if its calibration is traceable to a device such as an electronic calibrator or a film flow meter, and the rotameter is capable of maintaining accuracy with reasonable care and handling. Unlike an electronic calibrator, a precision rotameter requires periodic calibration.

Equipment required

- An air-sampling pump capable of sampling at the recommended flow rate with the sampling medium in line;
- An electronic calibrator (or precision rotameter);
- The sampling media as specified in the method; and
- Any additional equipment specified in the method.

(a) Setting up the electronic calibrator

Pour a small amount of film solution into the bottom opening of the flow cell. The amount of solution is not critical, but the solution level should just cover the bottom of the flow cell. A large amount of soap may cause a stream of bubbles at high flows.

(b) Setting up the sampling train

Prepare an appropriate sampling train as specified in the method. Ensure that the pump is in the appropriate mode (high- or low-flow) for the desired flow rate, and that any necessary flow accessories (such as pressure controllers) are in place. With flexible tubing, connect the outlet of the sampling media (filter cassette, sorbent tube, impinger, etc) to the inlet of the pump.

(c) Calibrating the flow rate

Turn on the pump and allow approximately five minutes for stabilisation. Connect the inlet of the sampling media to the electronic calibrator (see Figure D3), Make this connection with the shortest tubing length possible and avoid kinks and bends in the tubing for accurate measurements.

NOTE: Some electronic calibrators have two fittings: one for negative pressure and one for positive pressure. Please refer to your calibrator operating instructions for the proper fitting selection.

Prepare the calibrator for use by ensuring that the flow cell is completely wet with bubble solution. To wet the flow cell, start the soap film travelling up the flow cell by repeatedly pressing and releasing the plunger button or squeezing the rubber bulb. Continue to generate bubbles until the bubbles travel the entire length of the tube without breaking and the flow cell is completely wet with bubble solution.

To calibrate the flow rate, start a single bubble travelling up the flow cell by pressing the button or squeezing the bulb. Observe the bubble passing through the tube. The bubble must travel the entire length of the tube for an accurate measurement. A flow rate is displayed on the calibrator LCD. Perform a minimum of three readings to accurately determine the flow rate.

Using the flow adjust control on the pump, increase or decrease the flow rate until it approximates the desired flow rate as specified in the sampling method.

Several readings and adjustments may be needed until the desired flow rate is achieved.

(d) Sampling

When ready to begin sampling, set up a calibrated sampling train. Use pre-prepared sampling media of the same type. Attach the sampling media to the worker's clothing within the breathing zone and the pump to the worker's belt, Activate the pump and note the start time.

(e) After sampling

At the end of the sampling period, turn the pump off and note the stop time. Using the calibrator, measure the flow rate following the directions outlined earlier. Record this value as the 'post-sample' flow rate. Compare the pre-sample and post-sample flow rates to ensure that the two flow rates do not differ by more than 5%, The average of the pre-sample and post-sample flow rates should be reported to the weighing facility along with other relevant data including the sample time. Remove the sampling media, seal the sampling media for transport to the weighing facility and record pertinent sampling information.

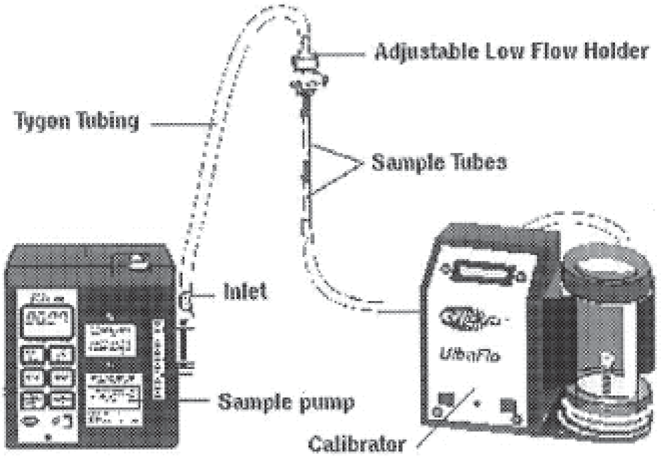
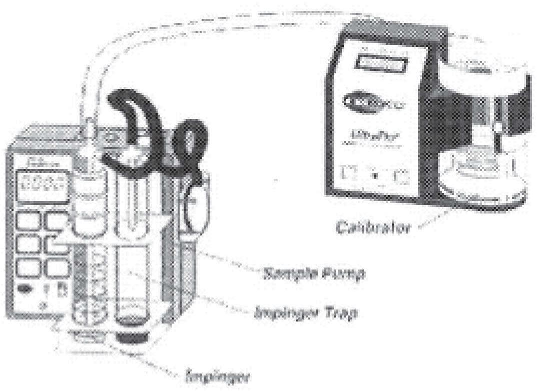
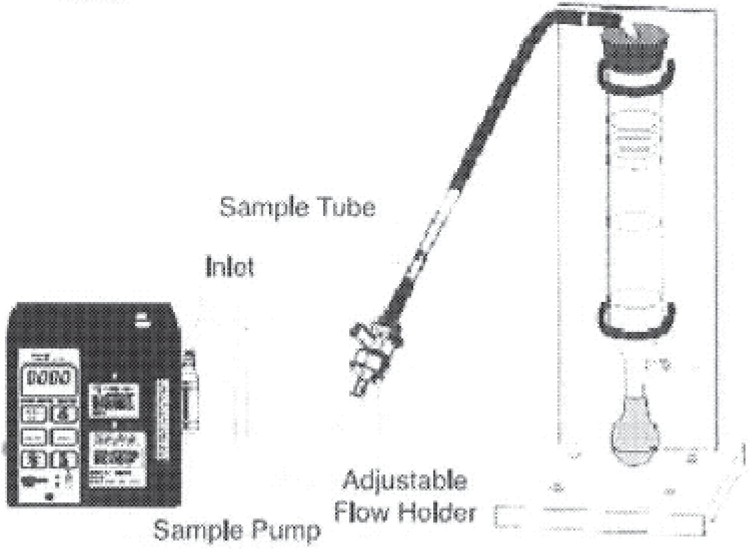


Figure D3: Air sampling pump connected to an electronic calibrator





6.4 Calibrating a pump with a film flowmeter

6.4.1 Equipment required

- Air sampling pump capable of sampling at the recommended flow rate with the sampling medium in line;
- Film flow meter - air flow calibrator or precision rotameter;
- Precision timing device;
- The sampling media as specified in the method; and
- Any additional equipment specified in the method.

6.4.2 Introduction

To determine the correct flow rate for the chemical being sampled, refer to the appropriate analytical method. Please refer to the operating instructions for the pump to ensure that it is capable of sampling at the correct flow rate.

(a) Setting up the film flow meter

Some film flow meters come with a separate stand or base. If so, stand the glass tube vertically using the base so that the rubber squeeze bulb is at the bottom. If no base is provided, use lab clamps and a support stand. Remove the rubber cap from the lower side arm of the glass tube. Pour film solution into the lower side arm so that the solution enters the rubber bulb and the level of the solution is about ¼ inch (6-7 mm) above the upper rim of the bulb. The solution level should not reach the side arm of the tube. A pipette may facilitate the filling procedure. Alternatively, film solution can be introduced through the top of the glass tube. Simply remove the stopper, tilt the tube and pour gently. When operating the flow meter, the cap must remain off the side arm.

(b) Setting up the sampling train

Prepare an appropriate sampling train as specified in the method. Ensure that the pump is in the appropriate mode (high- or low-flow) for the desired flow rate, and that any necessary flow accessories are in place. With flexible tubing, connect the outlet of the sampling media (filter cassette, sorbent tube, impinger, etc) to the inlet of the pump. Connect the inlet of the sampling media to the outlet (upper port) of the film flow meter.

(c) Calibrating the flow rate

Remove the rubber cap from the lower side arm of the flow meter. Turn on the pump. While the pump is operating, repeatedly squeeze the rubber bulb at the base of the glass flow meter tube until a flat soap bubble (film) enters the tube and rises up the column. Introduce several bubbles into the tube to wet the tube interior so that the soap film successfully travels the entire length of the tube. Observe the soap film as it passes the volume lines marked on the glass tube. Using a stopwatch or other precision timing device, accurately determine the time it takes for a single soap film to travel from one volume line to another. This time, together with the volume delineated on the tube, represents the flow rate:

Flow rate = volume bubble travels (ml or L) / time it took to travel (min)

Using the flow adjust control on the pump, increase or decrease the flow rate until it approximates the intended flow rate as specified in the sampling method. Several measurements and adjustments may be needed until the desired flow rate is achieved.

(d) Determining the flow rate

Once the desired flow rate has been achieved, accurately measure the flow rate at least three times using the flowmeter in the manner described above.

(Do not adjust the pump's flow adjust control this time.) Average the results. Record this averaged value as the 'pre-sample' flow rate.

(e) Sampling

When ready to start sampling, set up a new sampling train identical to the one used to measure and calibrate the flow. Use new sampling media of the same type. Do not discard the sampling devices that were used to calibrate the flow; these will be used to check the flow again when sampling is completed. Attach the sampling media to the worker's collar and the pump to the worker's belt. Activate the pump and note the start time.

(f) After sampling

At the end of the sampling period, turn the pump off and note the stop time. Remove the sampling media, seal the ends and record pertinent sampling information.

(g) Rechecking the flow

Reattach the sampling media originally used to calibrate the flow rate of the pump (if these are not available, use new media). Using the flow meter, measure the flow rate following the directions outlined in step 4. Record this averaged value as the 'post-sample' flow rate. Compare the pre- and post-sample flow rates to ensure that the two flow rates do not differ by more than 5%. The average of the pre- and post-sample flow rates will be reported to the weighing facility along with other relevant data.

7 Filters

The selection of a particular filter type for a specific application is invariably the result of a compromise of many factors. These factors include cost, availability, collection efficiency, analytical requirements and the ability of the filters to retain its filtering properties and physical integrity under the ambient sampling conditions. The sampling methodology adopted will determine the type of filter required. Recognised methodologies such as HSE or **NIOSH** analytical methods must be consulted.

A suitable backing pad is required to support the filter disk in the cassette.

7.1 Correction for the influence of moisture

Due to the hygros**COP**ic nature of most filters, it is necessary to quantify any variation in their moisture content. Reference filters are thus used in the weighing procedure as follows:

- Reference filters always remain in the weighing room and are weighed during both the 'before' and 'after' mass determinations of field filters.
- Any variation in mass between the 'before' and 'after' mass measurements will reflect the change in moisture content. This variance is then accordingly used to correct the mass of the field filter.

7.2 Weighing errors

A maximum allowable variation of 0.05 mg in the mass of filters in three consecutive weighings of the same filter, is allowed. Should these three measurements vary by more than the value mentioned above repeated mass determination must be performed.

7.3 Preparation of filters

An important step in ensuring accurate results and records is the correct marking and preparation of filters.

7.4 Identification of filters

(i) Filters from individual packs must be readily identified by means of a suitable marking system. A ball point pen can be used to mark filters. Marking to be done on the backing-pad facing down to be readable from the bottom as the chemicals in ink sometimes interfere with chemical analyses.

(ii) In order to ascertain the hygros**COP**ic character variances between individual filters with acceptable accuracy, three reference filters must be selected from each batch/pack which must not contain more than 100 filters.

(iii) These field and reference filters must be stored in petri-slides until needed.

7.5 Treatment of filters prior to weighing

Filters

(i) At least 12-hours before filters are due to be weighed the required number must be placed in a partially open Petri slide/dish in the stabilisation cabinet/chamber.

(ii) At the same time the Petri slide/dish containing the relevant reference filters must be partially opened and placed in the same cabinet/chamber for the same period of time.

8 Storage / Transportation of Samples

8.1 Description of carrying case (minimum requirements)

- The handle must be positioned as to ensure that samples remain 'dust deposit side facing upwards' at all time.
- The case should be constructed to prevent inadvertent opening during handling or transport.
- The case should have markings to indicate 'right side-up'.
- The case should be lined with a low-density sponge with suitable recesses for samples to protect them against shock and vibrations.

8.2 Method of transport between working place and weighing room

Briefing of persons responsible for transporting the sample carrying case.

8.3 Storage of samples before transportation to weighing facility / analysing authority

Samples awaiting transport are to be kept 'right side-up' in a suitable cabinet or in a suitable foam-lined carrying case.

8.4 Method of transport between concern and analysing authority

Public couriers, unless a specialised service, are not acceptable, only persons briefed on the contents and transport requirements may be used.

9 Weighing Room

9.1 The following points should be considered when selecting a weighing room:

(a) The location of the weighing room should be in an uncontaminated, dust free environment and away from any activity or equipment that can cause vibration.

(b) To avoid draughts and the ingress of dust, windows, if fitted, must at all times be kept closed (sealed) and the entrance to the weighing room must preferably be through an airlock or otherwise a self-closing door (any other condition that may affect a stabilised atmosphere must be addressed).

(c) Commercial air conditioners are not acceptable unless they are of the type designed to maintain a constant humidity and temperature.

(d) This room must be dedicated to the weighing and preparation of filter cassettes.

(e) The following signs should be displayed at the entrance to the weighing room:

(i) Weighing room.

(ii) No smoking.

(iii) No acclimatisation in progress (when applicable).

(iv) Weighing in progress (when applicable).

9.2 The transparent weighing/stabilisation cabinet

The transparent weighing/stabilisation cabinet may be used in conjunction with or in lieu of the weighing room and subject to the following:

(i) The criteria for filter weighing, as described in this supporting document must, as far as is compatible with the new method, be adhered to.

(ii) The construction of the cabinet should conform to the following:

(a) Dimensions

The minimum dimensions shall be:

0.8 m length

0.5 m width

0.5 m height

(Dimensions resulting in a smaller volume than that reflected above [0,2m3] will be problematic as it was found that the human body does affect the temperature and humidity inside the cabinet during the weighing process).

(b) The cabinet body

The cabinet body should be constructed of an angle strip metal frame housing not less than 3 mm thick transparent Perspex (or glass) panels bolted or screwed to the metal frame. The metal used should be a good conductor so as to assist in discharging static electricity from the Perspex panels. The body should consist of four side panels and one top panel.

(iii) Static electricity

(a) The cabinet shall be placed on an anti-static mat of slightly larger dimensions than the cabinet itself without any sealing material between the metal frame and the anti-static mat.

(b) The metal frame of the cabinet shall be properly earthed independently of the anti-static mat.

(iv) Surroundings

(a) The cabinet must not be exposed to wide variations in temperature and humidity. The following are examples of undesirable situations:

- The cabinet must not be exposed to direct sunlight.
- If an air-conditioning unit is operated in the same room it must not be switched on and off according to whim but must be kept running constantly to keep the temperature and humidity reasonably constant. The same principle applies to heaters during winter.
- Kettles must not be boiled in the same room as it creates a sharp increase in the humidity.

(b) Pollution of the surroundings of the cabinet by dust, cigarette smoke, etc must be avoided.

(c) The balance table, anti-static mat and cabinet must be dedicated solely to the purpose it was provided for.

(v) Acclimatisation

Both reference and field filters due to be weighed must be acclimatised for at least 12-hours. Steps must be taken to ensure that the cabinet is not lifted up or any of the apertures opened up during the acclimatisation period.

9.3 Weighing room equipment

(i) Filter weighing

A balance capable of weighing to the fifth decimal point of a gram is required eg reading to the nearest 10 micrograms.

(ii) The following is required with regard to weighing room equipment and practice:

(a) The balance, correctly levelled must stand on a rigid specially designed balance table on a properly earthed anti-static mat.

(b) The balance must remain uncovered at all times and if possible the side doors left slightly open to allow air circulation during the acclimatisation period.

(c) The balance must be regularly maintained and calibrated and a record kept. It is strongly recommended that a standard weight be used to check the accuracy of the scale in the interim periods.

(d) An additional anti-static mat for disassembly of cassettes is required.

(e) Sufficient storage space for filters and associated equipment must be provided.

(f) A filter stabilisation chamber or cabinet so designed as to allow free air circulation should be provided.

(g) Carpets are not allowed in the weighing room because of problems of static build up unless they are manufactured and installed according to the South African Bureau of Standards' specifications.

9.4 Weighing room accessories

(a) Suitable spring-loaded tweezers for handling filters.

(b) Petri slides/dishes.

(c) Suitable marking pen. Ball point for filters.

(d) Suitable means for recording weighing.

(e) Non-static cloth for cleaning purposes.

9.5 Weighing procedure

9.5.1 Filter weighing procedure

Switch on the balance and leave it to 'warm up' for at least 30-minutes. Certain balances, provided the power is on, remain in a 'standby' mode and in such a case no warm up period is needed.

In order to facilitate the removal of filters from the weighing pan it is recommended that a small 'O'-ring of an impervious material be positioned in the centre of the pan. An added advantage of using an 'O'-ring is that all weighing takes place at a centralised position on the weighing pan so avoiding corner load errors.

Weigh the three reference filters simultaneously or individually, three consecutive times. These three filters remain allocated to the remainder of the field filters from that batch of field filters for mass correction purposes.

If weighed simultaneously the three reference filters should be placed evenly around the centre of the weighing pan.

Weigh each of the first 10 field filters three times consecutively.

Repeat the weighing of the three reference filters (this serves as a dual function: a check on the stability of the weighing room atmospheric condition and for mass correction on the following batch of field filters).

If the difference is 0.1 mg or less per filter proceed to weigh the next 10 field filters. If the difference is greater than specified above, the weighing room environment is unstable and the reference filters must be weighed more often. Also re-weigh the previous 10 field filters.

NOTE: Samples once taken, are to be transported in suitable containers so as to minimise any possible particulate loss resulting from bumping, vibration or being transported in the inverted position. Filters should be transported with the dust deposit facing upwards.

9.5.2 Particulate mass determination (mg)

(a) Mass 1 (before sampling):

(i) Mass of field filter and moisture content.

(ii) Mass of each reference filter (normally three reference filters are used). If reference filters are weighed in batches of three, one third of the measured mass must be taken.

(b) Mass 2 (after sampling):

(i) Mass of field filter, particulates and moisture content.

(ii) Mass of reference filter and moisture content.

(c) Gross mass of particulates and moisture content on filter:

Mass 2 (b)(i) - Mass 1 (a)(i)

(d) Correction factor for moisture content change (derived from reference filters):

Mass 1 (a)(ii) - Mass 2 (b)(ii).

This gives a + or - factor.

(e) Absolute mass of the particulates on the filter:

Gross mass (c) + or - correction determined in (d).

NOTE: Any apparent negative value for the particulate mass must be examined critically and the reasons for this carefully analysed.

9.5.3 Remarks

(a) The above procedure is the minimum requirement for particulate mass determination.

(b) Wetted filter media, which have obviously been damaged physically, must be discarded. Others may be dried and weighed after the normal acclimatisation period. All filters, which appear to have been tampered with, must be discarded and air samples re-taken as soon as possible. Pre-weighed field fitters together with their respective reference filters are preferably to be used within a period of three months.

(c) Dust samples for radiation monitoring are conducted using the same methodology and quality assurance.

10 Analysis

The analysis and quality control must be in accordance with internationally recognised methods such as **NIOSH** or HSE standards.

A cellulose nitrate or a mixed ester of cellulose filter should be used if analysis is required. The sample must be forwarded to an accredited chemical analytical laboratory to determine the chemical composition of the collected sample.

Brief descriptions of the various analytical methods are included to help the occupational hygiene practitioner in discussions with the analyst and to make sure that the samples collected will be suitable for analysis - it is not to train the occupational hygiene practitioner in analytical techniques.

10.1 Atomic absorption spectrometry (AAS)

This is a common method used for analysts of metals such as:

- Lead
- Cadmium
- Nickel
- **COP**per
- Zinc.

There are some 60-70 metallic elements, which can be analysed individually by this technique, which uses the fact that atoms in a vapour absorb light at specific wavelengths.

10.1.1Basic operation of an AAS

The metal particulate is dissolved into a solution by immersing and heating the filter in a solvent (typically a diluted acid). Part of this solution is aspirated (sucked) into a flame, which vaporises first the solvent and then the metal. All vaporised atoms of solvent and metal pass into a chamber through which a beam of light passes. This beam is generated by a specific lamp, which produces a characteristic spectrum consisting of light specific wavelengths. For each specific metal, a lamp is chosen so that its light spectrum is compatible with the absorption characteristics of the metal.

As the atoms of the specific metal pass through the light, they absorb energy from the light and the intensity of the beam is reduced in proportion to the numbers of atoms present. The reduction in intensity is measured and by comparing this reduction (usually referred to as absorbance) with a calibration curve, a measure of the amount of element present can be obtained.

10.2 X-ray diffraction (XRD)

X-ray diffraction is an analytical technique used to identify and quantify the constituent compound in a substance. It works as follows:

- Many solids, and particular minerals, are crystalline (their atoms are arranged in a highly ordered three-dimensional lattice) and when x-rays are directed at them, this lattice acts as a diffraction grating. Every crystalline substance produces a unique diffraction pattern and in a mixture of substances each will produce its own pattern independently of the others. Therefore, different substances can be identified in a mixture.
- The x-ray detector is swung round in an arc and a chart is produced showing lines of all the diffracted x-rays, which are picked up at different angles. The analyst will compare the patterns of the lines produced with standards and will be able to identify what is present in the sample. The more of a particular substance in the sample, the more intense will be the lines in the pattern. A calibrated x-ray diffractor will, therefore, give information not only on the type of crystalline substance in the sample, but how much there is.
- X-ray diffraction only works for crystalline substances and is used particularly for analysing minerals such as quartz (a crystalline form of silica).

10.3 X-ray fluorescence (XRF)

X-ray fluorescence is another method using x-rays, but it is used to identify and quantify elements rather than compounds. A beam of x-rays is directed at the sample, very much in the same way as XRD, but instead of the compounds in the sample diffracting the beam, the beam excites the atoms of the elements present causing them to emit their own radiation. This is a form of fluorescence. It is this secondary or fluorescent radiation, which is detected. Every element will produce radiation containing a characteristic set of wavelengths so that the trace obtained from a particular sample is compared to standard traces to determine the elements present in the sample. The intensity of the radiation given off is proportional to the amount of each element present, so if the instrument has been calibrated, it is possible to find out not only what elements are present but also how much there is.

XRF can be used to analyse elements from atomic number 9 (fluorine) upwards and is used particularly for metals.

10.4 Infra-red (IR)

Infrared can be used as an alternative method to XRD to analyse minerals. Light in the infrared region is directed onto a sample, which absorbs some of the light. A detector picks up the reflected rays of the remainder and a material is then identified and quantified according to how much light has been absorbed and in what regions of the IR spectrum.

ANNEXURE F

Quality assurance

(For information purposes only)

1 Role of Weighing Quality Assurance Program

Analytical data are used to make a variety of decisions, eg, to decide whether a particular chemical agent is present in a workplace atmosphere, whether a hazard to workers' health exists in that atmosphere, or whether a workroom atmosphere complies with applicable standards. Errors in such data can have a variety of costly effects. The consequences of erroneous data may lead to the wrong decision being made as to whether a non-compliance situation exists. If the analytical results are a part of a larger experiment, perhaps the wrong conclusion might be reached or the results might be uninterpretable. If the presence or absence of a particular agent is erroneously reported, a threat to workers' health may be allowed to continue. It is the role of a weighing facility's quality assurance program to provide the necessary safeguards to minimise these occurrences and to provide a means of detecting errors when they do occur.

It is not possible to design a quality assurance program to fit all weighing facilities since no two weighing facilities serve the exact same purpose or operate in exactly the same manner. Each weighing facility must set its own operating procedures and quality control practices, and document them in a Quality Assurance Manual. This chapter, therefore, will not set forth concrete recommendations for implementing a quality assurance program, but rather will present aspects of weighing facility quality assurance and quality control, which should be addressed by each facility.

A successful quality assurance effort cannot be achieved through the efforts of only one individual. A weighing facility's quality assurance coordinator needs the assistance and cooperation of all facility personnel to be effective. To this end, it is necessary to discourage adversarial relationships between quality control personnel and bench chemists. Analysts must be trained and made aware of the purpose and value of quality assurance functions and, in turn, the quality assurance program must be designed so that its functions are based on sound goals directed toward improving the performance of both the individual analyst and the facility as a whole.

Frequently, analytical results are challenged months or years after the analysis is complete. In order to support the original data, an effective record-keeping system must be maintained. Another chemist must be able to reconstruct the exact treatment to which the samples were subjected solely from an analytical laboratory's records. Furthermore, if the appropriate quality control checks were performed with the analysis and documented, there can be no doubt regarding the results.

2 Organisation

A weighing facility, just as any other organisation, should have a clearly defined organisational structure. Responsibilities of each member of the facility's staff should be in writing and understood by all. In this way, confusion regarding tasks that need to be performed can be avoided.

The specific organisational structure of the facility will vary, depending on the facility's function. Two functions that relate to quality should be assigned in every facility:

- The quality assurance coordinator; and
- The sample clerks.

The size and nature of the facility may preclude assignment of a full-time position to these functions; however, a facility member should be assigned these duties and it should be understood that they are to have top priority.

(a) Quality assurance coordinator

The quality assurance coordinator's functions will depend on the size and nature of the facility. This professional has overall responsibility for assuring that reported data meet established standards for precision and accuracy and that these results can be supported scientifically by the various quality control checks performed with the analysis. One of the major functions of this individual is to perform audits of the quality control system and to implement changes that eliminate recurring errors. The quality assurance coordinator should not be under the direct supervision of management responsible for day-to-day weighing facility's operation. In this way, conflicts between the facility's dual responsibilities of providing analytical results in a rapid fashion while maintaining quality can be avoided. The quality assurance coordinator should also serve as a resource person for chemists or managers on questions or problems related to quality assurance and should have a working knowledge of statistics, including quality control charting, and experimental design.

(b) Sample clerk

The sample clerk's functions will also vary, depending on the size and function of the facility. As a minimum, the sample clerk is responsible for the receipt and log-in of samples. Field samples should be stored in a secure location under proper conditions (temperature, etc) until analysis. Logging and tracking of samples in the facility is important so that the history of these samples can be documented and processed in a timely manner. The sample clerk may also be given the responsibility of maintaining chain of custody documentation.

3 Quality Assurance in Sampling

Quality assurance procedures should not be overlooked by personnel performing field sampling. The field sampling parameters often have more effect on precision and accuracy of the final result than parameters of the measurement. Field personnel should become familiar with sampling and measurement methods that they will use. The methods usually specify the proper sampling media to be used, the correct flow rate and sample volume, as well as special precautions on sample handling, shipping and possible interferences.

Sampling equipment must be maintained in reliable working order. It is desirable to have one person or group given responsibility for the care, maintenance and stocking of field sampling equipment. This person or group should periodically inspect and repair all equipment and keep track of the use and location of sampling equipment when it is signed out. Sampling pumps should be calibrated with each use. This calibration should be performed with the sampler in line. Since differences in pressure drop across the sampler will affect flow rate, it is necessary to perform the calibration with the actual sampler to be used.

The exact sampling time must be known in order to accurately estimate the sampled volume. Recording only the start and stop time assumes that the pump functions properly over the entire sampling period. Occasional spot checks for proper operation should be made throughout the sampling period.

Since many modern analytical techniques are extremely sensitive, special care must be taken to avoid contamination of field samples. Samples must not be stored or shipped with bulk materials that might spill or otherwise present the possibility for contamination. The glassware or other containers used in sampling and shipping should be subjected to any cleaning procedures recommended in the analytical method.

Careful record keeping in the field is also important. Pertinent information such as temperature, humidity, possible interfering compounds, sampling location, etc should be documented. Special care should be taken in sample labelling and in preparation of paperwork accompanying the samples so that confusion in the facility is avoided.

Field blanks are used to estimate contamination that may occur immediately before and after sampling, during shipment, or while awaiting measurement in the facility. The nature and number of blanks taken will depend on the method and sampling situation; therefore, field sampling personnel must attempt to determine what sources of contamination are possible in the specific situation at hand. The field blank strategy must then be designed accordingly. Where possible, a written sample protocol should be developed before actual sampling begins. The protocol should contain a description of the environment being sampled; the assumptions made in derivation of the model of that environment; when, where, and how the sampling will be done; and how many samples will be taken. Samplers should be identified by batch or lot number of sampling media.

4 Quality Assurance in Measurement

Certain quality control checks should be performed with each sample set to further support the reported results on actual field samples. The exact number and nature of these checks depend on the specific method and circumstances under consideration and should be thought of as an integral part of the method itself (ie a measurement should not be considered completed without the quality control checks also being completed). Each analyst must take an independent responsibility for assuring that the analytical quality control system works. This can be accomplished by using known spiked samples that closely simulate field samples with regard to concentration and interferences. Since the analyst is most familiar with the methods being used and should know what range of recoveries to expect, problems with the system can be detected early. The following additional quality control checks should be considered as appropriate:

(a) Methods

First, and perhaps most important in the area of quality control, a laboratory must have adequate measurement procedures. These methods should be written so that there is no doubt in the analyst's mind of the exact steps which must be performed and so that future references to the work can be as exact as possible. The methods used should be evaluated, where possible (either by the laboratory itself or by some other organisation), to verify that the methods perform satisfactorily. Factors that could be evaluated include the recovery of the analyte of interest from both spiked samples and generated samples, the stability of collected samples or possible interferences for accurate use of the method. Methods should be tested for ruggedness so that critical steps in the analysis can be identified. Experimental designs have been published which permit rapid evaluation of a number of factors involved in the analysis.

(b) Standards

Standard solutions may be for either identification or quantitation of the analyte of interest. The bulk material used for preparation of standards should be of sufficient purity to avoid errors in the identification or quantitation. Where available, Standard

Reference Materials or other well-characterised standards are useful for assuring that results are consistent with other organisations and agencies. Laboratory reagents and standards should also be properly labelled with contents, and receipt and expiration dates.

For quantitation, sufficient numbers of standards should be prepared so that adequate confidence intervals on reported values can be obtained. As a guideline, it is recommended that calibration curves be prepared with triplicate points at each of at least five different concentration levels. The standard curve should be prepared so that linearity can be assured over the range of the curve. Also, it is important that the concentration of standard solutions be chosen to bracket the actual samples. In this way, extrapolation outside the range of standards is avoided. The concentration of standard solutions should be chosen to be consistent with the purpose of the sampling. That is, if it is desired to demonstrate whether exposure standards are being met, then the standard curve should be constructed to bracket the concentrations which would be encountered at or near the applicable exposure standard. If it is desired to demonstrate whether a compound is present in the atmosphere being sampled, then the calibration curve should be constructed closer to the limit of detection. During measurement, working standards should be interspersed with field samples. In this way, it should be possible to detect if instrument drift becomes significant. Internal standards are useful for correcting instrument response for the actual amount of sample injected into a chromatograph. The internal standard should be chosen so that its retention time is reasonably close, without peak overlap, to the peak of interest.

(c) Blanks

A particular analysis may involve several types of 'blank' measurements including reagent blanks, media blanks or field blanks. Reagent blanks measure the signal contribution from solvents, acids or other reagents used by the laboratory in preparing samples for analysis. Media blanks measure the signal contribution from the collection media (impinger solution, filter, sorbent tube, etc) and field blanks measure signal contribution of the media plus any contamination that may have occurred during handling, shipping and storage before analysis. The nature and number of blank measurements will depend on the method and circumstances, but the purpose of all blank measurements is to help prevent errors in identification and quantitation of field samples.

(d) Blind samples

Blind samples are prepared by someone other than the analyst performing the measurement and are to provide an independent check on the accuracy and precision of the measurement.

If blind samples cannot be prepared with confidence, their use should be avoided. In these cases, confusion may result when discrepancies occur and it will not be possible to say for certain whether the measurement or the blind sample was in error.

The results should be used in conjunction with control charting techniques to identify errors or malfunctions in the system. To accomplish this goal, quality assurance personnel should work closely with laboratory personnel to quickly identify and eliminate trouble spots.

It will not always be possible to isolate the source of error in the results of a blind sample. In these instances, it should be recognised that it will not be possible to defend quantitative results for that particular sample set; therefore, reporting of results where these discrepancies occur should be avoided.

(e) Recovery studies

Recovery studies should be performed as a part of the measurement whenever the analyte of interest must be liberated or separated from the sampling media. The analyte of interest should be added to the media at levels consistent with the field samples. These 'spiked' samples should then be treated in the same manner as the field samples. Corrections for recovery should be made whenever the measured recovery is significantly different from 100%. Even if recovery has historically been 100%, recovery studies can be useful as additional analytical and calculation checks. It is often helpful for a laboratory to maintain a record of past recovery studies so that current data may be compared for discrepancies. Samples for which estimated recovery is less than 75% should be reported as 'semi quantitative'.

(f) Duplicates

Duplicate preparations of bulk materials are useful as an indication of the uniformity of the bulk material. Duplicate injections or measurements from air samples are of lesser importance since preparations from air samples are generally fairly uniform in nature. True duplicates of air samples are useful as an indication of the uniformity of the atmosphere being sampled.

5 Inter-Laboratory Testing

Assignable analytical uncertainty can be considered as consisting of interlaboratory and intra-laboratory variability. Knowledge of the magnitude of these two sources of variability is essential in order to interpret and use analytical data property. Intra-laboratory variability can be estimated from the results of analysis of blind samples. Inter-laboratory testing requires the cooperation and coordination of a number of independent laboratories.

Inter-laboratory testing can also be useful for defining the relationship of data reported by different laboratories using either the same or different measurement techniques. Participation in such studies can be useful for uncovering errors in methodology or identifying critical steps in the procedures.

The Proficiency Analytical Testing (PAT) Program operated by the American Industrial Hygiene Association (AIHA) in cooperation with **NIOSH** is useful for measuring a laboratory's performance on a variety of common occupational hygiene samples, including solvent vapours on charcoal tubes and metals, asbestos and silica on filters. Participation in this program by laboratories performing occupational hygiene analysis is strongly encouraged.

Similarly, the AIHA operates a laboratory accreditation program for occupational hygiene laboratories. Site visits and application reviews can provide a useful review of a laboratory's overall quality assurance system, as well as the adequacy of personnel, facilities and equipment.

6 Reporting

The detail and nature of the analytical report will depend on the function of the laboratory. As a minimum, the report should include a description or reference to the method used, any deviations or special circumstances encountered with the sample set, estimates of the limits of detection and quantitation, the date of analysis, as well as the results themselves. The report should be signed by the analyst and at least one other person who is responsible for approving the report. The laboratory should adopt a standard report format and attempt to maintain that format with all reports.

The limit of detection (LOD) is defined as the amount of the analyte that can be distinguished from the background. The limit of quantitation is that amount of analyte above which the precision of the reported results is better than a specified level. There are numerous methods of determining these quantities and many opinions as to which method is correct. The laboratory should decide on a method for determining these quantities and be consistent to the extent possible in its use.

Sample data should be corrected for recovery or desorption efficiency and for reagent and media blank response. However, field blanks should be treated like field samples (corrected for reagent blanks, media blanks, and recovery). If correction for contamination in the field blanks is necessary, this correction should be performed by the person who submitted the sample.

Data should be reported simply and concisely and in a manner, that 'their meaning is not distorted by the reporting process. Attention should be given to the number of significant figures reported. Generally, only the last figure reported should be in doubt.

7 Laboratory Notebooks

Laboratory notebooks are used for recording all experimental and analytical notes and data. New notebooks should be logged out to a chemist. The notebook remains the property of the laboratory and should be kept in a central location by the laboratory after it is filled.

Notebooks used in the laboratory should be hard-covered and bound. Use of notebooks with removable pages (eg loose-leaf notebooks) should be discouraged. The pages of the notebook should be numbered and any entries made by an individual other than that to whom the book was assigned should be noted. Some laboratories require that the individual's notebook pages be signed by the chemist for legal reasons.

The notebook should contain all information gathered by the chemist pertaining to the sample. Where appropriate, lab number, field number, sequence number and other identifying numbers are noted. Measurements requested, identification of the method, modifications to the method and the sample originator should be included. A description of the sample (whether bulk material, charcoal tube, etc) should be included. Data on quality assurance aspects of the sample set such as blank values, recovery studies and duplicate determinations should also be included. Formula used to calculate results and a sample calculation should be shown.

If permanent retention of computer printouts, recorder charts or similar items is deemed necessary, they should be pasted, taped or stapled in the notebook, if practical.

The minimum data entered in the notebook should be sufficient to enable another chemist to derive the same results as the original worker, with no other source of information. In addition to this minimum data, any other facts appropriate and pertinent to the sample analysis are to be entered.

A chemist's notebook is always subject to inspection by his colleagues, supervisors or inspectors from outside the laboratory. Therefore, it is imperative that the notebook be maintained in a professional manner and contains all pertinent information that may be required by other parties, regardless of the particular importance of that information to the chemist. Furthermore, the notebook must be maintained in such a manner that it can withstand challenges as to the validity, accuracy or legibility of its contents.

8 Instrument Maintenance

Laboratory instrumentation must be maintained in proper operating condition. It has been found in numerous cases that the cause for out-of-control quality control samples has been traced to faulty instrument performance. In many of these instances, the operator was unaware that instrument performance had degraded. Performance checks can be useful in documenting instrument performance over time and in detecting deviations. To be of use, performance check procedures should be quick and easy to perform. Where appropriate periodic calibration should be performed and documented (eg balances, micros**COP**es). Records of calibration should be recorded in the logbook for that instrument.

An instrument's maintenance history is often valuable in troubleshooting problems with that instrument. The record of instrument maintenance should be maintained in an 'instrument logbook' and kept near that instrument or in a recognised location.

Service contracts or maintenance agreements for instrument repair are useful for assuring that instrumentation is serviced by qualified personnel and maintained in proper operating condition.

9 Sample Tracking

A laboratory should have a mechanism for logging and tracking samples after they are received in the laboratory so that all samples can be processed in the most efficient manner. The exact system used for sample tracking will depend on the size and nature of the laboratory and may range from hand-entry logbooks to sophisticated computer-based systems. The system should include a means of cross-referencing laboratory sample numbers with field sample numbers and it should be possible to determine the chemist, instrument, and other aspects of the sample set from the field number.

Sample tracking systems may also be used to produce management statistics which may aid in forecasting future sample loads or point to problem areas in sample turnaround.

10 Quality Assurance Records

Maintenance of quality assurance records aids in recalling details of a particular analysis at a future date. A condensation of quality assurance data can be used as supporting evidence to field personnel should the need arise. Quality assurance records can also be used to track various quality assurance parameters over time (such as desorption efficiency or blank values).

Computerised record keeping systems should be backed up periodically. Archive **COP**ies of computer data require specialised storage conditions and these archive **COP**ies may not be reliable for extended periods of time.

Filing of records should be current and accurate. If rapid retrieval of data is not possible, then maintenance of quality assurance records loses its purpose. The primary purpose is to provide a system to furnish information rapidly regarding the status of specific sample sets.