Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: OCCUPATIONAL HYGIENE CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 5 - OCCUPATIONAL HYGIENE **SUBJECT CODE:** COMMEC 5 **EXAMINATION DATE:** 14 OCTOBER 2019 **TIME**: 3 Hours	**EXAMINER:** D Senekal **MODERATOR:** BA Doyle **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 18

SPECIAL REQUIREMENTS:

THIS IS NOT AN **OPEN BOOK EXAMINATION**. **FORMULA HANDOUT IS AVAILABLE**

INSTRUCTIONS TO CANDIDATES:

1. Answer all questions **legibly** in English.
2. Write your **ID number** on the outside cover of each book used and on any graph paper or other loose sheets handed in.

NB: Your name **must not** appear on any answer book or loose sheets.

3. Show all calculations **and check calculations on which the answers are based.**
4. Hand-held electronic calculators may be used for calculations.
5. Write **legibly** in ink on the **right hand page** only – **left hand pages will not be marked**.
6. Illustrate your answers by means of sketches or diagrams wherever possible.
7. Answers must be given to an accuracy which is typical of practical conditions.

   NB Ensure that the correct unit of measure (SI unit) are recorded as marks will be deducted from answers if the incorrect unit is used. (even if the calculated value is correct).
8. In answering the questions, full advantage should be taken of your practical experience as well as data given.
9. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones are **NOT** allowed in the examination room.

QUESTION 1

(Total marks 15)

A gravimetric sampling pump is operated at 1.9 l/m for eight hours and twenty minutes. The following results were obtained:

Control/Blank filters		**Sample filters**	
Pre-filter mass (mg)	**Post-filter mass (mg)**	**Pre-filter mass (mg)**	**Post-filter mass (mg)**
20.10	20.16	20.12	20.66
20.11	20.18	20.11	20.65
20.09	20.17	20.13	20.67

a) Determine the sample volume (2 marks)
b) Determine the correction factor of the control/blank filter (3 marks)
c) Determine the sample mass (3 marks)
d) Determine the corrected sample mass (2 marks)
e) Determine the concentration (2 marks)
f) Determine the TWA dust concentration (3 marks)

QUESTION 1 [ANSWER]

[15 Marks]

a) Sample volume - The sample time must be determined:

Sample time = (8 x 60) + 20
500 minutes

The sample volume = Flow rate (litres/minute) x sample time
= 1.9 x 500
= 950 litres of air
= **0.950 m^3** **(2 Marks)**

b) The correction factor of the control/blank filter must be determined:

	Control/blank filters	
	Pre-filter mass (mg)	**Post-filter mass (mg)**
	20.10	20.16
	20.11	20.18
	20.09	20.17
Totals	60.30	60.51
Average	20.10	20.17

The correction factor = post filter mass – pre filter mass
= 20.17 – 20.10
= **0.07 mg** **(3 Marks)**

c) Determine the sample mass:

	Sample filter	
	Pre-filter mass (mg)	**Post-filter mass (mg)**
	20.12	20.66
	20.11	20.65
	20.13	20.67
Totals	60.36	61.98
Average	20.12	20.66

The sample mass = post weight sample mass – pre-weight sample
= 20.66 – 20.12
= **0.54 mg** **(3 Marks)**

d) Determine the corrected sample mass Sample mass – correction factor
0.54 – 0.07
0.47 mg **(2 Marks)**

e) Determine the concentration Mass / volume
0.47 / 0.95
0.49 mg/m^3 **(2 Marks)**

f) Determine the TWA dust concentration

TWA dust concentration = $\frac{\text{dust concentration x total sample time (minutes)}}{480}$

$\frac{0.49 \times 500}{480}$

0.51 mg/m^3 **(3 Marks)**

QUESTION 2

(Total marks 15)

Split sampling was done on an employee carrying out different tasks during a day. Separate samples for each task are taken to identify periods of high exposure and the result of the sampling are shown below:

Working period	**Duration sampling (h)**	**Measured concentration (mg/m^3)**
06h30 – 08h30	2.0	1.4
09h45 – 12h00	2.25	5.6
12h45 – 14h45	2.0	0.7
15h00 – 16h45	1.75	2.0

a) Determine the 8 hour time weighted average exposure (5 marks)

b) Comment on the exposures if the OEL is 2.8 mg/m^3

i. 8-hour TWA (2 marks)

ii. Specific working periods as stipulated above (3 marks)

c) State the formula to be used where substances act additively (2 marks)

d) Give the OEL for the following: (3 marks)

- Coal dust
- Alpha quartz
- Platinum

QUESTION 2 [ANSWER]

[15 Marks]

a) The 8-hour TWA $= \dfrac{(C_1t_1 + C_2t_2 + C_3t_3 + C_4t_4)}{\text{Sample time (hours)}}$

$= \dfrac{[(2 \times 1.4) + (2.25 \times 5.6) + (2 \times 0.7) + (1.75 \times 2.0)]}{8}$

$= \dfrac{2.8}{8} + \dfrac{12.6}{8} + \dfrac{1.4}{8} + \dfrac{3.5}{8}$

= **2.5475 say 2.55 mg/m³** **(5 marks)**

b)

i. The full shift sample would indicate an 8 hour OEL of 2.55 mg/m³, which is below the OEL, but can be considered to be within the action limit (within 80 % of the OEL) and appropriate controls should be considered. (2 marks)

ii. Exposure was high from 09h45 to 12h00, and for 15h00 to 16h45, so action should be taken to reduce exposure during these times. Investigation to be conducted to ascertain the activities taking place during that time and determine possible exposure sources. (3 marks)

c) The formula for several substances that act additively is:

$$\frac{C_1}{L_1} + \frac{C_1}{L_2} + \frac{C_1}{L_3} + \frac{C1}{L_4} + \ldots\ldots\ldots\ldots \frac{C_n}{L_n} \ldots\ldots\ldots < 1$$ (2 marks)

Where C_n = Time weighted concentrations

Where L_n = the corresponding exposure limits

d)

Coal dust	<5% SiO_2	2.0 mg/m³ respirable
Alpha quartz	>5% SiO_2	0.1 mg/m³ respirable
Platinum	<5% SiO_2	3.0 mg/m³ respirable

(3 marks)

QUESTION 3

(Total marks 15)

a) The illuminance level on the surface of a work station from a light source, which is 1 metre above the work station, is measured as 400 lux. If the light source is to be moved to 2 m and 3 m away from the work station, what will the illuminance level be at each of these distances? (4 Marks)

b) The light source described above was installed at a distance of 3 m away from the work station and the only position available was 45 degrees off the vertical. What will the illuminance level be on the work station? (4 Marks)

c) List the 7 factors to be considered in designing illumination where good vision is required. (7 Marks)

QUESTION 3 [ANSWER]

[Total marks 15]

a) The luminance intensity (I) for this situation (original) must be determined and is a function of the illuminance (or illumination (E)):

At 2 m $E = \frac{I}{d^2}$

$= \frac{400}{2^2}$

$= 100$ lux **(2 Marks)**

At 3 m $E = \frac{I}{d^2}$

$= \frac{400}{3^2}$

$= 44.4$ lux **(2 Marks)**

b) Cosine at 45° therefore Cos 45° **$= 0.71$ or 71%** **(2 Marks)**

Thus:

44.4 lux x 0.71 **$= 31.5$ lux** **(2 Marks)**

c) In designing illumination where good vision is required, consideration should be given to:

- The level of illumination in the work place (1 Mark)
- The distribution of light sources (1 Mark)
- The size of the objects to be handled (1 Mark)
- The reflectivity of the objects to be handled (1 Mark)
- The contrast of such objects (1 Mark)
- The time available to see the objects, and (1 Mark)
- The age of the persons required to perform the work (1 Mark)

QUESTION 4 **(Total marks 20)**

a) Noise has several physiological effects, list these effects? (6 Marks)

b) What measures could be considered to reduce noise? (6 Marks)

c) A workplace have three separate noise sources, each of the noise sources is active at different times during the working shift. The table below indicate the time each source is active as well as the respective Sound Pressure Levels (SPL) of each source. Use the information provided below to calculate the combined sound pressure level for each time indicated in the tables.

(8 Marks)

Time	**SPL of noise Source 1 [dB(A)]**	**SPL of noise Source 2 [dB(A)]**	**SPL of noise Source 3 [dB(A)]**
07H00	94	102	Off
07H30	94	Off	96
08H00	Off	102	96
08H30	94	102	96

Difference between 2 noise levels	**Amount dB to be added**
0	3
1	2.5
2	2
3	2
4	1.5
5	1
6	1
7	1
8	0.5
9	0.5
10	0.5
10+	0

QUESTION 4 [ANSWER]

[Total marks 20]

a) Noise has several physiological effects, some of which are:

- Raising blood pressure
- Accelerated heart rate
- Contraction of the blood vessels of the skin
- Increased metabolism
- Slowing down of the digestive organs
- Increased muscular tension

(6 Marks)

b) Control measures for noise reduction include:

- Substitution
- Reduction at source,
- Screening,
- Isolation,
- Attenuation, and
- Personal protection equipment.

(6 Marks)

c) Determine the combined sound pressure level at each time period:

At 07H00

Source 1 = 94 dB (A)

Source 2 = 102 dB (A) Difference = 8 thus add 0.5

Combined = 102 + 0.5 = 102.5 dB (A)

Overall sound pressure level at 07H00 is 102.5 dB (A)

(2 Marks)

At 07H30

Source 1 = 94 dB (A)

Source 3 = 96 dB (A) Difference = 2 thus add 2

Combined = 96 + 2 = 98 dB (A)

Overall sound pressure level at 07H15 is 98 dB (A)

(2 Marks)

At 08H00
Source 2 = 102 dB (A)
Source 3 = 96 dB (A) Difference = 6 thus add 1
Combined = 102 + 1 = 103 dB (A)
Overall sound pressure level at 08H00 is 103 dB (A)

(2 Marks)

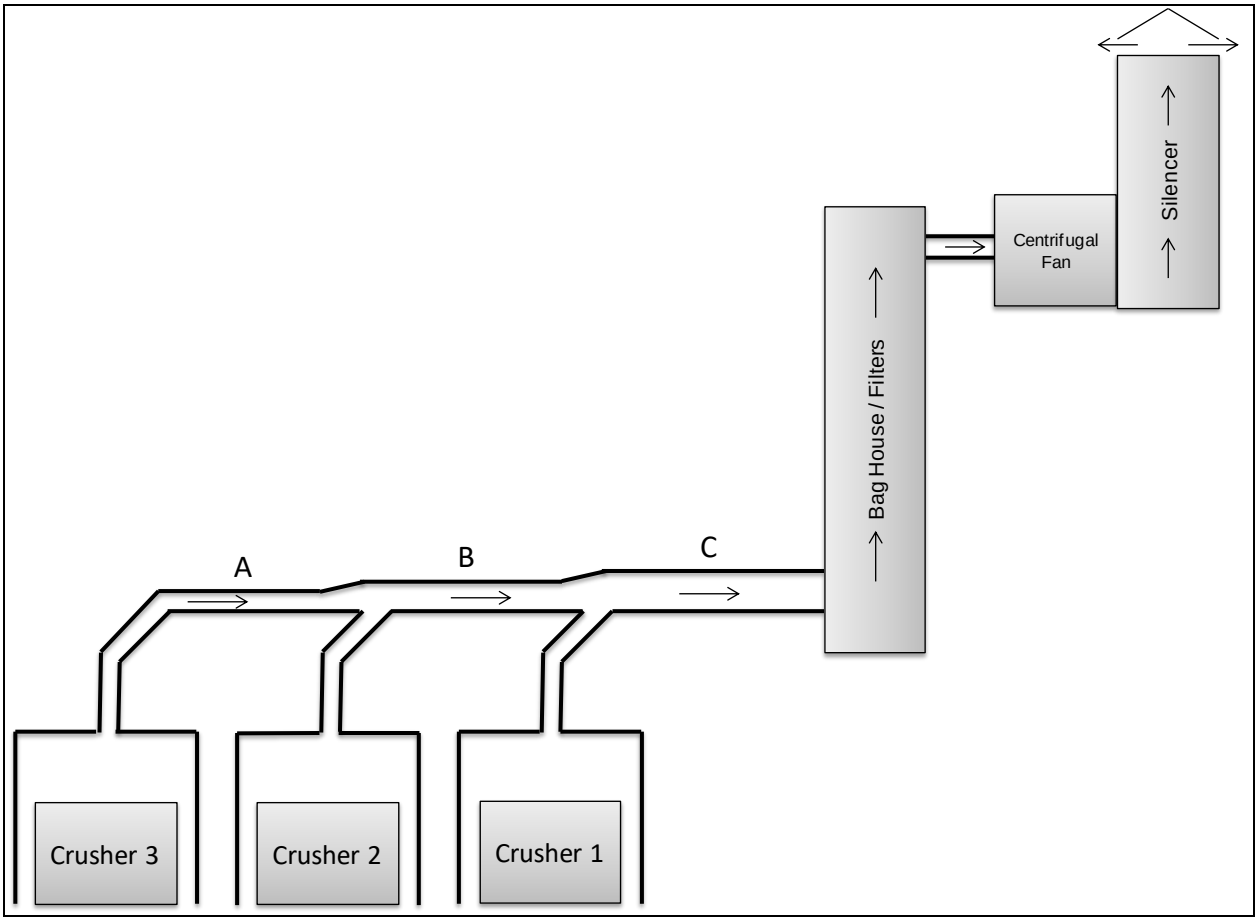
At 08H30
Source 1 = 94 dB (A)
Source 2 = 102 dB (A) Difference = 8 thus add 0.5
Combined SPL = 102 + 0.5 = 102.5 dB (A)
Source 3 = 96 dB (A) Difference = 6.5 thus add 1
Combined = 102.5 + 1 = 103.5 dB (A)
Overall sound pressure level at 08H30 is 103.5 dB (A)

(2 Marks)

QUESTION 5 **(Total marks 15)**

The engineer in charge of an essay laboratory has requested assistance with the design of a Local Exhaust Ventilation system (LEV system), to be utilised for the extraction of dust from a set of three small crusher units utilised for the crushing of ore for testing purposes. The engineer provided the layout drawing below and requested that you assist in the calculation of:

i. The required quantity of air that the fan should extract from the system, and
ii. Ducting sizes for sections A, B and C



You have subsequent to the request from the Engineer undertaken a literature review and have ascertained that the following design criterion is generally utilised as best practice for typical exercises:

- Capture air velocity required is 1.0 m/s
- Carry (transport) air velocity required is 20 m/s

The engineer indicated that the open area of the hoods over the crushers will be 1.0 m (W) x 2.0 m (H).

5.1 Calculate the required fan quantity (ignore leakage) (4 marks)
5.2 Calculate the required duct diameters for duct sections A, B and C (6 marks)

In addition to the above the Engineer requested advice on the following:

5.3 Should the velocity in a duct be 20 m/s, what would the velocity pressure be if the density is 1.1 kg/m^3 (2 marks)
5.4 What is the typical transport velocity for heavy metal dust? (1 marks)
5.5 Rank the control measure options listed below, from the most appropriate option for the least appropriate control for carcinogens? (2 marks)

- Total enclosure
- Substitution with alternative
- Monitor to ensure exposure is below the OEL
- Minimise number of people involved in the process

QUESTION 5 [ANSWER]

[Total marks 20]

5.1 Calculate quantity for each crusher based on capture velocity:

Q = V x A

= 1.0 x (1.0 x 2.0)

= 2 m^3/s

Calculate total fan quantity:

Fan Q = (2 + 2 + 2)

= **6 m^3/s** **(3 marks)**

5.2 Calculate duct diameter for each section:

Section A have to carry 2 m^3/s at 20 m/s, calculate the duct diameter.	Section B have to carry 4 m^3/s at 20 m/s, calculate the duct diameter.	Section C have to carry 6 m^3/s at 20 m/s, calculate the duct diameter.
Duct area= $\frac{Q}{V}$ = $\frac{2}{20}$ = 0.1 m^2	Duct area= $\frac{Q}{V}$ = $\frac{4}{20}$ = 0.2 m^2	Duct area= $\frac{Q}{V}$ = $\frac{6}{20}$ = 0.3 m^2
Calculate duct diameter for section A	Calculate duct diameter for section B	Calculate duct diameter for section C
Area = $\frac{\pi D^2}{4}$ D = $\sqrt{4 \times 0.1/\pi}$ = 0.356 m = 356 mmØ	Area = $\frac{\pi D^2}{4}$ D = $\sqrt{4 \times 0.2/\pi}$ = 0.504 m = 504 mmØ	Area = $\frac{\pi D^2}{4}$ D = $\sqrt{4 \times 0.3/\pi}$ = 0.618 m = 618 mmØ
2 marks	2 marks	2 marks

5.3 Calculate the velocity pressure

VP = $v_2w/2$ VP = 20^2 x 1.1/2

220 Pa **(2 marks)**

5.4 Typical transport velocity for heavy metal dust **25 m/s** **(1 mark)**

5.5 Most appropriate control measure for the control of carcinogens (2 marks)

- Substitution with alternative
- Total enclosure
- Minimise number of people involved in the process
- Monitor to ensure exposure is below the OEL

QUESTION 6 (Total marks 10)

Define:

6.3 Physical Hazard (2 marks)

6.4 Chemical hazard (2 marks)

6.7 Acute exposure (2 marks)

6.8 Chronic exposure (2 marks)

6.11 Capture velocity (2 marks)

QUESTION 6 [ANSWER]

[Total marks 10]

6.1 Physical Hazard:

Is the source of exposure to a danger that can cause physical harm to an individual.

- Typically, ergonomic stresses such as muscular, skeletal or impacts on organs such as the skin (e.g. abrasions, lesions, etc.), or internal organs such as the heart, lungs, hearing (ears), etc. apply here.

6.2 Chemical hazard:

Is the source of exposure to a danger that arises as a consequence of exposure to a chemical substance.

- Usually toxic substances (poisons) are involved here. These may be general poisons (i.e. poisons that affect virtually all people) but may also include substances to which only certain people are allergic (e.g. plant oils, pollen, etc.)

6.3 Acute exposure:

A short duration, high dose exposure of which the results may cause unconsciousness, shock, collapse, sever inflammation of the lungs or sudden death.

6.4 Chronic exposure:

Exposure, usually in very small doses over long periods of time, the results of which may cause adverse health effects ranging from mild effects to death.

6.5 Capture Velocity? (2)

The air velocity necessary at the point of contaminant generation to capture the contaminant and draw it into the hood

Question 7 **(Total marks 10)**

7.1	Define the term radiation?	(1)
7.2	Define radioactivity?	(2)
7.3	Radioactive emissions are categorised according to type, list the types?	(4)
7.4	What factors affect the rate or degree of injury?	(3)

Question 7 [Answer]

[Total marks 10]

Page 157 to page 159

7.1 Radiation is energy in the form of waves or particulates.

7.2 Radioactivity is the emission of very fast atomic particles or rays by atomic nuclei.

7.3 The emissions are categorised according to type, the categories being:

- Alpha ($\propto$) particles,
- Beta (β) particles
- Gamma (γ) waves, and
- Neutrons (n) particles.

7.4 Factors that affect the rate or degree of injury are:

- total dose received
- rate at which the dose was received, the kind (type) of radiation received and
- the body part receiving the radiation

TOTAL MARKS: [100]