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:** 11 MAY 2020 **TIME**: 3 Hours	**EXAMINER:** D Senekal **MODERATOR:** S Wheeler **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 (Airborne pollutants)

(Total marks: 20)

During a shift a gravimetric sampling pump collected 550 µg of particulates on a filter. The flow rate of the sampler was calibrated at 1.9 litres/minute and the sampling time was 6 hours and 30 minutes.

a) What is the sample concentration for this period? (5 Marks)

b) History indicates a 15% silica quartz concentration in the area that the sample was collected from, what was the respirable silica concentration of the collected sample? (2 Marks)

c) Was the TWA Occupation exposure limit for silica quartz exceeded for this collected sample?

(5 Marks)

d) State the OELs for the following airborne pollutants:

i) Coal dust (respirable)
ii) Silica fume (respirable)
iii) Platinum mine dust (respirable)

(3 Marks)

e) Before selecting an appropriate respirator for employees, the occupational hygienist should firstly assess the workplace, which aspects of the workplace need be considered? (5 Marks)

QUESTION 1 [ANSWER]

(Total Marks: 20)

a) The sample time must be determined:

Sample time = (6.5 x 60)
= 390 minutes (1 Mark)

The sample volume = Flow rate (litres/minute) x sample time
= 1.9 x 390
= 741 litres of air
= 0.741 m^3 of air (2 Marks)

Determine the sample concentration = Mass / volume
= 0.55 / 0.741
= 0.742 mg/m^3 (2 Marks)

b) Sample Respirable quart concentration = 0.742 x 15%
= 0.11 mg/m^3 (2 Marks)

Also accepted:

TWA Respirable quart concentration = 0.742 x (sample time / 480) x 15%
= 0.09 mg/m^3

c) TWA Respirable quartz Concentration = 0.11 mg/m^3 x (Sample time / 480)
= 0.11 x (390 / 480)
= 0.09 mg/m^3

No, the TWA OEL concentration was not exceeded (5 Marks)

d)

Coal dust	<5% SiO_2	2.0 mg/m^3 respirable
Silica fume		2.0 mg/m^3 respirable
Platinum	<5% SiO_2	3.0 mg/m^3 respirable

(3 Marks)

e) Before selecting a respirator, the occupational hygienist should assess the workplace, which covers the following aspects: (Workbook - p198) (5 Marks)

- The nature of the hazardous operation and its processes
- The type of respiratory hazard (dusts, fumes, mists, gases, vapours, etc.)
- The location of the hazardous area with respect to the nearest fresh / respirable air source
- How long the respirators must be worn for
- The worker's activities

QUESTION 2 (Illumination)

(Total Marks: 15)

a) The illuminance level on the surface of a workstation from a light source, which is 1 metre directly above the workstation, is measured as 900 lux. How far away can the light source be moved from the workstation if the minimum required level of illumination at the workstation is 200 lux? (3 Marks)

b) The light source described above was installed at the maximum distance as calculated in a) above, however the technician who moved the light source installed it at an angle of 40 degrees off the vertical. What will the illuminance level be on the workstation? (2 Marks)

c) List and describe three forms of glare. (6 Marks)

d) List the four factors that have an impact on visual acuity. (4 Marks)

QUESTION 2 [ANSWER]

(Total Marks: 15)

a) The maximum distance the light source can be moved to is:

$d = \sqrt{I / E}$
$d = \sqrt{(900 / 200)}$
$d = 2.12$ m (3 Marks)

b) Cosine at 40°, therefore Cos 40° = 0.76 or 76%
Thus:
200 lux x 0.76 = 152 lux (2 Marks)

c) Glare occurs in three forms: (6 Marks)

i) Relative glare, caused by contrasts in brightness

ii) Absolute glare, too bright for the eye to adapt to, and

iii) Adaptive glare, which is temporary and to which the eyes can adapt.

d) The following factors influence visual acuity: (4 Marks)

i) Visual acuity improves with illumination and is best at levels in excess of 1 000 lux

ii) It improves with contrast

iii) It is better with dark symbols on a light background, and

iv) It decreases with age.

QUESTION 3 (Noise)

(Total Marks: 20)

a) State the control measures that could be considered to reduce noise? (6 Marks)

b) A fan was tested at the fan manufacturer in an open, flat area that was free of obstructions. A sound pressure level of 0.9 Pa was measured at the surface of an imaginary hemisphere with a radius of 6 meters, assuming a density of 1.2 kg/m^3:

i) Calculate the Sound pressure level at surface of the hemisphere? (3 Marks)

ii) Calculate the sound power level of the fan? (11 Marks)

QUESTION 3 [ANSWER]

(Total Marks: 20)

a) Control measures for noise reduction include:

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

(6 Marks)

b)

i) Determine the Sound pressure Level on the surface PL:

SPL = 10 Log (Sound Pressure^2) / (2 x 10^{-5}) ^{2}

= 10 Log (0.9^2)/ (4 x 10^{-10})

= 10 x 9.306

= 93.06 dB (3 Marks)

ii) The sound intensity is:

I = p^2/ w c

= 0.9^2 / (1.2 x 344)

= 0.00196 W/m^2 (3 Marks)

Surface area of the hemisphere is:

Area = 2 π r^2

= 2 x π x 6^2

= 226.2 m^2 (2 Marks)

The acoustic power therefore:

= sound intensity x area of the sphere

= 0.00196 x 226.2

= 0.4433 W (3 Marks)

Fan sound power:

SWL = 10 Log Power / 10^{-12}

= 10 Log (0.4433/ 10^{-12})

= 10 x 11.64

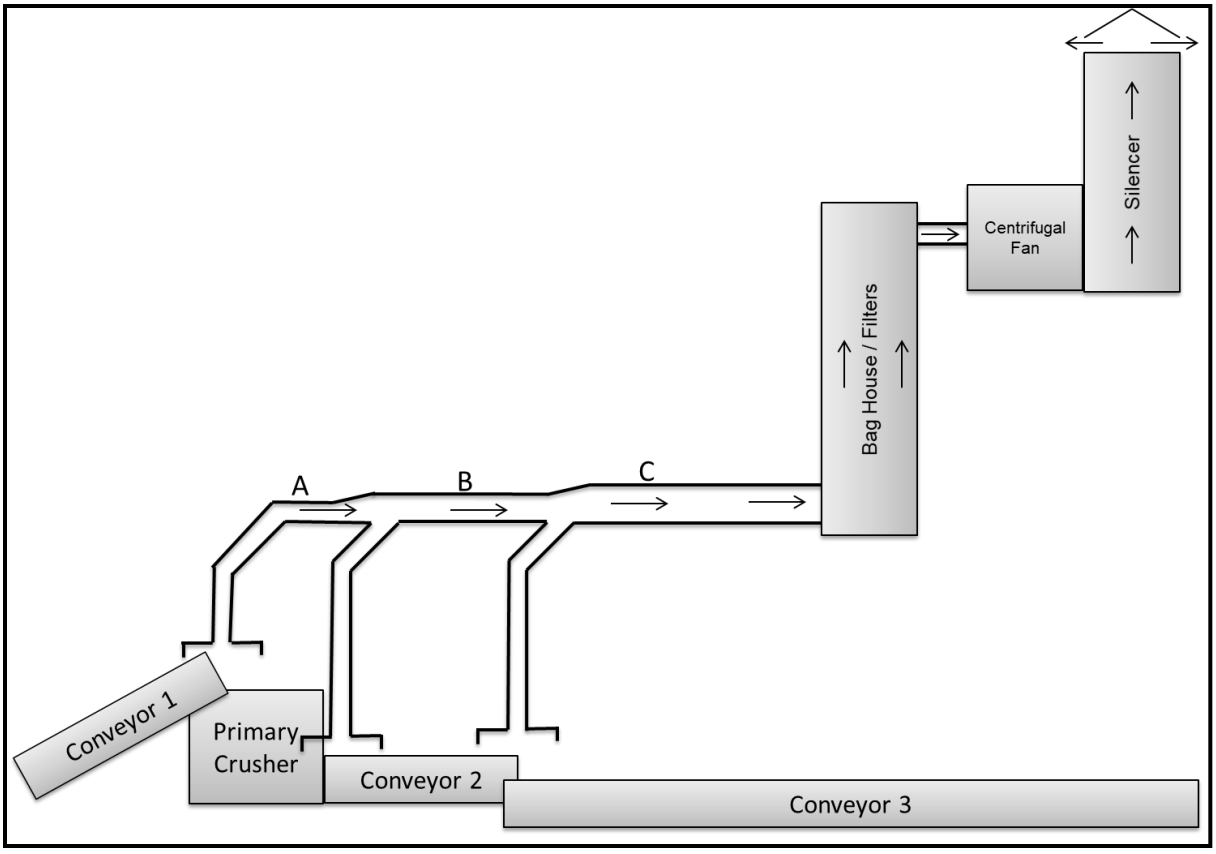
= 116 dB (3 Marks)

QUESTION 4 (Industrial ventilation)

(Total Marks 20)

An Engineer responsible for a crusher plant has requested assistance with the design of a Local Exhaust Ventilation system (LEV system), to be utilised for the extraction of dust from a Primary crusher and conveyor belt system. 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



After the request from the Engineer, you undertook a literature review and have ascertained that the following design criterion is utilised as best practices to determine these requirements:

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

The engineer indicated that the open area of the hoods over the transfer points will be 1.25 m (W) x 2.0 m (L).

a) Calculate the required fan quantity (exclude leakage) (3 marks)

b) Calculate the required duct diameters for duct sections A, B and C (9 Marks)

c) Calculate the overall required fan quantity, include 15% for leakage (2 Marks)

d) If the leakage was more than planned, what could be the consequences? (2 Marks)

e) Rank the control measure options listed below, from the most appropriate option to the least appropriate control for carcinogens? (4 marks)

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

QUESTION 4 [ANSWER]

(Total Marks: 20)

a) Calculate quantity for each transfer point based on capture velocity:

$Q = V \times A$

$= 1.0 \times (1.25 \times 2.0)$

$= \underline{2.5\ m^3/s}$

Calculate total fan quantity:

Fan $Q = (2.5 + 2.5 + 2.5)$

$= \underline{7.5\ m^3/s}$ (3 Marks)

b) Calculate duct diameter for each section:

Section A	Section B	Section C
Need to transport 2.5 m^3/s at 20 m/s, calculate the duct area.	Need to transport 5 m^3/s at 20 m/s, calculate the duct area.	Need to transport 7.5 m^3/s at 20 m/s, calculate the duct area.
Duct area= $\frac{Q}{V}$ $= \frac{2.5}{20}$ $= \underline{0.125\ m^2}$	Duct area= $\frac{Q}{V}$ $= \frac{5.0}{20}$ $= \underline{0.25\ m^2}$	Duct area= $\frac{Q}{V}$ $= \frac{7.5}{20}$ $= \underline{0.375\ m^2}$
Calculate duct diameter for section A	Calculate duct diameter for section B	Calculate duct diameter for section C
Area = $\frac{\pi D^2}{4}$ $D = \sqrt{4 \times 0.125/\pi}$ $= \sqrt{0.1592}$ $= 0.398$ mØ $= 398$ mmØ	Area = $\frac{\pi D^2}{4}$ $D = \sqrt{4 \times 0.25/\pi}$ $= \sqrt{0.3184}$ $= 0.564$ mØ $= 564$ mmØ	Area = $\frac{\pi D^2}{4}$ $D = \sqrt{4 \times 0.375/\pi}$ $= \sqrt{0.477}$ $= 0.690$ mØ $= 690$ mmØ
3 marks	3 marks	3 marks

c) Calculate total fan quantity (Including leakage):

Fan $Q = 7.5\ m^3/s + (7.5 \times 15\%)$

$= 7.5 + 1.125$

$= \underline{8.625\ m^3/s}$ (2 Marks)

d) Insufficient capture velocities at the hood

Insufficient duct carry (transport) air velocity (2 Marks)

e) Most appropriate control measure for the control of carcinogens (4 marks)

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

QUESTION 5 (Occupational Exposure Assessment)

(Total Marks: 11)

Define the following:

a) Occupational hygiene (as per MHSA, Act. 29 of 1996) (4 marks)

b) Control (2 Marks)

c) Biological Exposure Indices (3 Marks)

d) Ergonomics (2 Marks)

QUESTION 5 [ANSWER]

(Total Marks: 11)

a) Occupational hygiene: (4 Marks)

The Mine Health and Safety Act (MH&SA), Act 29 of 1996 defines occupational hygiene as follows: “means the anticipation, recognition, evaluation and control of conditions (at the mine or workplace) that may cause illness or adverse health effects to persons”.

b) Control: (2 Marks)

Control is therefore considered to be any process whereby the hazard is managed to reduce and maintain the risks at acceptable levels.

c) Biological Exposure Indices: (3 Marks)

Are advisory biological limit values, usually based on urine, blood or expired air samples. The limit may apply to the substance itself or may refer to a level of metabolite and is usually coupled to the value of that determinant obtained from a worker exposed at the 8-hour TLV(TWA) for the substance in question.

d) Ergonomics: (2 Marks)

Ergonomics is defined as “the study of human characteristics for the appropriate design of the living and work environment” (Reference: Plog - Fundamentals of Industrial Hygiene, Chapter 13, page 347).

Question 6 (Ionising Radiation)

(Total marks: 14)

a) Radioactive emissions are categorised according to type, list these types?
(4 Marks)

b) What factors affect the rate or degree of injury when exposed to ionising radiation?
(3 Marks)

c) How can external radiation exposure can be controlled?
(3 Marks)

d) How can internal radiation exposure be controlled?
(4 Marks)

Question 6 [Answer]

(Total Marks: 14)

Workbook: Page 157 to page 159

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

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

b) 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

Schoeman and Schroder p185

c) External exposure control:

- Increase distance from source
- Decrease time of exposure
- Provide shielding

d) Internal exposure control:

- Demarcating and controlling work areas
- Prevent contamination from spreading
- Provide proper handling facilities
- Provide personal protective clothing including RPE