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Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA **CERTIFICATE IN MINE ENVIRONMENTAL CONTROL** **PAPER 4**	**EXAMINER: R A Rabaji**
SUBJECT CODE: COMMEC4	**MODERATOR: A R Nundlall**
EXAMINATION DATE: 06 May 2021	**TOTAL MARKS: [100]**
TIME: 14:30 – 17:30	**PASS MARK: 60%**

Examination Instructions:

This examination question paper consists of **3** pages

FORMULA HANDOUT IS AVAILABLE

1. Answer all **5** questions in *English*.
2. Put your identification 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 your answers are based**.
4. Hand-held electronic calculators may be used for calculations only.
5. Write in ink on the **right hand page** only – the left hand page 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 units 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. This is **NOT** an open book examination but the approved formula hand out may be used.
11. Cell phones are **NOT** allowed in the examination room

QUESTION 1

a) What must be done to start managing risks? (1)

b) What does the MHSA require of the risk assessment process? (5)

c) Which reports and records must be analysed and compared when reviewing and revising the risk assessment? (9)

d) An uncomplicated approach to measure risk should be sufficient to: (Complete the following) (4)

Allow…………………………………………………………………………………….

Have……………………………………………………………………………………..

Communicate………………………………………………………………………

Demonstrate…………………………………………………………………………

e) Name six methods which can be used to measure risk. (6)

(25)

QUESTION 2

A fire detection system is being tested.

The system involves the measurement of carbon monoxide and carbon dioxide levels at the top of a mine's upcast shaft.

The test is carried out during the main working shift and involves lighting a test fire in one of the return airways leading to the shaft.

The air quantity flowing in this airway is 89 m^3 /s and the total air quantity in the upcast shaft is 738 m^3 /s (both air quantity measurements are at the same air density of 1,23 kg/m3).

The burning rate of the fire is expected to be reaching a peak value of 0,09 kg/s.

Assuming:

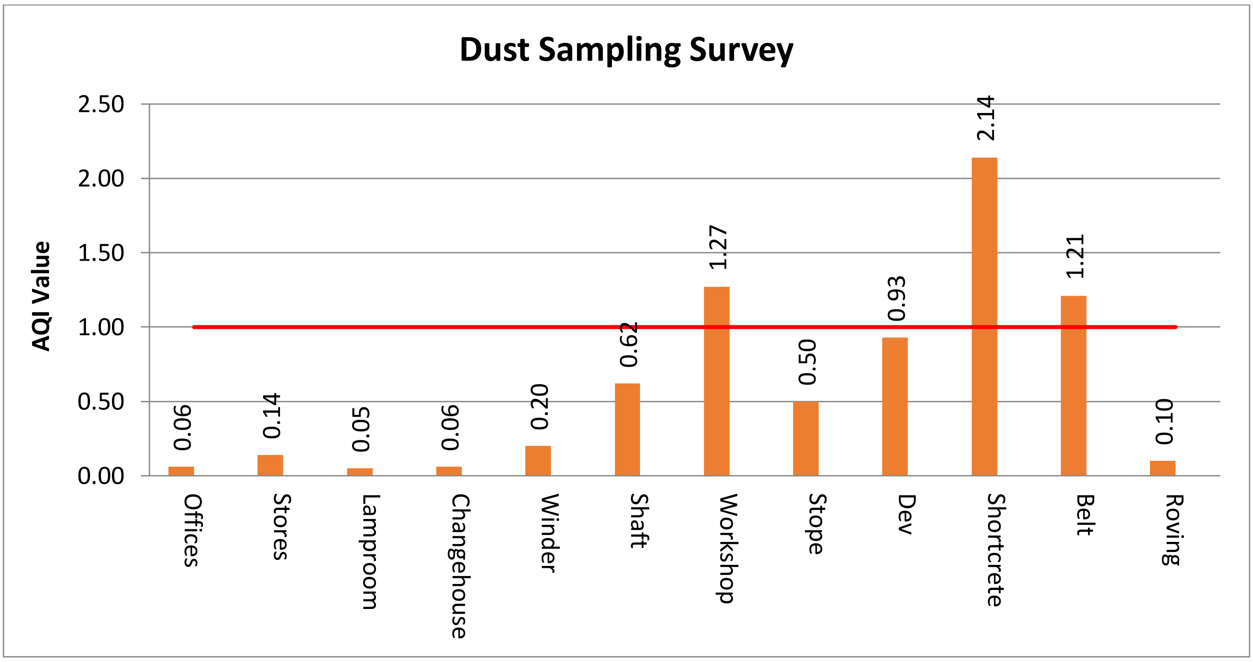
- That wood has a carbon content of 54 percent.
- That for each kilogram of carbon that is burnt 0,14 kg forms carbon monoxide and the remainder carbon dioxide.
- That 3 kg of carbon combines with 8 kg of oxygen to form 11 kg of carbon dioxide.
- That 3 kg of carbon combines with 4 kg of oxygen to form 7 kg of carbon monoxide.

a) Calculate the peak concentrations (by volume) of both carbon dioxide and carbon monoxide present in the air on the return side of the fire and at the top of the upcast shaft.

b) Comment on these two methods of fire detection (carbon dioxide and carbon monoxide) when used in this way, bearing in mind both the background levels and the variations in the levels of the two gases. **(25)**

QUESTION 3

An intensive dust sampling survey was carried out at a mine.
A total of 12 dust samples were taken over a period of 28 shifts using personal sampling pumps(PSP* s). Samples were analysed daily.



a) What is an AQI

b) How many samples exceeded the AQI

c) Give two things to be done in the case of over-exposures

d) Define a Homogeneous Exposure Group.

e) When is a homogeneous Exposure group re-evaluated

f) Calculate the following:

- The Mean
- The Maximum and Minimum values
- The Range
- The Geometric mean
- The Median
- The Standard deviation
- The 75 th; and 90 th Percentiles
- The Ranking of the 90 th percentile value you calculated
- Briefly explain what Confidence limits on calculated parameters means

g) As the ventilation officer on a mine you are required to ensure that certain requirements regarding reporting are met. List at least 10 of these requirements.

(25)

<u>QUESTION 4</u>

A force fan delivers 6.8 m^3/s of fresh air to the face of a development end. The concentration of flammable gas in the return is measured as 3.8%.

a) How much flammable gas is made in the end? (7)

b) What should the force quantity be to ensure the concentration of flammable gas does not exceed 2%? (5)

c) An underground workshop is 40m long, 15m wide and 15m high. Estimate the airflow required to dilute exhaust fumes from diesel engines of 200 kW mechanical output on the basis of 10 air changes per hour. (3)

Note:- employ an estimated airflow requirement of 8 m^3/s per 100 kW of rated diesel power or 0.08m3/s/Kw

c) How much fresh air should be directed to a source of 0.08m/s of carbon monoxide to ensure that the concentration does not exceed 0.005%? (4)

d) An airstream contains 0.8kg/s of carbon dioxide. Determine the quantity of carbon dioxide (Assume an air density of 1.1kg/m^3) (6)

Total (100)

Memorandum

Mine Environmental Control - Paper 4
May 2020

Question 1

a) What must be done to start managing risks?

- Managing risk starts by performing risk assessment

b) What does the MHSA require of the risk assessment process?

The Mine Health and Safety Act requires that this process:
- Follows a laid down procedure or system (systematic)
- Should be recorded for analyses and scrutiny (databases)
- Be reliable and responsive (dynamic, not just a paper exercise)
- Demonstrates complete analysis (risks identified and controlled)
- Is valid for the type of operation assessed (focussed, up to date and can be applied)

c) Which reports and records must be analysed and compared when reviewing and revising the risk assessment?

- Employee compliance with the required standards for safe and healthy work
- Accident / incident rates
- Compensatable disease pay outs
- Insurance claims
- Legal penalties
- Productivity levels
- Employee job satisfaction
- Efficiency of training
- Industrial relations between employees and management regarding health and safety issues

d) An uncomplicated approach to measure risk should be sufficient to: (Complete the following)

- Allow acceptable decision-making
- Have a high confidence level
- Communicate easily to employees, inspectorate and other stakeholders
- Demonstrate competent and responsible management

(e) Name six methods which can be used to measure risk. (6)

- The risk matrix type
- Monograms to determine Risk Rankings
- Risk Ranking tables
- Risk equations
- Failure Mode and Effect Analysis
- Hazard and Operability Study

Question 2

RETURN SIDE OF FIRE

The total carbon liberated must be established:

Carbon liberated	=	burning rate of fire x carbon content %
	=	0,09 x 0,54
	=	0,0486 kg/s

Considering carbon dioxide concentrations

The amount of carbon produced which forms CO_2:

Carbon amount	=	amount of carbon from fire x % CO_2
	=	0,0486 x (100 – 14)/100
	=	0,0418 kg/s

To determine the amount of O_2 required the following ratios were given and must be used:

8 O_2 combines with 3 C
? O_2 combines with 0,0418 C

This means that the amount of O_2 required can be established as follows:

$$\text{Amount of } O_2 \text{ required} = \frac{0{,}0418\ C \times 8\ O_2}{3\ C}$$

$$= 0{,}1115 \text{ kg/s } O_2$$

The amount of CO_2 produced is therefore the sum of the C and O_2 liberated:

$$\text{The mass flow of } CO_2 = 0{,}1115 + 0{,}0418 = 0{,}1533 \text{ kg/s } CO_2$$

Since CO_2 is approximately 1,55 times heavier than air (*note, this is one of the catches to the question*), and the air density is given as 1,23 kg/m^3, the quantity and the volume of the CO_2 produced can be established:

$$\text{The density of the } CO_2 = SG_{gas} \times \text{density of air} = 1{,}55 \times 1{,}23 = 1{,}9065 \text{ kg/m}^3$$

$$\text{Volume of the } CO_2 = \frac{\text{mass of } CO_2}{\text{density of } CO_2} = \frac{0{,}1533}{1{,}9065} = 0{,}08041 \text{ m}^3\text{/s } CO_2$$

Also the amount of CO_2 in normal air is approximately 0,03% (or 300 ppm, *note, this is also a catch in this question*).

The volume of CO_2 in the normal air of 89 m^3/s can now be established:

$$\text{Volume of } CO_2 = 89 \times 0{,}03/100 = 0{,}0267 \text{ m}^3\text{/s}$$

$$\text{The total quantity (volume) of } CO_2 = 0{,}08041 + 0{,}0267 = 0{,}10711 \text{ m}^3\text{/s (volume of } CO_2 \text{ coming from fire)}$$

The percentage of CO_2 in the return airway on the return side of the fire can now be established:

$$\% CO_2 = \frac{q_{CO_2}}{Q_{mix}} \times 100\% = \frac{0{,}10711}{89} \times 100\% = 0{,}120\,\%\ CO_2 \text{ (or 1200 ppm)}$$

Considering carbon monoxide concentrations

The amount of carbon produced which forms CO:

$$\text{Carbon amount} = \text{amount of carbon from fire} \times \%\ CO = 0{,}0486 \times 14/100 = 0{,}0068 \text{ kg/s}$$

To determine the amount of Oxygen required the following ratios were given and must be used:

4 O combines with 3 C
? O combines with 0,0068 C

This means that the amount of O required can be established as follows:

$$\text{Amount of O required} = \frac{0{,}0068\text{ C} \times 4\text{ O}}{3\text{ C}} = 0{,}0091 \text{ kg/s O}$$

The amount of CO produced is therefore the sum of the C and O liberated:

The mass flow of CO = 0,0091 + 0,0068
= 0,0159 kg/s CO

Since CO is approximately 0,97 times lighter than air (*note, this is one of the catches to the question*), and the air density is given as 1,23 kg/m^3, the quantity and the volume of the CO produced can be established:

The density of the CO = SG_{gas} x density of air
= 0,97 x 1,23
= 1,1931 kg/m^3

$$\text{Volume of the CO} = \frac{\text{mass of CO}}{\text{density of CO}} = \frac{0{,}0159}{1{,}1931} = 0{,}01333 \text{ m}^3/\text{s CO}$$

Also the amount of CO in normal air is NIL.

The total quantity (volume) of CO = 0,01333 + 0
= 0,01333 m^3/s (volume of CO coming from fire)

The percentage of CO in the return airway on the return side of the fire can now be established:

$$\%\,CO = \frac{q_{CO}}{Q_{mix}} \times 100\% = \frac{0{,}01333}{89} \times 100\% = 0{,}015\%\ CO \text{ (or 150 ppm)}$$

TOP OF THE UPCAST SHAFT

The quantity of the CO at the top of the upcast shaft does not change and is therefore the same as calculated above. The % CO at the top of the upcast shaft can now be determined:

$$\%\,CO = \frac{q_{CO}}{Q_{mix}} \times 100\% = \frac{0{,}01333}{738} \times 100\% = 0{,}00181\ \%\ CO \text{ (or 18 ppm)}$$

The quantity of CO_2 present in the return air, which has not flowed past the fire, must still be determined (*note this is another catch of this question*). The quantity is as follows:

Quantity of air not past fire = 738 – 89
= 649 m^3/s

The amount of CO_2 in this volume of air must now be determined:

Quantity of CO_2 = 649 x 0,03/100
= 0,1947 m^3/s

The total amount of CO_2 top of shaft = $0{,}1947_{\text{fresh air side}} + 0{,}10711_{\text{fire side}}$
= $0{,}30181\ m^3/s$

The concentration of the CO_2 at the top of the upcast shaft can now be determined:

$$\% CO_2 = \frac{q_{CO_2}}{Q_{mix}} \times 100\%$$
$$= \frac{0{,}30181}{738} \times 100\%$$
$$= 0{,}0409\ \%\ CO_2 \text{ (or 409 ppm)}$$

The concentration of the CO at the top of the upcast shaft can now be determined:

$$\% CO = \frac{q_{CO}}{Q_{mix}} \times 100\%$$
$$= \frac{0{,}01333}{738} \times 100\%$$
$$= 0{,}0018\ \%\ CO \text{ (or 18 ppm)}$$

Comments

Most fires on gold mines are free burning and produce large quantities of CO_2. Hence a CO_2 monitoring system has certain advantages. However, the background levels of CO_2 on a gold mine can vary considerably and can be high due to diesels and the air exhaled by the underground workforce. In the question it is 0,03% at the top of the upcast shaft when the fire is not burning and 0,04% when the fire is burning. The high background level and the considerable variation in that level are disadvantages of CO_2 monitoring.

The background level of CO is under normal conditions zero and varies minimally on a gold mine. In the question this increases to 0,0018 % (or 18 ppm) and this level can easily be detected.

QUESTION 3

a) What is an AQI

- A figure that indicates how polluted the air is

b) How many samples exceeded the AQI

- 3 (Three)

c) Give two things to be done in the case of over-exposures

- Investigate reasons for overexposures
- Implement meausres to avoid overexposures

d) Define a Homogeneous Exposure Group.

- homogeneous exposure group" means a group of employees who experience pollutant exposures similar enough that monitoring exposures of any representative subgroup of employees in the group provides data useful for predicting exposures of the remaining employees.

e) When is a homogeneous Exposure group re-evaluated

- Employee complaints
- Process change
- Occupational illness
- Other events warrant re-evaluation:

f) Calculate the following:

- The Mean

  (0.06+0.14+0.05+0.06+0.20+0.62+1.27+0.50+0.93+2.14+1.21+0.10)/12

  0.606mg/m^3

- The Maximum and Minimum values

  2.14mg/m^3 and 0.05mg/m^3

- The Range

  2.14mg/m^3 – 0.05mg/m^3 = 2.09

- The Geometric mean
- $\sqrt[12]{(0.06x0.14x0.05x0.06x0.20x1.27x0.50x0.93x2.14x1.21x0.10)}$

  0.309
- The Median

  0.35
- The Standard deviation
- 0.661
- The 75 th; and 90 th Percentiles

  0.232 & 0.343
- The Ranking of the 90 th percentile value you calculated

  10.8
- Briefly explain what Confidence limits on calculated parameters means

  The confidence intrvalis a range on either side of the sample

As the ventilation officer on a mine you are required to ensure that certain requirements regarding reporting are met. List at least 10 of these requirements.

- To provide information on the current status of work and work conditions
- To act on substandard conditions or practises that can increase risk
- To formulate policy with regard to the work processes
- For determining efficiencies and budgetary requirements
- For legislation requirements
- For formal risk management purposes
- To provide a history and work conditions for record purposes
- To create database on occupational hygiene, health and safety
- To answer questions
- To make recommendations
- To convey ideas

QUESTION 4

a) $\boldsymbol{L}et\ qm\ be\ the\ quantity\ of\ flammable\ gas\ in\ m^3/s$

$$\therefore \%\ gas = \frac{total\ quantity\ gas}{total\ quantity\ mixture}\ x\ 100$$

$$\therefore 3.8\% = \frac{qm}{6.8 + qm} x100$$

$$\therefore 3.8(6.8 + qm) = qm\ x\ 100$$

$$25.84 + 3.8qm = 100qm$$

$$\therefore 100qm - 3.8qm = 25.84$$

$$96.2qm = 25.84$$

$$qm = \frac{25.84}{96.2}$$

$$\therefore 0.269m^3/s$$

The flammable gas made at the end is 0*.269m³/s*

b) $Let\ the\ force\ qty\ be\ qf, \therefore \%\ gas = \frac{total\ quantity\ gas}{total\ quantity\ mixture}\ x\ 100$

$$1.4\% = \frac{0.269}{0.269 + qf}\ x\ 100$$

$$1.4(0.269 + qf) = (0.269\ x\ 100)$$

$$0.377 + 1.4qf = 26.9$$

$$1.4qf = 26.9 - 0.377$$

$$1.4qf = 26.523$$

$$\therefore qf = \frac{26.523}{1.4}$$

$$18.945m^3/s$$

The required force quantity is 18.95m³/s

c) Employing an estimated airflow requirement of 8m³/s per 100kW of rated diesel power

$$\therefore \frac{200}{100} x\ 8 = 16m^3/s$$

$$\text{Volume of the room } 40 \text{ x } 15 \text{ x } 15 = 9000\text{m}^3$$

$$\therefore Required\ airflow\ at\ 10\ air\ changes\ per\ hour$$

$$\frac{9000\ x\ 10}{60\ x\ 60}$$

$$= 25m^3/s$$

$$\therefore \text{required airflow} = 25\text{m}^3/\text{s}$$

d) $Quantity\ fresh\ air = \frac{Q_1\ x\ 10^6}{MAC-N} - Q_1$

$$= \frac{0.0008\ x\ 10^6}{50-0} - 0.0008$$

= 15.999m³/s

∴ Required fresh air is 16.0m³/s

e) Carbon dioxide has a relative density of 1.5, which means it is 1.5 heavier than air

∴ Density of Carbon dioxide = 1.5 x 1.1 = 1.65kg/m³

M = Q x W

$$\therefore Q = \frac{0.8\ kg/s}{1.65kg/m^3}$$

$$= 0.485\text{m}^3$$