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Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: **CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL - PAPER 4** **SUBJECT CODE: COMMEC4** **EXAMINATION DATE 06 November 2020** **TIME: 14:30 – 17:30**	**EXAMINER: R A Rabaji** **MODERATOR: A R Nundlall** **TOTAL MARKS: [100]** **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) Give short definitions of the following when used for Risk Management.

i. Tolerate
ii. Process
iii. Legal liability
iv. Health
v. Safety (5)

b) Define and provide an example to illustrate the following concepts in Risk Management. (5)

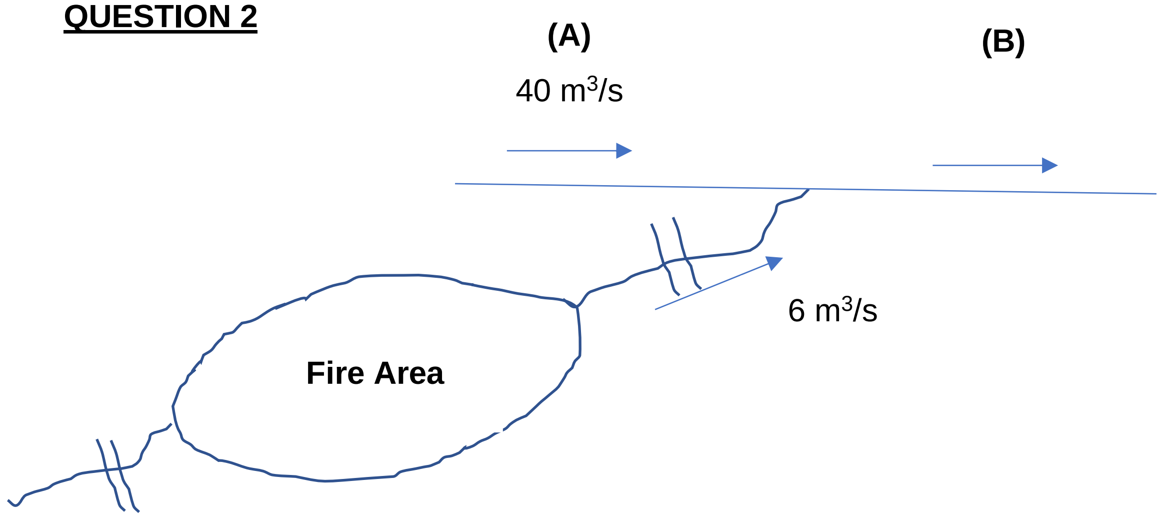
i. Prevention
ii. Consequence
iii. Eliminate
iv. Control at Source
v. Minimise

c) List the 10 steps of effective Risk Assessment, with an example to illustrate each step. (10)

d) What are the legislative aims of Risk Management for mines according to section 11(2) of the MHSA 1996, and provide an example of Programmes to monitor risk to which employees may be exposed" as per section 11(2) (d)(ii) ? (5)

(25)

QUESTION 2



In the sketch above a volume of $6m^3/s$ mixed with gases from a fire in a stope containing 38000ppm of CO_2 and 3200 ppm CO mixes with $40m^3/s$ (from position A) containing no CO and 800ppm CO_2 .

Calculate:

a) The concentration (%) of CO and CO_2 after mixing. (10)

b) The additional quantity on mine air at A required to ensure the TWA OEL - RL for CO (MH & SA Regulations) is not exceeded after mixing at point B Comment on your answer. (5)

c) When a gas sample taken underground has been analysed, percentages of various gases can be used to calculate the Graham's, Willet's and Young's ratios.

i) Explain the meaning and use of each ratio. (3)

ii) Determine the value of each of the above ratios for a gas sample which is analysed as follows: (7)

O_2 20,15%

N_2 78,60%

CO_2 0,032%

CH_4 1.20%

H_2 0,01%

CO 0.008%

(25)

QUESTION 3

a) List 12 processes or places that produce float coal. (12)

b) Which six main recognised methods are required to prevent coal dust explosion in a mine. (6)

c) What does LEL means when used in relation to the explosibility of coal dust? (1)

d) What is the average LEL for most combustible dusts? (1)

e) List five principles of the spark arrestors and flame inhibitors (Dampers) (5)

(25)

QUESTION 4

A diesel vehicle travels along the airway. The total gas emission is $0.2m^3/s$. The exhaust gases contains 1 500ppm of carbon monoxide and 750ppm of nitrogen. The cross sectional area of the airway is $9m^2$ and the air velocity is 3m/s. What will be the concentration of carbon monoxide and oxides of nitrogen in the air after complete mixing?

a) If the vehicle travels at 8km/h in the opposite direction to the airflow (9)

b) When the vehicle is standing still (3)

c) If the vehicle travels at 6km/h in the same direction as the airflow (7)

d) If the vehicle travels at the same speed and in the same direction as the airflow. (5)

e) When will the gas concentrations reach the above figures? (1)

(25)

Total (100)

Memorandum

Mine Environmental Control - Paper 4
May 2020

Question 1

a) Give short definitions of the following when used for Risk Management. (5)

i. Tolerate - Reasonable or justifiable acceptance or allowance of a condition or situation. √

ii. Process – A formal or prescribed way in which work or other tasks are done. √

iii. Legal liability – Responsibility or accountability with regards to criminal and civl law. √

iv. Health – A maintained acceptable degree of physical, mental and social well being of an employee while performing the tasks and duties of employment. √

v. Safety – The maintained protection of employees from excessive risks resulting from work factor hazards that may cause harm. √

b) Define and provide an example to illustrate the following concepts in Risk Management. (5)

i. Prevention – protection of employees from excessive risks reuslting from work hazards. √

ii. Consequence – degree of harm, or potential severity of the injuries or ill health. √

iii. Eliminate – Remove a hazardous substance i.e. stop a hazardous process or work practice√

iv. Control at Source – restrict formation of a susbstance, i.e. dilute with ventilation, scrub out or filter√

v. Minimise – supply, use protective devices, i.e. restrict worker exposure times in potentially hazardous situations. √

c) List the 10 steps of effective Risk Assessment, with an example to illustrate each step. (10)

i. The assessment process must be practical and realistic√
ii. The affected parties must be involved in the process√
iii. Use a systematic approach to adequately address all the risks and hazards√
iv. Aim to first identify the mayor risks√
v. Gather and analyse the relevant information before starting√
vi. Start by identifying the mayor risks√
vii. Assess the risks from these hazards by looking at existing controls√
viii. Look at and record what actually happens at the workplace√
ix. Include all persons at risk as well as visitors and contractors√
x. Record all observation in writing with any assumption and reasons√

d) What are the legislative aims of Risk Management for mines according to section 11(2) of the MHSA 1996, and provide an example of Programmes to monitor risk to which employees may be exposed" as per section 11(2) (d)(ii) ? (5)

i. Hazard assessments – (Identify the hazards) √
ii. Risk assessments – (Assess the risks) √
iii. Control measures – (Develop the systems) √

Question 2

a) The concentrations (%) of CO and CO_2 after mixing. (10)

i. % CO_2 $= \frac{38000ppm}{10000}$ = 3.8% CO_2 √

Qty of CO_2 from the stope = % CO_2 x Q_{stope}

$= \frac{3.8}{100}$ x 6 m^3/s

= 0.228 m^3/s √

ii. Qty of CO_2 from mine air = % CO_2 x $Q_{mine\ air}$

$= \frac{0.08}{100}$ x 40 m^3/s

= 0.032 m^3/s √

iii. Total Qty of CO_2 = 0.228 m^3/s + 0.032 m^3/s

= 0.26 m^3/s √

iv. Total Qty of mixture = 6 m^3/s + 40 m^3/s

$= 46\ m^3/s$ √

v. $\%\ CO_2 = \frac{Qty\ CO2}{Qty\ mixture} \times 100\%$

$= \frac{0.26}{46} =$ 0.5652 % CO_2 or 5652ppm √

i. $\%\ CO = \frac{3200ppm}{10\ 000} = 0.32\%\ CO$

Qty of CO from the stope = % CO x Q_{stope}

$= \frac{0.32}{100} \times 6\ m^3/s$

$= 0.0192\ m^3/s$ √

ii. Qty of CO from mine air = Nil √

iii. Total Qty of CO $= 0.0192\ m^3/s + 0\ m^3/s$

$= 0.0192\ m^3/s$ √

iv. Total Qty of mixture $= 6\ m^3/s + 40\ m^3/s$

$= 46\ m^3/s$

v. $\%\ CO = \frac{\text{Qty CO}}{\text{Qty mixture}} \times 100\%$

$= \frac{0.0192}{46} =$ 0.041739 % CO or 417ppm √

b) The additional quantity on mine air at A required to ensure the TWA OEL - RL for CO (MH & SA Regulations) is not exceeded after mixing at point B Comment on your answer. (5)

i. Total Qty of CO $= 0.0192\ m^3/s + 0\ m^3/s$ √

$= 0.0192\ m^3/s$√

ii. Total Qty Fresh $= \frac{\text{Qgas x 10^6}}{MAC - \text{N}} - Q_{gas}$

$= \frac{\text{0.0192 x 10^6}}{30-0} - 0.0192$

$=$ 639.9 m^3/s or 640 m^3/s√

Comment:- The quantity of 640 m^3/s is not practical, therefore it would be ideal to seal off the fire area completely. √√

c)

i) Explain the meaning and use of each ratio. (3)

- The Graham's ratio is the CO/O_2 and relates the level of carbon monoxide production to the rate at which oxygen is being absorbed in the oxidation process. √
- The Young 's ratio can be called the carbon dioxide, oxygen deficiency ratio. √
- The Willit's ratio takes all the gases in the sample other than air (free air analysis) and expresses the carbon dioxide as a percentage of these gases. √

ii) Determine the value of each of the above ratios for a gas sample which is analysed as follows: (7)

- Graham's ratio $= \frac{CO}{\text{O2 } deficiency} \times 100\%$

O_2 corresponding to 78.6% N2 $= \frac{\%N2\ in\ sample}{\%N2 \text{ in normal air}} \times \%O_{2\ \text{normal air}}$

$= \frac{78.6\%}{79.04\%} \times 20.93$

$= 20.814\%$ √

O2 deficiency $= 20.814 - 20.150$

$= 0.664\%$ √

Graham's ratio $= \frac{CO}{O2\ deficiency} \times 100\%$

$= \frac{0.008}{0.664} \times 100\%$

$= 1.2\%$ √

There is therefore no oxygen deficiency !

- Willit's ratio $= \frac{CO2}{\text{Excess N2+total combustibles+CO2}} \times 100\%$

Total combustibles = CH4 + H2 + CO

= 1.2 + 0.01 + 0.008

= 1.218% √

Excess N2 = N2 sample – 3.7778 O2 sample

= 78.6 – 3.7778 x 20.15

= 2.477 √

Willit's ratio $= \frac{0.032}{2.477+1.218+0.032} \times 100\%$

= 0.858% √

% CO low in comparison to the other gases present.

Note:- O2 deficiency = 0.569% (as before)

Young's ratio $= \frac{CO2}{\text{O2 deficiency}} \times 100\%$

$$= \frac{0.032}{0.664} \times 100\%$$
$$= 4.8\% \surd$$

QUESTION 3

a) List 12 processes or places that produce float coal. (12)

1) Mechanical miner operations, 2) Longwall operations, 3) Roof bolting, 4) Feeders and crushers, 5) Section tramming routes, 6) Blasting operations, 7) Drilling operations, 8) Coal transfer points, 9) Conveyor belts, 10) Tail ends, 11) Transport, 12) Road surge bins

b) Which six main recognised methods are required to prevent coal dust explosion in a mine. (6)

The dust must be:

- As much as possible removal of fine coal spillage
- Reduce/control dust creating sources
- Effective ventilation to dilute or remove flammable gas emissions
- Sufficient and effective application of incombustible stone dust in the workings
- Sufficient well designed and effectively spaced flame quenching barriers
- Prevent/control potential ignition and high temperature sources

c) What does LEL means when used in relation to the explosibility of coal dust? (1)

- Lowe Explosibility Limit of coal

d) What is the average LEL for most combustible dusts? (1)

- The average lower explosibility of for moat of the dusts are about 0.01Kg up to 0.5Kg of combustible dust mixed with m^3 of normal air with 21% O_2 content

e) List five principles of the spark arrestors and flame inhibitors (Dampers) (5)

- Containing the spark or flame
- Preventing the ingress of flammable gas or vapour
- Using non sparking metals to reduce friction sparks
- Quenching systems
- Reduce the temperature of the spark
- Prevent flash backs of ignition

QUESTION 4

a) If the vehicle travels at 8km/h in the opposite direction to the airflow (9)

The total gas emission is $0.2m^3/s$

The gas concentrations:- CO = 1 500ppm = 0.15%

NO_x = 750ppm = 0.075%

The cross sectional area of the airway = $9m^2$

The air velocity = 3m/s

The speed of the vehicle must be expressed in m/s, at 8km/h the vehicle travels

$$\text{Vehicle speed in m/s} = \frac{\text{km/h} \times 1000}{3600}$$

$$= \frac{8 \times 1000}{3600}$$

$$= 2.222\text{m/s}$$

When the vehicle travels in the opposite direction to the air flow, the effective air velocity is

= vehicle velocity + air velocity

= 2.22 + 3.0

= 5.22m/s

The effective air quantity = V x A

= 5.22 x 9

= $47m^3/s$

The quantity of CO from the exhaust = $Q_{exhaust}$ x % CO

= 0.2 x 0.15/100

= $0.0003m^3/s$

The quantity of NO_x = $Q_{exhaust}$ x % NO_x

= 0.2 x 0.075/100

= $0.00015m^3/s$

% CO in the airway = $\frac{q_{CO} \times 100\%}{Q_{mix}}$

$$= \frac{0.0003 \times 100}{47}$$

= 0.000638 or 6.4ppm

%NO_x in the airway = $\frac{q_{NOx} \times 100\%}{Q_{mix}}$

$$= \frac{0.00015 \times 100}{47}$$

= 0.000319 or 3.2ppm

b) When the vehicle is standing still (3)

The quantity of CO emitted from exhaust = $0.0003 m^3/s$

% CO in the airway $= \dfrac{q_{Co} \times 100\%}{Q_{mix}}$

$= \dfrac{0.0003 \times 100\%}{(3 \times 9)}$

$=$ 0.0011% CO or 11ppm

The quantity of NO_x emitted from exhaust $=$ $0{,}00015\ m^3/s$

% NO_x in airway $= \dfrac{q_{NO_x}}{Q_{mix}} \times 100\%$

$= \dfrac{0{,}00015}{(3 \times 9)} \times 100\%$

$=$ 0,000556 % NO_x (or 5,6 ppm)

(c) The speed of the vehicle must be expressed in m/s, at 6 km/h the vehicle travels:

$$\text{vehicle speed in m/s} = \frac{\text{km/h} \times 1000}{3\,600} = \frac{6 \times 1000}{3\,600} = 1{,}67 \text{ m/s}$$

When the vehicle travels in the same direction to the air, the effective air velocity is as follows:

$$\text{Effective air velocity} = \text{air velocity - vehicle velocity} = 3{,}0 - 2{,}22 = 1{,}33 \text{ m/s}$$

The effective air quantity available for mixing must now be determined:

$$Q_{effective} = V \times A = 1{,}33 \times 9 = 11{,}97 \text{ say } 12 \text{ m}^3/\text{s}$$

The quantity of CO from exhaust = 0,0003 m^3/s (same as before)

The quantity of NO_x from exhaust = 0,00015 m^3/s (same as before)

$$\%\text{ CO in airway} = \frac{q_{CO}}{Q_{mix}} \times 100\% = \frac{0{,}0003}{12} \times 100\% = 0{,}0025\,\% \text{ CO (or 25,0 ppm)}$$

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c) If the vehicle travels at the same speed and in the same direction as the airflow.(5)

$\% NO_x$ in airway $= \dfrac{q_{NO_x}}{Q_{mix}} \times 100\%$

$= \dfrac{0{,}00015}{12} \times 100\%$

$= 0{,}00125\ \%\ NO_x$ (or 12,5 ppm)

(d) When the vehicle travels at the same speed as the air and in the same direction that is at 3 m/s the effective air velocity is 0 m/s.

The effective air quantity available for mixing must now be determined:

$Q_{effective}$	=	0 m/s (still air)
The quantity of CO from exhaust	=	0,0003 m^3/s (same as before)
The quantity of NO_x from exhaust	=	0,00015 m^3/s (same as before)
The gas concentration of CO	=	0,150% (1 500 ppm exhaust emission)
The gas concentration of NO_x	=	0,075 % (750 ppm exhaust emission)

The gas concentrations will reach the above figures if the condition persists for long enough.

d) When will the gas concentrations reach the above figures? (1)

The gas concentrations will reach the above figures if the condition persists for long enough.