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Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA	**EXAMINER: M. R Melk**
CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 4	**MODERATOR: R A Rabaji**
SUBJECT CODE: COMMEC4	**TOTAL MARKS: [100]**
EXAMINATION DATE: May 2022	**PASS MARK: 60%**
TIME: 14:30 – 17:30	

Examination Instructions:

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

FORMULA HANDOUT IS AVAILABLE

1. Answer all **4** 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) Define the following? (6)

i. Risk

ANS The probability that a hazard will cause bidily harm or Injury

ii. Respirable combustible dust

ANS that portion of a respirable dust sample that can be burned off a silver membrane filter when exposed to a temperature of 400 ^{0}C for two hours

iii. Narcosis

ANS Stupor or unconciousness produced by chemical substance

iv. Hazardous material

ANS Any substance or compound that has the capability of producing adverse effects on the health and safety of humans

v. Covid-19

ANS An acute respiratory illness in humans caused by a corona virus, capable of producing severe symptoms and in some cases death, especially in older and those with underlying health conditions

vi. Chronic

An illness/condition persisting for a long time or constantly recurring

b) Briefly discribe the process you will follow to clear confined space containing flammable substances (10)

Ans 1. Confined space must be drained prior to entry

2. Chemicals should be flushed out and nutralised

3.Proper earthing to prevent static electricitty

4. isolation and lock-out must be in place

5. if hot work is required intrinsically safe equipment must be used

6. Fan must be connected to ventilate and flush out the contaminants beforehand

7. Buddy system to be used at all time

8. Confined space must be cleared safe for entry by a competent person and a clearance certificate be issued before any work can commence

9 A spotter to be always outside the confined space for access control and have a mode of communication at all times with entrants

10. Entrants to have valid confined space training

11. A rescue plan should be in place

12.Fire extiguisher to be readily available where hot work is performed

13.Confined space must be barricaded and demacated as such to prevent unauthorised entry

14.Correct PPE to be provided and ensure continous monitoring is done where required

15. on completion of work inside the confined space the permit must be signed off and equipment must be handed over to responsible person

c) Certain conditions must exist before a coal dust explosion can occur; briefly discuss the factors that cause the explosibility of coal dust (9)

ANS:
The student is expected to explain how the following are applicable
The dust must be:

- Of a composition, which includes sufficient volatile matter
- Of the necessary fineness
- In a dispersible condition
- Present in sufficient quantity so that if raised as a cloud in the mine air it will be present in a concentration above a certain minimum

(25)

QUESTION 2

a) . A fire detection system is being tested. The system nvolves a measurement of carbon monoxide and carbon dioxide levels at the top of the mine 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 91 m3/s and the total air quantity in the upcast shaft is 738 m3/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 56 percent.
- That for each kilogram of carbon that is burnt 140g 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.

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. 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 2

Answer

Return side of the Fire

The total carbon liberated must be established:

Carbon liberated = burning rate of fire x carbon content %

= 0.09 x 0.56

=0.0050kg/s

Considering carbon dioxide concentration

The amount of carbon produced which forms CO2:

Carbon amount = amount of carbon from fire x % CO2

= 0.0050 x (100-14)/100

= 0.0043 kg/s

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

8 O_2 combines with 3C

? O_2 combines with 0.0043 C

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

Amount of O_2 required = 0.0043C x 8 O_2/3C

= 0.0114 kg/s O_2

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

The mass flow of CO_2 = 0.0114+0.0043

= 0.0157kg/s CO_2

Since CO_2 is approximately 1.55 times heavier than air (note, this is the catches to the question), and the air density is given as 1.23 kg/m3, the quantity and the volume of the CO_2 produced can be established:

The density of the CO_2 = SG gas x density of air

= 1.55 x 1.23

= 1.9065 kg/m3

Volume of the CO_2 = Mass of CO_2/Density of CO_2

= 0.0157/1.9065

= 0.0300 m3/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 0f 91 m3/s can now be established:

Volume of CO_2 ………..= 91 X 0.03/100

=0.0273 m3/s

The total quantity (volume) of CO_2 =0.0841 +0.0273

= 0.1114 (volume of CO_2 coming from fire)

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

% CO_2 = Qco2/Qmix x 100%

= 0.1114/91 x 100

= 0.1224 % of CO_2 (or 1224 ppm)

Considering carbon monoxide concentration

The amount of carbon produced which form CO:

Carbon amount = amount of carbon from the fire x % CO

= 0.0504 x 14/100

= 0.0071 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 0.0071 C

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

Amount of O required = 0.0071 C x 4 O/3C

= 0.0094 kg/s O

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

The mass of flow = 0.0094 +0.0071

= 0.0165 kg/s of CO

Since the 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/m3, the quantity and the volume of the CO produced can be established

The density of CO = SGgas x density of air

= 0.97 x 1.23

= 1.1931 kg/m3

Volume of the CO = Mass of CO/Density of CO

= 0.0165/1.1931

=0.0138 m3/s CO

Also the amount of CO in the normal air is NIL

The total quantity (volume) of CO = 0.0138 + 0

= 0.0138 m3/s (volume of CO coming from the fire)

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

%CO = qCO/Qmix x 100

= 0.0138/91x100

= 0.0151 % CO (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 = Qco/Qmix x 100%

= 0.0138/738 x100%

= 0.00186 % CO (or 18.6 ppm)

The quantity of CO2 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 follow

The quantity of air not past the fire = 738-91

= 647 m3/s

The amount of CO2 in this volume of air must now be determined:

Quantity = 649 x 0.03/100

= 0.1947 m3/s

The total amount of CO2 top of the shaft = 0.1947 +0.1114

= 0.3061 kg/s **(25)**

The concentration of CO2 at the top of the upcast shaft can now be determined

% CO2 = Qco2/Qmix x 100

……………….= 0.3061/738 x100

= 0.0415% of CO (or 415 ppm)

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

% CO ………………..= Qco/Qmix x 100

………………..= 0.0138/738 x 100

= 0.0019 % (19 ppm)

QUESTION 3

a). The following are PNOC TWA dust concentration in mg/m3 from a gravimetric dust sampling program:

2.3	2.82	3.4	1.32	3.6
2.11	1.55	0.98	0.99	0.82

i. 90^{th} percentile

= 10 x 0.90

= 9 (this is the index)

= 90th percentile is 3.4mg/m3

Interpretation:

ANS: since the OEL for PNOC is 3mglm3, the above-mentioned HEG will be classified as an A-HEG and quarterly sampling will be required, at least 5 % or 5 samples must be taken per quarter (whichever is higher). 90th percentile is used to determine the HEG classification for the following year.

ii. the mean pollutant concentration

= (0.82+ 0.98 + 0.99 + 1.32 + 1.55 + 2.11 + 2.3 +2.82 + 2.98 + 3.4 + 3.6)/10

= 2.29 mg/m3

1. The mean pollutant concentration is 2.29 mg/m3 interpret the answer

ANS: This number represent the average mean of the HEG and this value will be allocated to the employee or HEG medical records for risk based medical surveillance. The mean pollutant concentration will also be used on the Exit medical form

b) What are the areas most likely for spontenious combustion of coal mines and briefly explain why? (15)

ANS

- Major subsidence with cracks involving top coal or roof shales that extend to surface (can allow air leakage’s from surface due to action of ventilating fan pressures)
- Accumulations of broken and fine coal (sluggish airflow over these)
- Where pillar extraction is practised (goaf areas with sluggish airflow)
- Sloughing of pillar sides (crushing allows coal to accumulate around base)
- Roof coal falls in old areas (accumulations with sluggish airflow’s)
- Junctions (crush on solid coal at corners may have air short circuiting through these)
- Air crossings cut into the seam (crush on solid coal at corners may have air short circuiting through these)
- Doors, regulators and connecting roads (forces air through cracks around the frames)
- Obstructions in roads (forces air through breaks in roadways cut into solid coal)

QUESTION 4

a) It is planned to start up a new shaft with normal operation of a mine (either coal or metalliferous) and an issue-based risk assessment needs to be prepared with the focus on fire and explosions. Please prepare such an assessment using your experience and evaluate your current practice, standard and procedure.

The following should be addressed in the risk assessment:

1. Hazards

Hazard sources subdivided into energy and substance

Energy –

Mechanical : acid coming into contact with corroded steel resulting in the release of hydrogen which is explosive

Gravity: equipment from surface falling into the shaft

Electrical : use of intrinsically safe equipment/ fire protection

Radiation

Heat

Substance

- Chemicals (acid, caustic, poisonous, flammable, explosive)
- Dusts, respirable fibre (pneumoconiosis's, toxic, explosive, flammable)
- Gas, fumes, mists, vapour, aerosol (toxic, suffocating, flammable, explosive)

2. Risk Assessment

THE ISSUEBASED ASSESSMENT This is normally associated with management of change Additional assessments must be carried out when:

- A new machine is introduced
- A system of work is changed (procedures, guidelines)
- The operations alter (multi-shift systems are started)
- An accident or incident has occurred
- New knowledge about specific hazards are made known
- Data base updating indicates a previous assessment is now invalid • Changes in legislation requires re-assessment
- New training systems are introduced The Issue Based Assessment may also be viewed as a requirement for review and revision of the Risk Profile on

a more regular basis. It may also stem from the outcomes of the Baseline Assessment where a more in-depth study is required.

3. Control strategy

THE CONTROL STRATEGIES

(ELIMINATE)

- Remove the hazardous substance
- Substitute for a non-hazardous substance
- Stop a hazardous process or work practice
- Substitute for a less hazardous process or work practice
- Remove the people from the hazard until the situation is made safe
- Stop potential formation or liberation of hazardous substances

(CONTROL AT SOURCE)

- Restrict formation, liberation or accumulation of hazardous substances • Dilute with ventilation, scrub out and/or filter off
- Clean up, store and dispose of properly (MINIMISE)
- Supply, install and / or use protective devices and equipment.
- Restrict worker exposure times in potentially hazardous situations

15

b) Briefly discuss the function of the central emergency control room and the responsibility of the senior Environmental control official (Linked to the control room)? (5)

Answer – The purpose of the central control room (five of the following:

• Provision of the mine rescue and ventilation plans • Ensure that plans are up to date and that sufficient quantities are available •

Plans showing fire points, fire patrol routes, water and compressed air reticulation systems •

Helping to identify sealing sites for the construction of fire or airflow stoppings and any proposed changes to the ventilation system •

Giving advice on airflow directions, quantities, temperature, and water pressure requirements and whether work may safely resume in areas not affected by the fire

Interpreting the results of gas samples and interpreting the course of the fire or sealing and fire fighting operations

• Provide instruments for gas detection, temperature, airflow, and pressure monitoring

• Supply staff to assist with taking gas readings and seal construction

• Ensure that main and booster fans are operating normally and check on main airlocks, seals, and all matters relating to the overall ventilation system that may be affected by the fire.

c) What are the factors that contribute to the explosibility of dust (5)

i. Particle size distribution
ii. Volatile content
iii. Air Mixture concentration
iv. Moisture content of the combustible dust portion
v. Housekeeping

(25)

Total (100)