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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: October 2021** **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) Define the following? (6)

i. Toxic gas
Is a gas,if breathed in sufficient concentrations for a sufficent time will disable or kill a person.

ii. Simple asphyxia
Occurs when suffient air is breathed, but contains too little oxygen (i.e the air has an oxygen defficiency,) common gases that displace oxygen causing an oxygen defficiecy are methane (CH_4) and carbon dioxide (CO_2)

iii. Chemical asphyxia
Occurs when a toxic substance present in the air, prevents the transfer of oxygen from the lungs to the blood or from the blood to the tissues i.e common gases that act this way are carbon monoxide (CO) and hydrogen sulphide (H_2S)

iv. Explosive gas
Are gases which are safe to breath, but may in certain cases be explosive also known as “flammable gases”. These gases usually explode when they are mixed with air, reaching the explosive concetrations or range, and are ignited by the flame, spark or any other potential source of ignition.

v. Gas
A formless fluid that expands and fill the space they are in whose exerted pressure is the same in all directions.

vi. Confine space
means an enclosed or partially enclosed space that is not intended or designed primarily as place of work

b) List four conditions that must exist for an underground flammable gas explosion to occur (4)

- the gas must be produced or present
- the gas concetrations must reach the gas exposive range
- there must be sufficient oxygen present in the atmosphere
- a flame or spark must ignite the gas

c) Descibe six means on how adequate ventilation can be maintained to prevent flammable gas accumulation. (6)

- Proper distribution and control of available air to all workings
- Minimise air leakages and wastage of air into worked out areas
- Install and mainatin effective in stope ventilation controls
- Correct installation and maintanance of development ventilation appliances
- Daily inspection by the responsible mine or supervisor on conditions and operation of ventilation appliances

- Adherence to mine standards in respect to ventilation layout

d) State 9 recommeded actions that must be implemented if a flammable gas is detected. (9)

- Stop all work in progress, immediately
- Withdraw all people from the workings to fresh air, preferably upstream from the workings (i.e intake air side of the workings)
- Notify the next senior official and the ventilation department – communication to all is of utmost importance in order to action such conditions.
- Place guards at all entrances to such workings until barricades ca be errected to prevent inadvertent entry.
- Barricade all entrances with effective barricades and post up the following notices: “No Entry” “Flammable gas present”
- Stop all electrical and diesel equipment on the return air side of such workings
- Isolate the power supply to all electrical equipment in such workings at the isolation switch in through ventilation, except fans in operation.i.e fans installed, but not operating in such workings should not be restarted.
- Warn all people working on the return air side of such workings and withdraw them if necessary.
- Report the occurrence verbally and in writing to the people coming on the next shift cycle.

(25)

QUESTION 2

a) You are responsible for determining the ventilation requirements for an underground chamber in which a stationary diesel powered generator is located. You must provide the minimum amount of fresh air to dilute all gases to the allowable OEL. The local OELs for the various gases are as follows: (8)

CO	30 ppm
NO	25 ppm
NO_2	3 ppm
CO_2	5000 ppm

The quantities of gases produced by the diesel engine are as follows:

CO	2.0 litres/second
NO	1.1 litres/second
NO_2	0.1 litres/second
CO_2	100 litres/second

Note:-Make the assumption that the fresh air you will supply contains no CO, NO, or NO_2, and the concentration of CO_2 in the fresh air is 400ppm.

Answer

Convert all the gas flow rates from litres/second to m^3/s:
CO 2.0 litres/second = 0.002 m^3/s
NO 1.1 litres/second = 0.0011 m^3/s
NO_2 0.1 litres/second = 0.0001 m^3/s
CO_2 100.0 litres/second = 0.1 m^3/s

Use the formula to determine the required dilution quantity for each gas

$$Q = \frac{Q_{1\ x\ 10^6}}{MAC - N} - Q_1$$

where Q is the required dilution quantity, Q_1 is the gas flow quantity, MAC is the Maximum Allowable Concentration (OEL), and N is the gas concentration in the dilution air.

Solving for CO:

$$Q = \frac{0.002\ x\ 10^6}{30 - 0} - 0.002$$

$$= 66.665 m^3/s \text{ or } 66.7 m^3/s$$

Solving for NO, NO_2, and CO_2, we obtain 44.0m^3/s, 33.3m^3/s, and 21.6 m^3/s respectively. Therefore to dilute all these gases to their OELs, the highest quantity must be used. This is the 66.7 m^3/s required to dilute CO.

b) List 12 elements that must be included in the permit to work inside the confine space as per the guideline for mandatory COP management of working in confine spaces . (12)

- A risk assessment, including the need for a competent person monitoring identified hazards, concentrations of flammable and explosive substances;
- Specify the work to be performed in the confined space;
- Isolation procedures for airborne pollutants and other energy sources;
- The requirement for control measures;
- The sign-in and sign-out of all persons entering the confined space;
- Display of the permit;
- Communication equipment;
- Safety specification of equipment to be taken into the confined space;
- Barricading;
- Rescue plan and equipment;
- Standby person/Control Attendant; and
- A completion procedure.

c) .Define the following terms in relation to the confine space guideline (5)

i. Bump test

Bump test" means a brief exposure of gas monitor to gas to verify that the sensors respond and the instrument alarms function accordingly.

ii. MOHAC

Mining Occupational Health Advisory Committee.

iii. Permit

an official document giving someone authorization to do something.

iv. Risk

the likelihood that occupational injury or harm to persons will occur

v. Standby person

means a person located outside the permit space who controls and records Confined Space entry and performs other duties as defined by the COP.

(25)

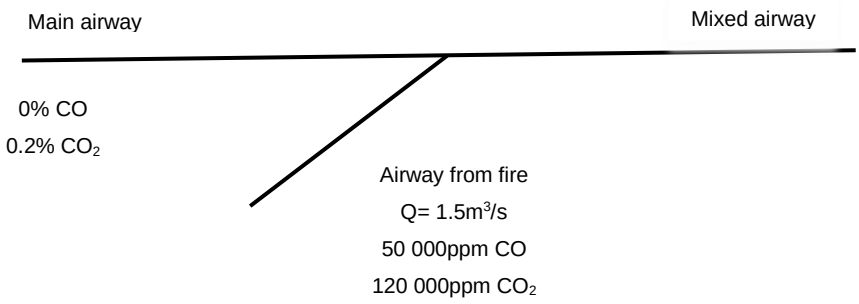
QUESTION 3

During a fire in a section of a mine the exhaust gases are found to contain the following gases and concentrations.

50 000 ppm of CO

120 000ppm of CO_2

The total flow of air and gases from the fire is 1.5m^3/s. The dilution air contains no CO and 0.2% CO_2



a) How much dilution air is required to ensure that in the exhaust gases both CO and CO_2 are below the maximum levels permitted by law? Comment on the quantities obtained. (14)

Answer

Consider the CO gas

The fresh air quantity needs to be determined as follows:-

$$Q_{Fresh} = \frac{q_{gas\ x\ 10^6}}{MAC-N} - q_{gas}$$

The quantity of the gas = 50 000ppm x Q_{mix}

$= \frac{50\,000}{1000\,000} \; x \; 1.5\text{m3/s}$

$= 0.075\text{m}^3\text{/s CO}$

Now apply the formula, $Q_{Fresh} = \frac{q_{gas\ x\ 10^6}}{MAC-N} - q_{gas}$

$$Q_{Fresh} = \frac{0.075\ x\ 10^6}{100 - 0} - 0.075$$

$$Q_{Fresh} = 749.925\text{m3/s}$$

Consider the CO_2 gas

The fresh air quantity needs to be determined as follows :-

$Q_{Fresh} = \frac{q_{gas\ x\ 10^6}}{MAC-N} - q_{gas}$

The quantity of the gas = 120 000ppm x Q_{mix}

$= \frac{120\,000}{1000\,000} \; x \; 1.5\text{m3/s}$

$= 0.18\text{m}^3\text{/s } CO_2$

From fresh air for dilution = Q_{fresh} = Y m^3/s

Assume no leakages, the air from the two airways will mix in the following manner (Remember that 0.2% = 2 000ppm)

$\therefore \quad Q_1C_1 + Q_2C_2 = Q_1C_1$

$\therefore \quad$ Y x 2000ppm + 1.5 x 120 000 = (Y + 1.5) x 5000ppm

$= 57.5\text{m}^3\text{/s}$

The quantity of air required is therefore $750m^3/s$, and it is obviously impractical to dilute gase and the fire area must be sealed off.

b) This fire was extinguished by sealing. The sealed area has a volume of 80 $000m^3$ and the gas in this sealed area is 50 000ppm of CO. If $4m^3/s$ of air is used to flush out the gases and the mixture of exhaust gases contains 1 200ppm of CO, how long will it take to clear all the CO from the sealed area? (7)

The amount of gas flushed from the area = 0.12% x $Q_{flushed}$

$= \frac{0.12}{100} \; x \; 4 \; m^3/s$

$= 0.0048 \; m^3/s$

The amount (volume) of gas in the sealed area = 50 000ppm x 80 000 m^3

= 5% x 80 000

= 4000m^3

The time required to clear the area = $\frac{Volume}{quantity\,(flushed) x\ 24\ x\ 60\ x\ 60}$

= $\frac{4000}{0.0048\ x\ 60\ x\ 60}$

= 9.645 say 10 days

c) It is found that during flushing with 4m^3/s of fresh air, the exhaust gases contain 0.2% methane. This methane is issuing from a fissure in the fire area. What is the methane flow rate?

(4)

The methane flow rate = 0.2% x 4m^3/s

= $\frac{0.2}{100}$ x 4 m^3/s

= 0.008m^3/s

QUESTION 4

a) Describe how the measurements taken by the occupational hygiene practitioner, appointed under Chapter 2, Section 12.(1),(b) of the Mine Health and Safety Act, can be linked to medical surveillance records. (5)

This linking and record keeping can be done various ways:

- Sophisticated computer programmes to quickly assimilate and process all relevant occupational hygiene, health and medical information to one common database. However, the data still has to be manually inputted.
- Less complicated but tedious manual processing to data process systems
- The results and findings of the baseline and resultant issue based risk assessments will determine the level of database required.

- In all cases, there must be good lines of communication between the occupational hygienist and the occupational medical practitioner.

b) What elements should be present in working procedures that will ensure the safety and health of operational staff? (5)

Current legislation requires that employers must:

- Establish and maintain a system of medical surveillance of employees exposed to health hazards if it is a regulatory requirement, or if it is necessary according to risk assessment results.
- Keep record of such surveillance
- Conduct occupational hygiene measurements
- Keep record of such measurements
- Link these records to an employee's medical surveillance record
- Safely keep all such records for a period of 40 years from the last date of the medical surveillance of that employee
- . Compile and submit an annual report to the Medical Inspector that covers employees of the mine giving an analysis of the employees' records of medical surveillance, without disclosing the names of the employees.

c) List the requirements of investigation into an event arising from adverse occupational exposure in a workplace. (5)

The main items of information are usually:

- Person or persons exposed and relevant occupations.
- Type of exposure (gas, dusts, mist, fume, vapour, heat, cold, radiation, biological and ergonomic) OR, can be listed as chemical, physical or ergonomic related exposure
- Duration of exposure (exceeded OEL or other)
- Results of exposure. (Physical injury, acute or chronic ill health)
- If chronic ill health or exposure: History of environmental conditions and/or occupational hygiene monitoring of the worker or workers' normal place of work to be submitted and medical surveillance link to this for worker, or each individual worker exposed, to be analysed
- If acute ill health or exposure: Place of exposure and work process involved, time reported and date of exposure, prevailing conditions at time of exposure
- Possible cause or causes of exposure. (Ventilation system failure, spillage, fire, explosion, emissions, adverse weather, PPE use. systems failure)
- Reason for cause of exposure. (Training or risk assessment deficiencies)
- Preventative or protective measures that should have been taken.
- Whether a breach of legislation or duties was the cause of exposure.

d) • Measures taken to avoid another such exposure.

e) Explain how the following statistical parameters are determined and state the meaning of each parameter.

i. Mean

This is the arithmetical average of a set of values. The number of values to give the mean or average divides the total of the values by the number of values

ii. Geometric mean

The geometric mean, sometimes referred to as compounded annual growth rate or time-weighted rate of return, is the average rate of return of a set of values ...

iii. Median

The median is the number in the middle of a set of numbers, that is, half the numbers have values that are greater than the median, and half have values that are less.

iv. standard deviation

The standard deviation is a measure of how widely values are dispersed from the average value (mean).

Percentile

This is the k-th percentile of values in a range. It can be used to establish a threshold of acceptance. Percentiles are fractals, which relate hundredths of the way through a data set arranged in order of magnitude and are used as “cut-off” values in a data set. (10)

(25)

Total (100)