Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: **CHAMBER OF MINES OF SOUTH AFRICA –INTERMEDIATE CERTIFICATE IN MINE ENVIRONMENTAL CONTROL**	EXAMINER**: NEO DIKGALE**
PAPER 1	MODERATOR: INUS LABUSCHAGNE
SUBJECT CODE: **COMIMEC1**	TOTAL MARKS: **[100]**
EXAMINATION DATE: MAY **2022**	PASS MARK: **(60%)**
TIME: **14:30 – 17:30 (3 HOURS)**	

NUMBER OF PAGES: 3

SPECIAL REQUIREMENTS:

THIS IS **NOT** AN **OPEN BOOK EXAMINATION**.

FORMULA HANDOUTS ARE AVAILABLE TO CANDIDATES:

1. Answer all 4 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 your 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 measurement (SI unit) is recorded, as marks will be deducted from answers if the incorrect unit is used (even if the calculated value is correct).

8. Please note that you are not allowed to contact the examiner or moderator regarding this examination.
9. Cell phones and any other electronic devices are **NOT** allowed in the examination room.

QUESTION 1

1.1 Demonstrate your understanding of how a typical deep level mine is ventilated, making use of a sketch to assist in explaining the type of ventilation of your choice (8)

Upcast or downcast (Ascentional/ descentional) ventilation definition, include ventilation appliances to direct air to workings.p23-24

1.2 What are the requirements of an ideal airlock? (5)

(Any 5 of the following)

- It must not leak excessively
- It must be self-closing and kept closed at all times
- The installation must be as such that only one door can be opened at a time (interlocking)
- It must be economical, efficient and require minimum maintenance
- It should be robust, strong and easy to open
- Each door must be equipped with proper handle on both sides pressure release flap and an effective water trap
- It should be painted with black and yellow shevron lines (or any otherv colour as per your mine's standard) to make it visible

1.3 Ventilation doors are connected/ installed in series to form an airlock. What is the objective of an airlock? (1)

- To prevent the flow of air from workings, while at the same time allowing travelling and transport to take place.

1.4 Describe one method of ventilating a development end and provide advantages of such a method of ventilation. (4)

<u>Forcing system</u>

Air is acquired from a point at least 10m upstream in the nearest through ventilation and with the aid of a fan forced through the ventilation duct and discharged to within 12 meters from the face.

<u>Advantages:</u>

- Air flows to the face inside the pipe at a high velocity, thus good quality air is delivered at the face
- The fresh air is discharged right at the face, where the workers derive maximum benefit from it
- A single fan and a single column are required (economical)
- The fan and motor are always in fresh air, causing less wear and tear on the fan
- Leakage in the column is outward and hence easily detectable

OR

<u>Exhaust overlap System</u>

An exhaust fan, at least 10m in through ventilation is installed and connected to a ventilation column, which is extended into the development end up to ± 30m from the face. A second smaller sized force fan is installed, 10m upstream from the exhaust column intake. A ventilation column is fitted to this fan and extended to within 12.0m from the face, to force air onto the face. Force fan must not handle more than 2/3 of the exhaust fan intake volume.

Advantages:

- Persons travelling and working in the development end do so in fresh air as the return air is inside the exhaust pipe

- Short re-entry periods are possible when used in multi-blast or high speed development ends
- Return air is under control
  OR
  Exhaust system
  A fan is installed in through ventilation, 10m downstream from the development end break away. A ventilation column is attached to this fan and extended into the development end, up to as close as possible to the face, to exhaust air from the face.
  Advantages:
- Persons working in or travelling in the development end, away from the face, derive maximum benefit from the fresh air
- Return air can be controlled
- Single fan and column is required

1.5 Why do we measure two pressures across an airlock? Why do these pressures differ? (2)
The pressures differ due to leakages.

(20)

QUESTION 2

2.1. What is a refuge bay? List and discuss the parameters that need to be considered when constructing a refuge bay? (10)

It is a place underground, in which workers can find refuge to escape the dangerous by-products of a mine fire or explosion, for a determined period (up to 24 hrs) possibly until a rescue operation can be conducted.

<u>Parameters to be considered when constructing a refuge bay</u>

i. <u>Location</u>
   - Refuge bays should be ideally located on the normal route followed by workers to and from the workplace as well as on alternative escape routes.
   - At a distance as close as possible to the workplace, but not exceeding a distance of 750m from any position inside the working place
   - At positions close to main station to cater for possible intake airway or shaft barrel fires
   - Where possible, in an area free of combustible material

ii. <u>Access routes-</u>
   - escape routes/access routes to be clearly demarcated with symbolic signs from inside the workplace and along the route to the refuge bay,
   - escape routes should be the shortest possible way from the workings.

iii. <u>Design and construction</u>
   - Ensure that materials used to construct the refuge bay is fire resistant
   - The exact size of the refuge bay must take into consideration the number of workers in the area to be served, allowing a minimum area of $0.6m^2$ for every worker
   - Cater for stretchers (injured workers)

iv. <u>Air supply and ventilation</u>
   - Compressed air must be piped into the refuge bay in such a way that it is evenly distributed throughout.
   - The air valve should be positioned inside the refuge bay at the entrance
   - Install a by-pass with a 30mm orifice in the compressed air supply to the refuge bay, in order to continuously ventilate it, to prevent the build up of heat and noxious gases when not in use

v. <u>Air whistle/ flashing light</u>

- Install air whistle in the compressed air supply, outside the refuge bay
- A flashing light should be installed opposite the refuge bay entrance for easy identification of the refuge bay during emergencies or when there is poor visibility.

vi. Entrance: (front wall)

- The entrance of the refuge bay should be large enough to allow access for men with a stretcher
- Equipped with a proper weighted door to maintain a positive pressure within the refuge bay, and considered to effect an air-tight seal when the air supply fails and pressure cannot be maintained
- The entrance must be designed in such a way that toxic gases cannot be introduced into the refuge bay by turbulence
- Demarcated with a number or locality name on both sides of the wall (inside and outside)

vii. Potable water

- Sufficient supply of potable water (25mm pipe)

viii. Toilet facilities

- Install basic ablution facilities towards the entrance of the refuge bay

ix. Equipment

- First aid equipment
- Means of communication
- Procedure to be followed on arrival at the refuge bay, conforming to individual mine standard

x. Inspections /Maintenance

- Shiftboss inspections of the refuge bay on a weekly basis
- Detailed monthly inspection by the ESH department with finding of refuge bay condition

2.2. List 5 factors essential to an effective escape strategy. (5)

- Training
- Regular fire drills
- Demarcation of route
- Accessibility of route
- Shortest route to the refuge bay

2.3. What 5 factors must occur simultaneously for an explosion to occur? (5)

Fuel, Heat, Oxygen, Suspension and Confinement

QUESTION 3

3.1. What is refrigeration? (1)

It is a process of cooling, whereby heat is removed from a substance (air), where it is not wanted (workings), and put back where it does not affect workers (return airways).

3.2. Sketch and describe the refrigeration plant cycle, incorporating both the hot and chilled/cold water circuits. (15)

See diagram on p 157

The refrigeration plant contains 4 main components: Evaporator, Compressor, Condenser and Expansion valve.

Evaporator:

The refrigerant liquid enters the evaporator and absorbs heat from the medium to be cooled (water) which flows inside the evaporator tubes. As the refrigerant liquid absorbs heat from the warmer tubes, it starts to evaporate into a gas state, by absorbing latent heat at a constant temperature. The refrigerant leaves the evaporator as a gas at low temperature and pressure

At the cooling coils (chilled water circuit)

Hot air is passed through the cooling coils by means of a fan

As the air flows over the coils, heat is transferred from the hot air to the chilled water that flows inside the coil tubes

After absorbing heat from the air, the water leaves the coil at a higher temperature than the water entering the coil and flows back to the evaporator

The cool air leaves the coil and enters the working place at a lower temperature.

Compressor:

The refrigerant gas at a low temperature and pressure is sucked into the compressor where it is sucked into the compressor where it is compressed, adding sensible heat to the gas. The refrigerant gas now leaves the compressor at a high temperature and pressure

Condenser:

The hot refrigerant gas at a high pressure flows into the condenser and transfer the heat to a medium (water), which flows inside the condenser tubes. The water absorbs the sensible heat added by the compressor and latent heat added by the evaporator. The refrigerant gas condenses to a liquid and leaves the condenser at a high temperature and pressure.

Hot water circuit:

This circuit connects the condenser to the condenser cooling tower/sprays in the RAW to the upcast shaft.

Hot water leaving the condenser is passed through the condenser cooling tower by means of pumps and sprays

As the water is sprayed into the hot return air, the heat is transferred from the hot water to the hot air, which is at a lower temperature than the hot water

After absorbing heat from the hot water, very hot air leaves the condenser cooling tower via the upcast shaft to surface

The cooler water is collected in a dam, leaves the condenser cooling tower and flows back to the condenser

Expansion valve:

The refrigerant liquid then enters the expansion valve where the pressure is released, the refrigerant liquid expands, cools down and flows back to the evaporator, where the whole cycle is repeated, continuously.

3.3. List three (3) types of refrigeration systems (3)

- Vapour compression system
- Absorption system
- Steam-jet system
- Ice-making system
- Water Vapour system

3.4. What is the current cost of 1kW of electrical power per annum? (1)

1.3399 x 24 x 365 = R11 737.52/ kW/ year

QUESTION 4

4.1. $80m^3/s$ of air at a density of $1.0kg/m^3$ flows in a heavily supported airway. The haulage is 3.0m wide and 3.5m high, with a resistance of $0.059Ns^2/m^8$. Calculate the length of this haulage. (4)

C= 2 (h+w)
= 2 (3+3.5)
= 13m

$A= 10.5m^2$
$R= KCL\omega/ 1.2\ A^3$
$0.059 = (0.018 \times 13 \times L \times 1.0)/ 1.2 \times (10.5^3)$
$0.059 = 0.234L / 1389.15$
$81.95985 = 0.234L$
L= 350m

4.2. $68m^3$ /s of air flows in a rock-lined haulage, (3.5m x 3.2m) at a specific volume of $0.893m^3$ /kg. The haulage is 257m long.

Calculate:

4.2.1 The velocity pressure (4)

$VP= v^2\omega/2$
V= Q/A
= 6.07m/s
$VP= (6.07^2 \times 1.11982) / 2$
= 20.64Pa

4.2.2 The total pressure (2)

TP = SP+ VP
$SP= KCLQ^2\omega/ 1.2\ A^3$
$= (0.011 \times 13.4 \times 257 \times 68^2 \times 1.11982)/\ 1.2 \times 11.2^3$
= 196153.76 /1685.9136
= 116.35Pa
TP= 20.64 + 116.35
= 136.99
= 137 Pa

4.3. A 45kW fan is to be installed on a 760mm diameter ventilation column in an ultra-deep section of a mine. The column length will be 200m with a frictional k-factor of $0,0037Ns^2/m^4$. The fan will be operating at a density of $1,5kg/m^3$.

4.3.1. Draw the fan performance and column resistance curves on the graph paper and determine the fan operating point. Show the table and calculations in your examination book. (6)

$R= KCL\omega/ A^3 \times 1.2$
$=(0.0037 \times\ (3.1429 \times 0.76) \times 200 \times 1.5/\ (0.454^3) \times 1.2$
$=\ 23.6\ Ns^2/m^8$

Assume quantities, use $P= RQ^2$ to calculate pressures

Quantity (Q)	Fan Pressure (Pa) ω= 1.2kg/m³	Fan Pressure (Pa) ω=1.5kg/m³	Column Resistance Pressure (Pa) $P=RQ^2$
8	1800	2250	1510
9	2260	2825	1912
10	2420	3025	2360
11	2340	2925	2856
12	2000	2500	3398
13	1550	1938	3988
14	1000	1250	4626
15	400	500	5310

4.3.2 Determine the fan operating point and comment on the suitability of a standard 45kW fan to be used in the ultra-deep level mining. (2)

The fan operating point is 11 m³/s at 2856 Pa. The standard fan will be suitable for the specific installation of only 200m but will not be able to be used in longer columns of 300m

4.3.3. Make a recommendation to management regarding the type of fans to be purchased in future for the ultra-deep level mining project. (2)

Future fans must be purchased with larger fan motors to cater for the reduced volume flow delivered by the fan (1). Improving the efficiency of fans will be more beneficial, especially when considering the increased cost of electrical power in the near future

QUESTION 5

5.1 The following data was recorded during a fan test on surface:

Motor:
Volts – 6600
Pf - 0.94
Efficiency - 94%
Phases – 3
Gearbox:
Efficiency - 90%
Drive:
Efficiency - 91%
Fan:
Efficiency - 85%
Quantity - 241m3/s @ 3.1 kPa

Calculate:

5.1.1. Fan input power (2)

Fan Input power = Air power x 100/85

= PQ x 100/ 1000 x 85
= 3100 x 241 x 100 / 1000 x 85
= 879 kW

5.1.2. Motor input power (3)

Motor input power = Fan input x (100/ drive eff) x (100/ gearbox eff) x (100/ motor eff)
= 879 x (100/91) x (100/ 90) x (100/ 94)
= 1142 kW

5.1.3. Amps consumed by motor (3)

W = EIpf √n
1142 = 6.6 x I x 0.94 x √3
1142 = 10.7456 I
I = 106.3 Amps

5.2 You are working on a deep level gold mine. Your line manager is concerned about the excessive costs of running the 3 main surface fans, these fans run in parallel to each other, they handle a volume of 400m³/s at a pressure of 2.4 kPa and have an efficiency of 80%. You are further aware from your quantity surveys that 40% of all ventilation is lost in the ventilation circuit due to leakage. Assume that the electrical cost is R1.33c per kW/hour. Calculate:

5.2.1 The input power to each fan (2)
Wa = PQ/1000
= (2400 X 400)/1000
= 960kW

Fan Input = Wa/ efficiency
=960/0.8
= 1200kW

5.2.2 The total running cost of these fans, per annum (3)

1200kW x 24 hrs x 365 days x R1.33 = R13 980 960
For 3 fans, R41 942 800 p.a.

5.2.3 The cost of your ventilation circuit's losses per year (3)
Cost of losses = 0.4 x annual running cost
= R 5 592 384 p.a.

5.3. List four indicators of a fan operating in a stall zone (4)
- The fan vibrates excessively, which may cause mechanical failure
- The fan makes unusual noises i.e. it whines
- An ammeter measure the input amps can be seen to fluctuate markedly
- The quantity and pressure of the fan alter considerably