Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: MINERALS COUNCIL SOUTH AFRICA - CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 1 - FLOW DYNAMICS, AIRFLOW, FANS, MINE WATER **SUBJECT CODE:** **COMMEC1** **EXAMINATION DATE:** 04 MAY 2020 **TIME**: 14:30 – 17:30	**EXAMINER:** Tsietsi B Letanta **MODERATOR:** Frank von Glehn **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 11

SPECIAL REQUIREMENTS:

THIS IS **NOT** AN OPEN BOOK EXAMINATION. FORMULA HANDOUT IS AVAILABLE

INSTRUCTIONS TO CANDIDATES:

1. Answer all 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 the 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.

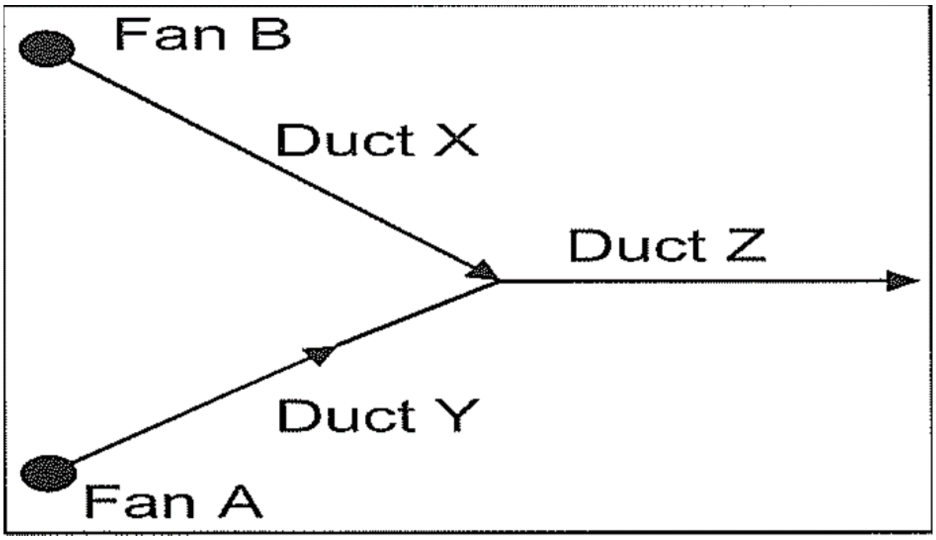
   NB Ensure that the correct unit of measure (SI unit) are recorded as marks will be deducted from answers if the incorrect unit is used. (even if the calculated value is correct).
8. In answering the questions, full advantage should be taken of your practical experience as well as data given.
9. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
10. Cell phones are **NOT** allowed in the examination room.

When marking please note that units must be shown

We are using a mixture of decimal point and decimal comma – we should only use one or the other

QUESTION 1

1.1 The duct system shown in the sketch below consists of two fans, A and B, arranged as shown on three ventilation columns, X, Y and Z.



The characteristic curves of the two fans are shown on the attached graph page.

The duct resistances are as follows:

- Duct X – 70 Ns^2/m^8
- Duct Y – 20 Ns^2/m^8
- Duct Z – 7.5 Ns^2/m^8

i) What is the air quantity flowing in each of the three ducts? (12)

ii) At what air quantities and pressures do the two fans operate? (8)

1. Draw system curve X (2)
2. Draw system curve Y (2)
3. Draw residual curve B-X (2)
4. Draw residual curve A-Y (2)
5. Draw parallel residual fan curve (2)
6. Draw system curve Z (2)
7. Come back horizontally to Residual A
8. Read Q from X-axis (2)

9. Read P from original fan curve (2)
10. Come back horizontally to Residual B.
11. Read Q from X-axis (2)
12. Read P from original fan curve (2)

1.2 The following parameters are known about a development end:

i. Length 120m
ii. Height 4m
iii. Width 4m
iv. Force quantity 10m3/s

a. Assuming that you need 8 air changes per hour. calculate the re-entry interval for this end. (3)

Re-entry period: = $LWhxAir\ changesQx60$
where L = length; w = width; h = height (1)
= $120X4X\ 4X\ 8$ (1) this is the volume of air required – They need to show units
= 15360/ 600 (=15360/10 / 60)
= 25.6 (1)
= 26 minutes

b. When told about the re-entry interval, the manager wants you to work out how to ventilate three more ends, which have the same parameters, sequentially with this one. What considerations will you make? (2).

i. The spacing between the ends is the same. (1)
ii. The capacity of the haulage connecting the ends to the RAW. (1)

I presume that this means that a total of 40m3/s is available and that we are not just using the same 10m3/s! We might some different answers from people who have not read the book.

[25]

QUESTION 2

2.1 Define natural ventilation pressure [NVP]. (3)

NVP is the pressure created in a ventilation network due to the density difference between air at the top and bottom of the downcast and upcast shafts (1). In deep hot mines there is usually a large difference between surface and underground temperatures – there is a difference in density between air on surface and underground and this causes air to move from high to low density (1). The NVP will either assist or retard fans in the system. When NVP assists a fan, it tends to move air in the same direction as the fan. (1) The NVP can be said to lower the system resistance curve against which the fan operates. This means the fan will handle more air at lower pressure. The value of NVP can be subtracted from the system resistance curve at several different quantities until sufficient points are obtained to plot a system – NVP curve. The fan operating point is then given by the intersection of the system – NVP curve and the fan curve.

2.2 The surface barometric pressure on a mine is 86 kPa. The mean density in the 2000m downcast shaft is 1.2 kg/m³. Ignoring secondary air flow effects, determine the nominal barometric pressure at the shaft bottom. (4)

delta p = rho g H (1)
= 1.2 x 2000 x 9.8
= 23.52 kPa (1)
=> BP = 86 + 23.52 (1)
= 109.5 kPa (1)

2.3 In the same mine the mean density in the upcast shaft is 1.1 kg/m³. What is the approximate natural ventilation pressure in this system? (4)

delta p = 1.1 * 2000*9.8 (1)
= 21.56 kPa. (1)
NVP = 23.52 – 21.56 (1)
= 1.96 kPa (1)
OR
NVP=(wdown-wup) * H * g

2.4 If the air flow in the shafts is 500 kg/s, what is the net air power saving and what annual cost savings are related to this air power? Assume an electricity cost of 116 c/kWh. (4)

Air power = 500*1.96/wmean (1)   wmean = (1.2+1.1)/2=1.15
500*1.96/1.15 = 852 kW.
116 c/kWhr = R10161.60/kW/yr (1)
so, saving = 852*10161.60 (1)
= R8 657 683.20 (1)
= R8 657 683 or R8.66m

2.5 What is the static pressure [kPa] in a water column at the bottom of the same shaft? Ignore secondary flow effects. (3)

P = rho g h (1)
= 1000 * 9.8 * 2000 (1)
= 19.6 MPa (1)

2.6 If the head loss in the column is 1 m/100 m, and assuming a water flow of 200 l/s, what power could potentially be generated by a turbine which is 80 % efficient? (4)

Head loss = 20 m. (1)
Turbine power = 200 * (2000-20) *9.8 * 0.8 /1000 (2)
= 3.1 MW (1)

2.7 Assuming a pump efficiency of 75% and again assuming a head loss of 1 m/100 m, what is the annual pumping cost of returning this water to Surface? (3)

Pump power = (2000+20) *9.8*200/1000/0.75 (1)

= 5279 kW* R10161.60 (1)
= R 53 643 086 (1)

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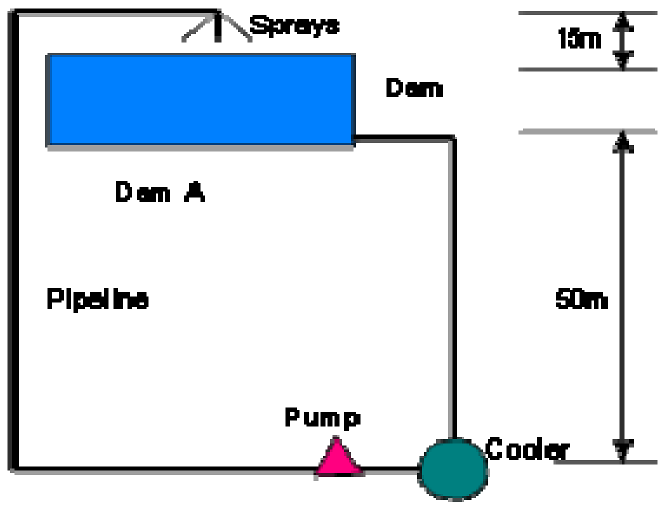
QUESTION 3

3.1 The water reticulation system below has a total piping length of 150 m. The pipe diameter is 203mm. There are three gate valves and 15 elbows in the pipe line. The spray pressure is 220kPa and the head loss through the cooler is 40 kPa. The water quantity to be circulated is 60l/s. The vertical lift above the water level in the dam is 15 m. One gate valve head loss = loss through 1,3m of straight pipe, one standard elbow head loss = loss through 6 m of straight pipe.



i) Ignore the effect of the water in the dam and determine the total head in kPa against which the pump must operate. (10)

From the pipe friction chart: Head loss due to friction for a 203 mm pipe and a mass flow of 60 litres/second is 1,8 m/100 m

The total 'effective' pipe length (straight) for the system must be determined:

Total pipe length = 150 m + (1,3 m x 3 gate valves) + (6 m x 15 elbows)

= 150 + 3,9 + 90

= 244 m straight pipe length

The head loss to overcome frictional resistances:

$$Hf = 1{,}8/100 \times 244$$
$$= 4{,}392 \text{ m}$$

The head loss due to elevation differences (vertical height difference):

$$hs = 15 \text{ m}$$

Note: A common mistake made is to add the 50 m as well, it is however

cancelled by the 50 m down, therefore, 50 m +15 m – 50 m = 15 m.

The total head loss through the water sprays (220 kPa, given) and cooler

(40 kPa, given) is:

Total head loss = 220 + 40

= 260 kPa

This must be converted to an equivalent m pipe length and is done as follows:

$P = \frac{w \times g \times h}{1000}$ (but density of water is 1000kg/m^3)

$= gh$

$h = p/g$

$= 260/9.79$ 9.8?

$= 26.6 \text{ m}$

Total head of pump:

$h_t = 4.392 + 15 + 26.6$

$= 45.99 \text{ m}$

Converting head to kPa:

$$P = \frac{w \times g \times h}{1000}$$

$$= \frac{1000 \times 9.79 \times 45.99}{1000}$$

$$= 450 \text{ kPa}$$

ii) Calculate the pump shaft power and pump motor input power (the necessary assumptions must be shown). (5)

The pump shaft power can be calculated as follows (pump efficiency assumed as 75%)

$$\text{Pump shaft power} = \frac{\text{Q x g x h x density of water}}{\text{1000 x efficiency of pump}}$$

$$= \frac{0.06 \times 9.79 \times 45.99 \times 1000}{1000 \times 0.75}$$

$$= 36 \text{ kW}$$

Where;

Q the volume flow of water and assumed that 1 m^3 =1000kg=1000 litres

The pump motor input power can be calculated as follows (pump motor efficiency assumed as 95%)

$$\text{Pump motor input power} = \frac{\text{Pump shaft power}}{\text{Pump motor efficiency}}$$

$$= \frac{36}{0.95}$$

$$= 37.9 \text{ kW}$$

3.2 Describe any five methods of controlling physical fouling of water. (5)

I. Water clarification to prevent deposition of solids.
II. System design. Ensure turbulent flow is maintained to reduce solids deposition.
III. Limiting concentrations by increasing the blowdown rate, which decreases the concentration of suspended solids
IV. Slipstream filters minimises problems caused by suspended matter.
V. Air rumblings and back flushing assist in dislodging material that has settled in the system.
VI. Chemical dispersants are used to aid in the dispersion of suspended solids.

3.3 What is meant by “terminal velocity” of water? (2)

The velocity of water flowing down an open-ended vertical column, where the friction losses are equivalent to the gravitational acceleration.

OR

When the water cannot flow any faster down the column, because the shear and drag forces within the column fully cancel the gravitational force of the earth.

3.4 Define the following terms with refence to water:

I. Hardness (2)

The soap-consuming capacity of water which is caused by dissolved calcium and magnesium salts.

II. Total Dissolved Solids (TDS) (1)

The sum of all material dissolved in the water.

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QUESTION 4

4.1 State typical velocities for the following:

i) Intake airways

5.0 – 6.0 m/s

ii) Return airways

8.0 m/s

iii) Upcast shafts

18.0 – 20.0 m/s

iv) Downcast shafts

10.0 m/s (at mean density)

v) Stope faces

1.0 – 2.0 m/s (5)

4.2 Briefly describe what happens to the flow rate, pressure, power and efficiency of a fan when:

I. The fan speed is varied with constant air density. (4)

a. Flow rate varies directly as the speed.
b. Pressure varies as the square of the speed.
c. Power varies as the cube of the speed.
d. Efficiency remains constant.

II. The density is varied but the speed is constant. (4)

a. The flow rate remains constant.
b. Pressure varies directly as the density.
c. Power varies directly as the density.
d. Efficiency remains constant.

4.3 50 m3/s of air, at a density of 1.05 kg/m3 and 710 Pa flows in an airway. It is required to reduce the quantity to 35 m3/s by installing a regulator.
Calculate the size of the regulator required. (6)

To pass 50 m^3/s requires 710 Pa.

To pass 35 m^3/s will require:

$P_2 = P_1 \times (Q_2)^2/(Q_1)^2$

$= 710 \times (35)^2 / (50)^2$

$= 348$ Pa

This will be the pressure used up by the airway. The regulator must use up the rest.

Pressure use by regulator = (710 – 348) Pa

= 362 Pa

Area of regulator = $1.2 \text{x} Q \text{x} \sqrt{W/P}$

$= 1.2 \text{x} 35 \text{ x} \sqrt{1.05/362}$

$= 2.62 \text{ m}^2$

4.4 State the advantages and disadvantages of the of the Force-Exhaust system when multi-blasting. (6)

Advantages

I. Rapid clearance of blasting fumes allows short re-entry period.
II. Persons travelling and working in the drive do so in fresh air.
III. Blasting fumes are exhausted directly to the return.

Disadvantages

I. The quality of air supplied to the face is inferior to that supplied by a forcing system.
II. Two fans and two columns are required.
III. Poor conditions can exist in the overlap section.

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TOTAL MARKS: 100