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:** 07 OCTOBER 2019 **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.

QUESTION 1

1.1 An area of a mine is served by a fan that operates at a duty of 80 m^3/s and 256 Pa. The fan inlet density is 1.10 kg/m^3. A new section is to start up and an additional 30 m^3/s will be required. The fan will need to be replaced, and a used fan is available with performance figures as shown below (at the same density and 12 r/s).

Quantity (m^3/s	70	80	90	100	110	120
Pressure (Pa)	460	440	400	340	260	160

The proposed replacement fan is belt driven and the speed can be adjusted.

i) Plot the new fan and system curves on the graph paper provided. Provide as much information about the system on the graph as possible (6)

Determine the system resistance curve:

$R = P / Q^2 = 256 / 80^2 = 0.04$ Ns2/m8

Point A would be the duty point at the original fan speed (95 m^3/s at 370 Pa).

To determine the required duty, move up on the system curve to the required quantity (110 m^3/s). The required duty point is 110 m^3/s at 484 Pa (read off curve or calculated by $110^2 \times 0.040$).

ii) Determine the speed at which the fan must run to meet the new requirements of the mine (3)

The required speed would be 12 x 110/95 = 13.9 r/s.

iii) The replacement fan is supplied with a 55 kW motor. In your opinion, will the motor need to be replaced in order to run at the new speed? Justify your answer. (2)

The air power at the final duty will be 110 x 0.484 = 53.24 kW. Unless the fan is nearly 100% efficient, the motor will need to be replaced.

1.2 Briefly define shock losses and list five sources of shock losses in a ventilation duct. How is the amount of shock loss usually stated? (7)

When the direction of flow of air is deviated from a straight line or its velocity is changed, swirls and eddies are set up which destroy some of the ventilating pressure.

i) Entrance to the duct
ii) Exit of the duct
iii) Bends in the duct
iv) Sudden changes in the duct size
v) Obstruction in the duct

Shock losses are related to air velocity and are usually stated as a percentage of velocity pressure.

1.3 Describe laminar and turbulent flow. Where might you find laminar flow in a mine? (3)

i) Laminar flow – layers in the air stream flow smoothly over each other in the airway.
ii) Turbulent flow – the airflow is restricted by eddies in the airflow that results in more energy being required to move the air.
iii) A small amount of air moving through a large open stope could result in laminar flow.

1.4 State Bernoulli's equation (in terms of pressure) for the ideal incompressible fluid in full. List all the symbols which form this equation and give their units. (5)

$P_1 + ((w_1v_1^2)/2) + gw_1H_1 = P_2 + ((w_2v_2^2)/2) + gw_2H_2$

where;

P = absolute pressure (kPa)

w = density (kg/m³) V = velocity (m/s)

g = gravitational acceleration (m/s²)

h = elevation (m)

Subscripts 1 and 2 denotes two opposite faces of a volume where air is flowing through.

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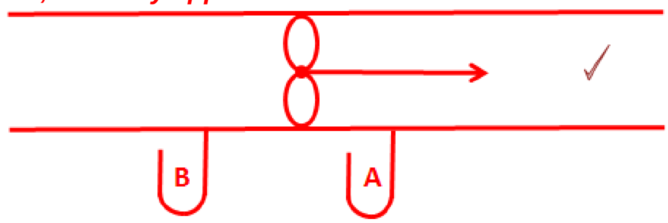
QUESTION 2

2.1 Describe 3 different ways which may be used to determine fan total pressure (FTP). Illustrate your answer with sketches indicating how these methods may be used. (10)

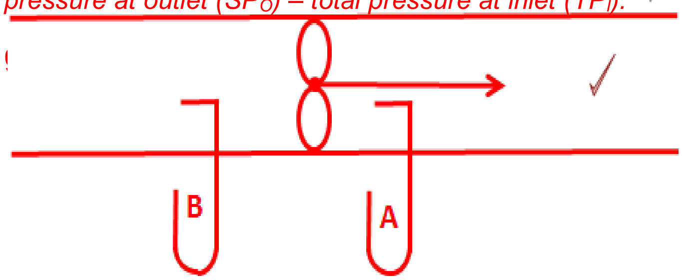
a) Fan total pressure = side gauge at fan outlet (SG_A) – side gauge at fan inlet (SG_B) or static pressure at outlet (SP_O) – static pressure at inlet (SP_I).

NB; this only applies where inlet diameter = outlet diameter.



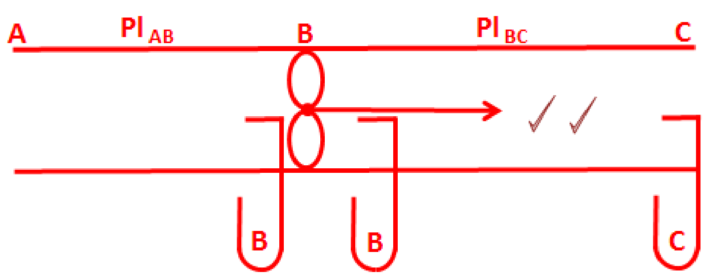
b) Fan total pressure = facing gauge at fan outlet (SG_A) – facing

pressure at outlet (SP_O) – total pressure at inlet (TP_I).



c) Fan total pressure = total pressure loss in duct (Pl_{AB}+Pl_{BC}) + VP_C VP_C = TP_C, VP_C = facing gauge.

FTP = (0 - facing gauge B) + (facing gauge B – facing gauge C) + facing gauge C.



2.2 List the advantages and disadvantages of four different methods of performing mine pressure surveys. (10)

Method	Advantages	Disadvantages
Pressures over doors and stoppings	Little skill required	Cannot accurately pinpoint areas of high resistance
	Can be updated from routine measurements	
	No special instruments required	
Density method	Reasonably accurate results	Depend on an accurate measurement of densty
	Does not require great skill	
Trailing hose method	Easy to use in horizontal airways	Correction required when used over vertical or incline
	No special instruments required	
Full-reduced volume	No special instruments required	Main fans have to be switched off
	Measurements done in short time	Difficult to calculate
	No elevation corrections required	

½ per point plus ½ if all points are correct

2.3 Three airways, connected in parallel, have the following resistances:

A: 0.085 Ns^2/m^8

B: 0.162 Ns^2/m^8

C: 0.024 Ns^2/m^8

i) Calculate the overall resistance of these airways if the total air flowing through the system is 260 m^3/s (2)

$\frac{1}{\sqrt{R}}$ = 1/(√R1) +1/(√R2) +1/(√R3)

= 1/(√0.085) +1/(√0.162)+1/(√0.024)

= 3.43 + 2.485 + 6.455

= 12.37

R = $1/12.37^2$

= 0,00654

Pressure drop over the system: $P = RQ^2$

$= 0.00654 \times 260^2$

$= 442.1$ Pa

ii) Calculate the quantity of air flowing in each of the airways (3)

$Q_A = \sqrt{(0.00654/0.085)} \times 260$

$= 72.12\ m^3/s$

$Q_B = \sqrt{(0.00654/0.162)} \times 260$

$= 52.24\ m^3/s$

$Q_C = \sqrt{(0.00654/0.024)} \times 260$

$= 135.72\ m^3/s$

A correct answer would also be to say, because the pressure drop across each airway is the same flow in each is $\sqrt{384.34/0.085} = 67.24\ m^3/s$ etc…

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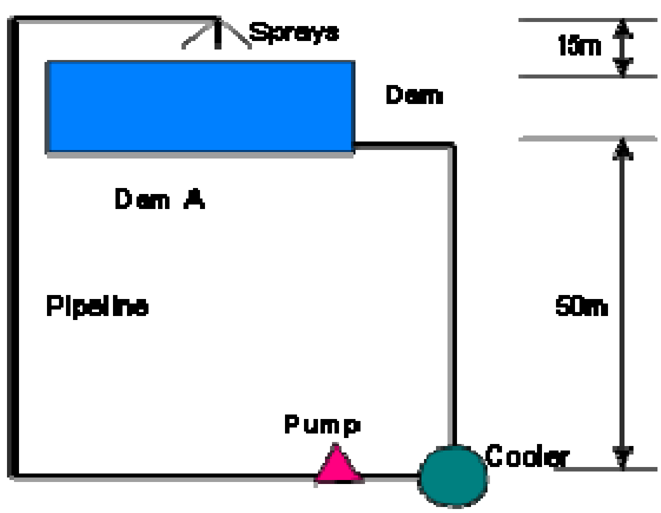
QUESTION 3

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 x 244

= 4,392 m

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

hs = 15 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

= 26.6 m

Total head of pump:

h_t = 4.392 + 15 + 26.6

= 45.99 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%)

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

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

$$= 36 \text{ kW}$$

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 List any five factors that influence fouling of mine water. (5)

I. Water characteristics
II. Temperature
III. Flow velocity
IV. Microbiological growth
V. Corrosion
VI. Contamination

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 Mention any three methods of treating water with a scaling problem. (3)

I. Dilution of the concentration of the critical species in the water by make-up water.
II. Reduce alkalinity by acid dosing.
III. Increase the temperature in the water by increasing the number of passes to reduce the water velocity.

Scaling <u>increases</u> at higher temperatures and <u>reduces</u> at higher velocity Black book pg 903 III should say Increase the velocity to reduce the temperature

IV. Introduce chemical scale inhibitors into the water system.

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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 5 issues to consider when designing ventilation for board-and-pillar mines. (5).

V. Ventilation circuits rely on large numbers of controls (walls, brattices, cross-overs).,
VI. Air utilization is typically low (50 -70%).
VII. There are many large excavations requiring large volumes of air.

VIII. Low pressures are required to move air, thus small changes in the mine network can result in unexpected changes in the airflow.

IX. Large walls and doors can be subjected to tremendous forces and must be suitable and robust.

4.3 Explain the concept "Residual Fan Curve", when applied to fan curves (2)

It is the curve representing what usefully remains after the fan has overcome an airway or system.

4.4 52.5 m^3/s of air, at a density of 1.05 kg/m^3 and 720 Pa flows in an airway. It is required to reduce the quantity to 30 m^3/s by installing a regulator.

Calculate the size of the regulator required. (6)

To pass 52.5 m^3/s requires 720 Pa.

To pass 30 m^3/s will require:

$P_2 = P_1 \text{ x } (Q_2)^2/(Q_1)^2$

$= 720 \text{ x } (30)^2/ (52.5)^2$

$= 235$ Pa

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

Pressure use by regulator = (720 – 235) Pa

= 485 Pa

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

$= 1.2\text{x}30 \text{ x}\sqrt{1.05/485}$

$= 1.68 \ m^2$

4.5 List the advantages and disadvantages of the of the Force-Exhaust system when ventilating sinking shafts. (6)

Advantages

I. Good ventilation on the face

II. Persons not exposed to high dust levels during re-entry.

III. Less exposure to high dust levels during blow over.

Disadvantages

I. Two pipes required in the shaft,

II. Persons in the shaft in the upper areas not well ventilated.

III. It is difficult to achieve the high volumes required in large shafts.

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TOTAL MARKS: 100

Question1.1