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:** 06 MAY 2019 **TIME**: 14:30 – 17:30	**EXAMINER:** Tsietsi B Letanta **MODERATOR:** Frank von Glehn **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 10

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 increased.

i) Plot the new fan and system curves on the graph paper provided. (4)

Determine the system resistance curve:

$R = P / Q^2 = 256 / 80^2 = 0.04$ Ns^2/m^8

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)

$P_1 + ((w_1 v_1^2)/2) + g w_1 H_1 = P_2 + ((w_2 v_2^2)/2) + g w_2 H_2$

where;

P = absolute pressure (kPa)

w = density (kg/m^3) V = velocity (m/s)

g = gravitational acceleration (m/s^2)

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 Compare the characteristics of axial-flow and centrifugal fans and give reasons why you would select one type ahead of the other in different applications. Discuss aspects such as size, ease of installation, flexibility, efficiency, volume, pressure, reliability, stall characteristics and noise. (10)

i) Size – axial-flow fans are generally less bulky than centrifigul fans, especially for volumes below 165 m^3/s and pressures ≥ 3000 Pa.

ii) Ease of installation – Axial-flow fans are generally easier to install because there is no change of direction of the air flowing through the fan. Easier to install in vent columns.

iii) Flexibility – Axial-flow fans with adjustible pitch blades are more flexible and cover a wider range of duties than centrifugal fans. Even when these are equiped with adjustable inlet guide vanes.

iv) Efficiency – Although axial-flow fans were at one time regarded as having a greater efficiency than centrifigul fans, improvement in the design of the latter type has resulted in these fans now equalling and sometimes exceeding the perfromance of axial-flow fans.

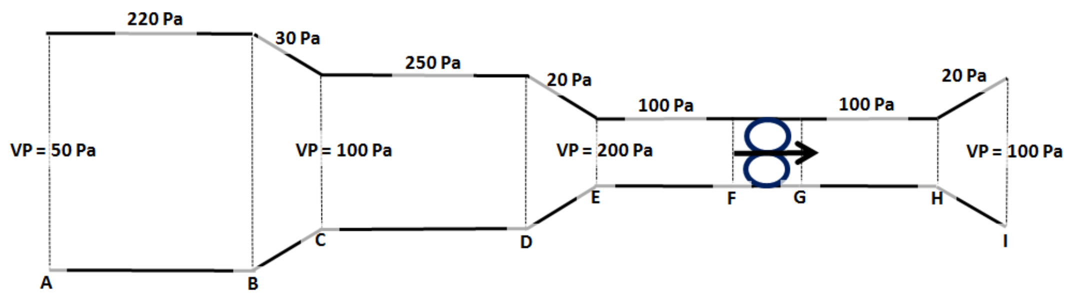
v) Large volumes and high pressure – It is here that centrifigul fans are popular and cheaper for volumes > 235 m^3/s or pressures > 3000 Pa.

vi) Reliability – Centrifigul fans ussually run at lower speeds than axial-flow fans of the same performance and last longer and are more reliable.

vii) Stall characteristics – Centrifigul fans generally have very mild stall characteristics whereas the stall charateristics of some axil-flow fans are rather violent.

viii) Noise – Centrifigul fans have a marked advantage as axial-flow fans tend to be noisier.

2.2 The sketch below depicts a fan handling air in a ventilation column. The various velocity pressures within the ventilation column are indicated on the sketch. Pressure losses in each section of the ventilation column are also indicated on the sketch. Assume there is no leakage throughout the entire duct.



At each point along the ventilation column, determine;

Total pressure, static pressure, velocity pressure. **(10)**

Tabulate your answer (in a table similar to that shown below):

	A	B	C	D	E	F	FAN	G	H	I
VP	50	50	100	100	200	200	200	200	200	100
SP	-50	-270	-350	-600	-720	-820	640	20	-80	0
TP	0	-220	-250	-500	-520	-620	840	220	120	100

2.3 Determine the Fan Total Pressure and Fan Static Pressure. (3)

FTP = (220) -(-620) [dif. of 2 facing gauges]

= 840 Pa

Or

FTP = (20) -(-820) [dif. 2 side gauges, equal areas delivery]

= 840 Pa

FSP = (20) -(-620) [diff, facing gauge inlet, side gauge delivery)

= 640 Pa

2.4 How can the resistance on this system be reduced? (1)

This could be done by putting a bell mouth at the inlet, this would reduce shock losses at the inlet.

2.5 What are the effects upon pressure and quantity when fans are installed in series? (2)

For fans in series the fan pressure of each fan is added to the existing fan(s).

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QUESTION 3

3.1 Briefly describe the following water reticulation systems for an underground mine:

i) Open system (2)

This is a system where the water is discharged at the end of the pipe column into the air. The water then runs back towards a centralised collection point, where it is treated and pumped back to surface.

ii) Closed system (2)

This system is not open to the air. Water is re-circulated through a distribution network, such as the evaporator circuit of a cooling plant. Heat is transferred by means of air to water heat exchangers and the warmer water again re-cooled in the refrigeration plant.

iii) Integrated system (1)

A combination of the open and closed systems.

3.2 250l/s of water chilled to a temperature of 5ºC on surface, enters a vertical shaft through a 15-year-old, 305mm diameter pipe. This water is discharged through a turbine station (situated 1500m below surface) into an underground storage dam. At a flow rate of 250 l/s, the turbine has an efficiency of 75%.

i) Determine the amount of energy recovered by the turbine. (7)

The 1500m x 305mm pipe in the shaft is 15 years old.

From the age factor table (provided), this pipe has a factor of 1.45

Thus the equivalent length of new piping would be:

1,45 x 1500m = 2175m.

From the friction chart (provided), for 305mm pipe at 250 l/s;

The head loss due to friction (hf) = 3m / 100m

For 2175m pipe, $h_f = \frac{2175 \times 3}{100}$m

$h_f = 65.25$ m

250l/s = 0.25 m^3/s

Potential energy to be recovered

$= \frac{\text{mgx hf}}{1000}$kW

$= \frac{250 \text{ x } 9.79 \text{ x}(1500-65.25)}{1000}$kW

= 3512 kW.

But turbine is 75% efficient, therefore amount of energy recovered;

=3512×75/100=2634 kW

ii) Determine the temperature of the water discharged into the storage dam. (4)

Energy converted to heat = (3512 – 2634) kW

= 878 kW;

but: q = m x cp_w x ΔT

where;

q = heat energy (kW)

m = mass flow of water (kg/s)

cp_w = thermal capacity of water (kJ/kg°C)

ΔT = change in water temperature (°C)

Therefore;

$= \frac{q}{\text{m x cp w}}$ °C

$= \frac{878}{250 \text{ x } 4.187}$ °C

ΔT=0.84 °C

Therefore, temperature of water discharged into dam;

= (0,84 + 5,0) °C = 5.8°C

iii) If this turbine were to be removed, what would the temperature of the water discharged into the storage dam be? (4)

Total potential energy converted to heat = 3519 kW

Therefore; $\Delta T = \frac{q}{m\ x\ cpw}$°C

ΔT=3512/(250 x 4.187) °C

ΔT=3.36 °C

Therefore, temperature of water discharged into dam;

= (3.36 + 5,0) °C = 8.4°C

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QUESTION 4

4.1 Name five criteria that you need to satisfy when planning ventilation requirements for a mechanised mine. (5)

i) Air quantity required to dilute and remove diesel exhaust gases, particulates and fumes.

ii) Air quantity required to dilute and remove blasting fumes and dust.

iii) Air quantity required to dilute and remove the heat from rock, ground water and equipment.

iv) Air quantity required to dilute and remove flammable and other gases.

v) Air quantity require to dilute and remove dust and other pollutants.

vi) Air quantity required to remove radiation (where required).

vii) Air quantity required to adequately ventilate excavations where men and machinery / equipment operate.

viii) Air quantity required to comply with regulations or existing ventilation standards.

4.2 Mention five factors that influence fouling of mine water. (5)

i) Water characteristics.

ii) Temperature

iii) Flow velocity.

iv) Microbiological growth.

v) Corrosion.

vi) Contamination.

4.3 Name 5 hazards you will consider when conducting a health hazard identification for a workplace (5).

i) Noxious fumes from blasting.

ii) Dust created by blasting.

iii) Flammable gas

iv) Thermal environment.

v) Diesel emissions.

vi) Virgin Rock Temperature.

4.4 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.

4.5 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:

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

$= 720 \times (30)^2/(52.5)^2$

$= 235$ 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 = $1.2 x Q x \sqrt{W/P}$

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

$= 1.68 \ m^2$

4.6 List the advantages and disadvantages of the full volume- reduced volume method of pressure surveys. (7)

Advantages:

i) Few instruments used and easy to use.
ii) Measurements do not take long.
iii) Measuring is done at fixed positions.
iv) Corrections due to differences in elevation are not required.

Disadvantages:

v) Main fans have to be stopped during measuring.
vi) Results are not always reliable.
vii) Calculations are a little difficult.

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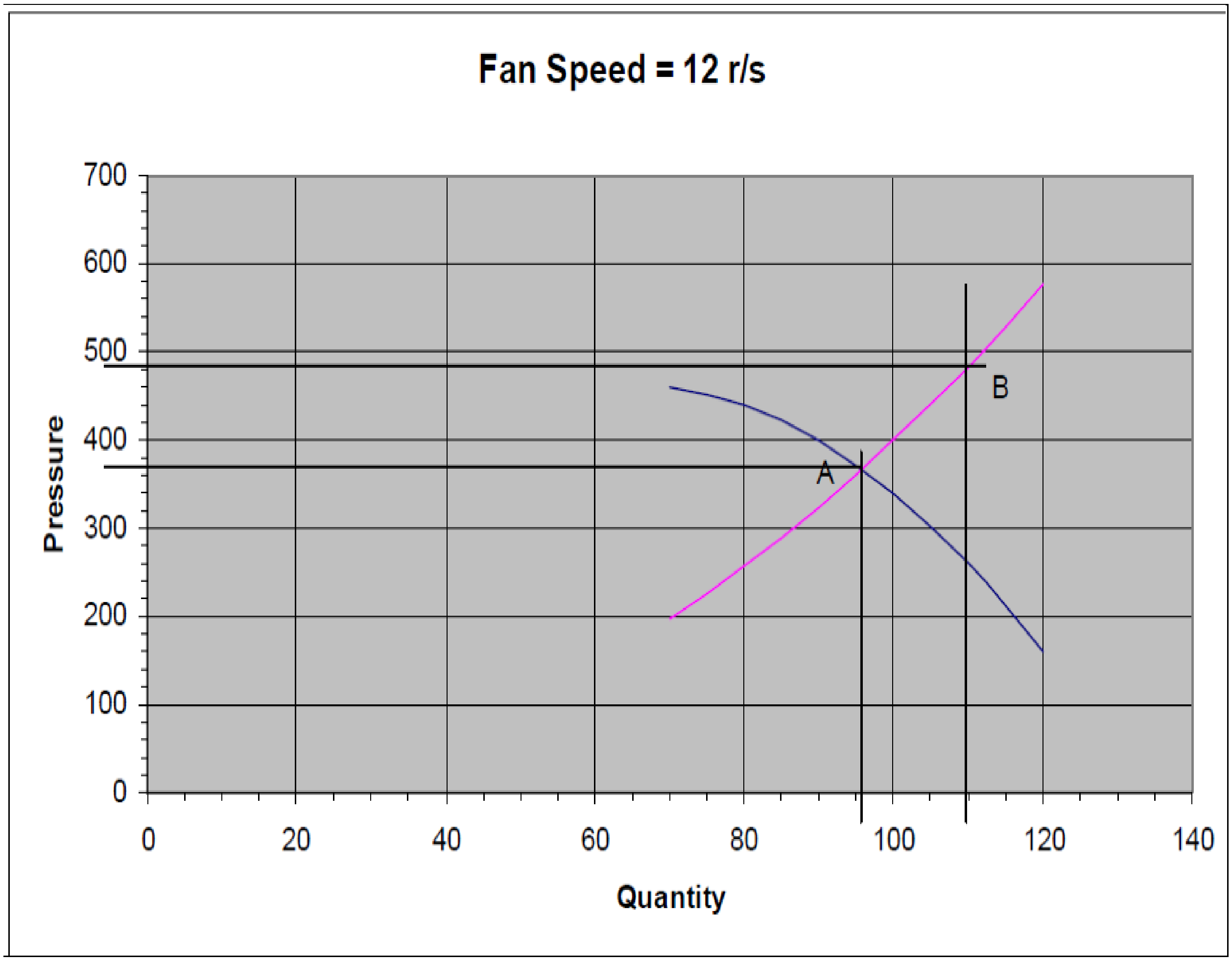
TOTAL MARKS: 100

Question 1.1


Fan Speed = 12 r/s
Pressure
700
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
Quantity
A
B