Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: **CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL** **PAPER 1 – FLUID DYNAMICS, AIRFLOW, FANS, MINE WATER** SUBJECT CODE: **COMMEC1** EXAMINATION DATE: **08 May 2023** TIME: **14:30 – 17:30 (3 HOURS)**	EXAMINER**:** **Tsietsi B Letanta** MODERATOR: **Eugene Botha** TOTAL MARKS: [**100]** PASS MARK: (**60%)**

NUMBER OF PAGES: **6** including this cover page

SPECIAL REQUIREMENTS:

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

FORMULA HANDOUTS ARE AVAILABLE TO CANDIDATES:

1. Answer all 5 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 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 12r/s).

Quantity (m^3/s	75	82	85	98	105	118
Pressure (Pa)	450	430	380	320	240	150

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)

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

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)

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)

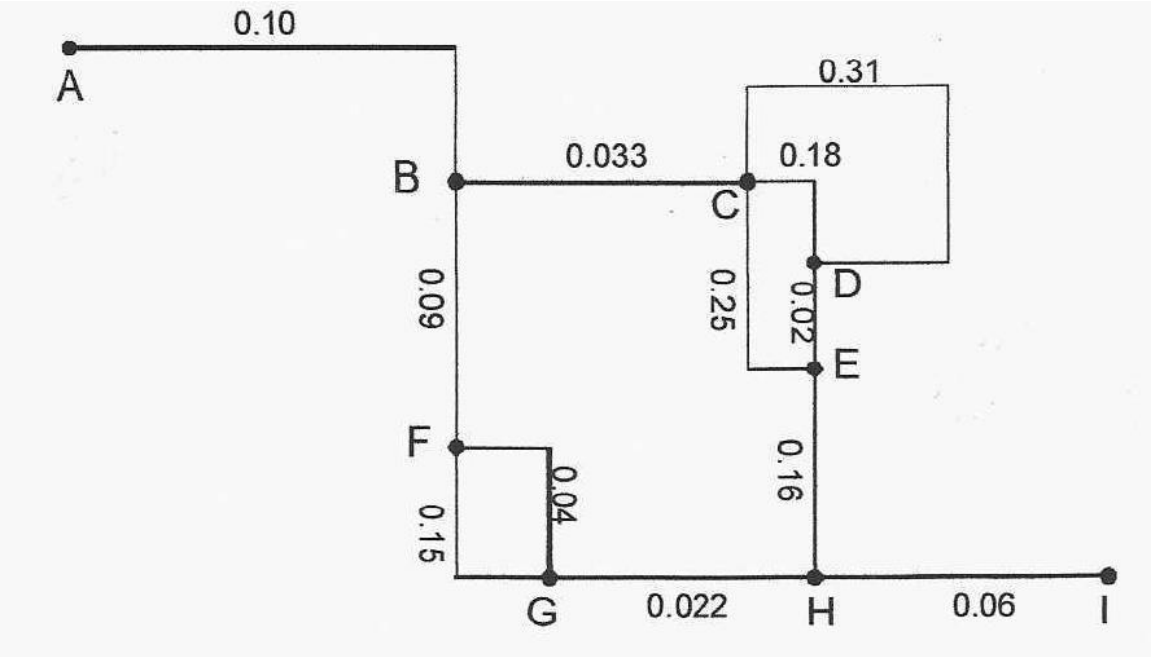
1.3 Describe laminar and turbulent flow. (2)

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)

[25]

QUESTION 2

The sketch below depicts a layout of an underground section of a mine and the given figures are resistances in Ns^2/m^8.



2.1 Determine the overall resistance of the whole section (A-I). {Hint: Start the analysis in the CED area.} (12)

2.2 Calculate the airflow in section EH if the overall flow in the whole network is 120 m^3/s. (4)

2.3 A scale model is used to predict the airflow characteristics in an upcast shaft of 6.0m diameter. The scale model is 1:10(i.e., the diameter of the model is 600mm). and the test section is 20 meters long.
The mean velocity in the test section is 40 m/s for a pressure loss of 1.6 kPa, with a mean density of 0.98 kg/m^3.
The upcast shaft will be 1000 meters in length and will exhaust 500 m^3/s at an average density of 1.10 kg/m^3.

Calculate the pressure loss that you expect in the shaft based on the results of the scale model test. (Hint: Assume that the Reynolds number is such that the k-factor will remain constant). (6)

2.4 Give reasons why an evaseé is fitted to the outlet of a ventilation system (3)

[25]

QUESTION 3

Water is pumped at an average rate of 13.0 mega litres per day to surface from the main pump station 1 800m below surface. The amount of fissure water entering the mine is equivalent to 0.4 tons per ton of rock broken.

3.1 The total rock broken is 200 000 tons per month. Assuming a 30-day month, what is the service water usage in tons per ton broken? (3)

3.2 If the mine pumps water for 24 hours every day:

i) What size pipe would be used? (Assume standard sizes). State any assumptions made. (Hint: Make use of the chart provided). (2)

ii) Assuming the pipe size determined above, what is the pump shaft power (pump input power) required? Assume a pump efficiency of 70%. (5)

3.3 The electrical supply contract (with ESKOM) allows the mine to pump for 19 hours per day:

i) Assuming standard sizes, what size pipe would you use? Give reasons for your answer. (2)

ii) Using the pipe size as determined above, what is the pump shaft power (pump input power) required? Assume a pump efficiency of 70%. (5)

3.4 Define terminal velocity. (2)

3.5 Briefly describe any three methods of controlling physical fouling within a water reticulation system. (6)

[25]

QUESTION 4

A vertical circular mine shaft has a diameter of 10.50m, the shaft is sunk to a depth of 2500m below surface. The shaft is divided into both a down- cast (intake) shaft and an up-cast (return) shaft by means of concrete wall (vertical brattice wall) installed immediately after the shaft was sunk (See figures 1 and 2 below).

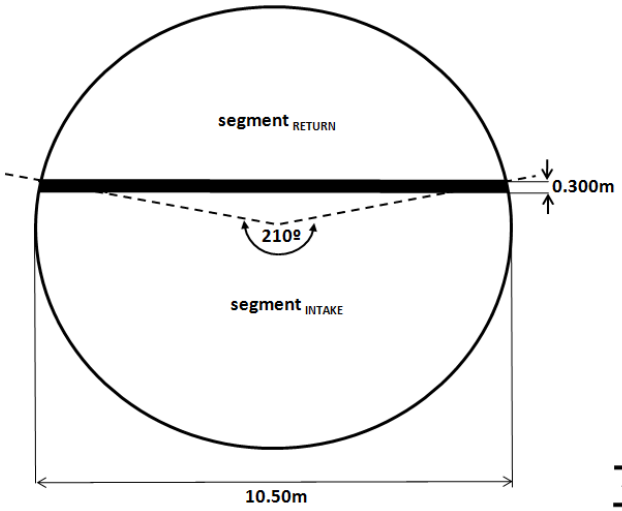


Figure 1. Horizontal cross-section of shaft

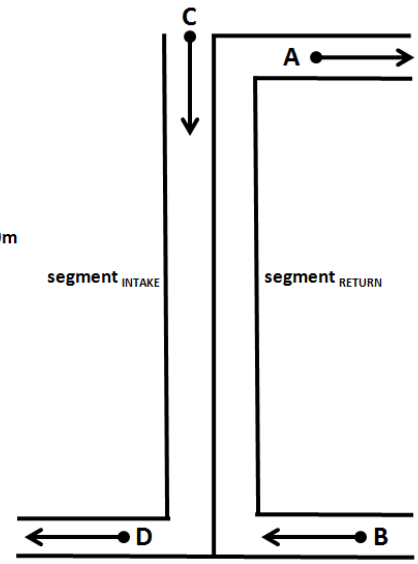


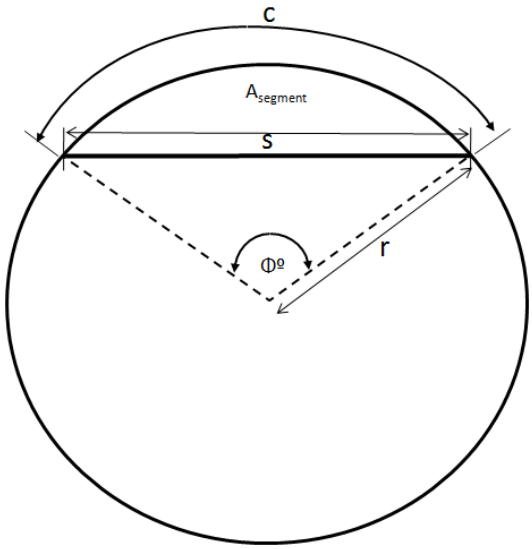
Figure 2. Vertical cross-section of shaft

During routine measurement of environmental conditions in both the down-cast and up-cast sections of this shaft, the following conditions were noted.

	Barometric Pressure (kPa)	Temperature (•C)	Density (kg/m^3)	Quantity (m^3/s)
A	76.227	22.0 / 22.0	0.89	708.4
B	104.817	30.0 / 30.0	1.19	------
C	84.979	10.0 / 13.0	1.03	------
D	109.487	20.0 / 29.0	1.26	------

Hint; **ignore the effects of dynamic (shock) losses at the inlets and outlets of both shafts.**

The shaft dividing (brattice) wall comprises of 2500 pre-cast concrete slabs. Each of these slabs has two 80 mm holes through the body of the slab (these holes were required during the installation of the dividing wall). Once each slab was installed, each of these holes was sealed with a heavy-duty plastic "plug". Recently, during an examination of the down-cast shaft it has been observed that 100 of these 80mm holes are still open. Use this formula to answer 4.1



$$A_{segment} = \left(\frac{\pi r^2 \text{Ø}^{\circ}}{360^{\circ}}\right) - \left(\frac{\sin \text{Ø}^{\circ} r^2}{2}\right)$$

$$s = 2r \sin\left(\frac{\text{Ø}^{\circ}}{2}\right)$$

4.1 Determine the Friction factor (k-value) of the up-cast section of this shaft. (10)

4.2 Determine how much ventilation leaks directly from the down-cast section of the shaft into the up-cast section of the shaft. Express your answer in; m^3/s, kg/s and as a percentage of the total up-cast volume assuming the open holes where leakage is occurring are evenly spaced across the full depth of the up-cast section of the shaft.

4.3 Discuss the logical steps you would follow in implementing a dust and fume extraction system at a surface plant on at a mine. (10)

[25]

TOTAL MARKS: [100]