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:** 10 MAY 2021 **TIME**: 14:30 – 17:30	**EXAMINER:** Tsietsi B Letanta **MODERATOR:** Eugene Botha **TOTAL MARKS:** [100] **PASS MARK:** (60%)

NUMBER OF PAGES: 9

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.

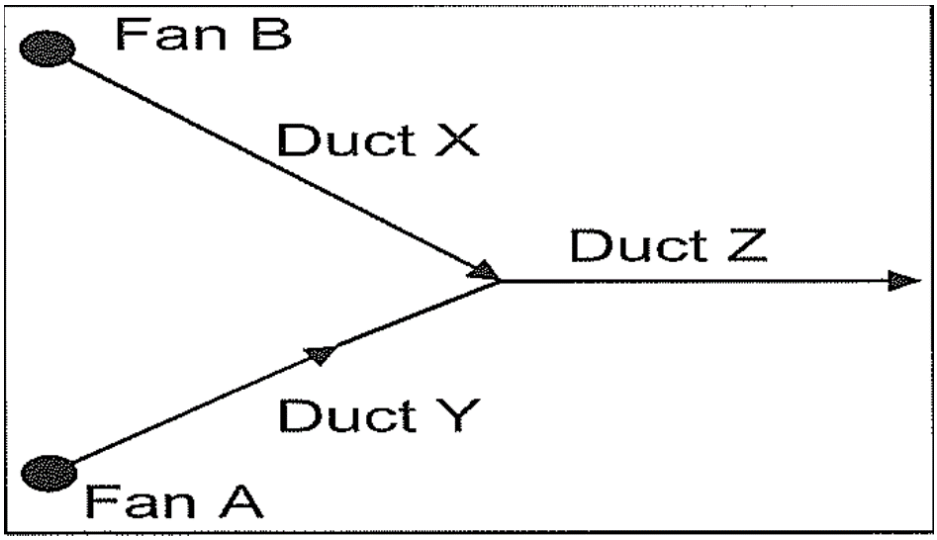
NB: Your name **must not** appear on any answer book or loose sheets.

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 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

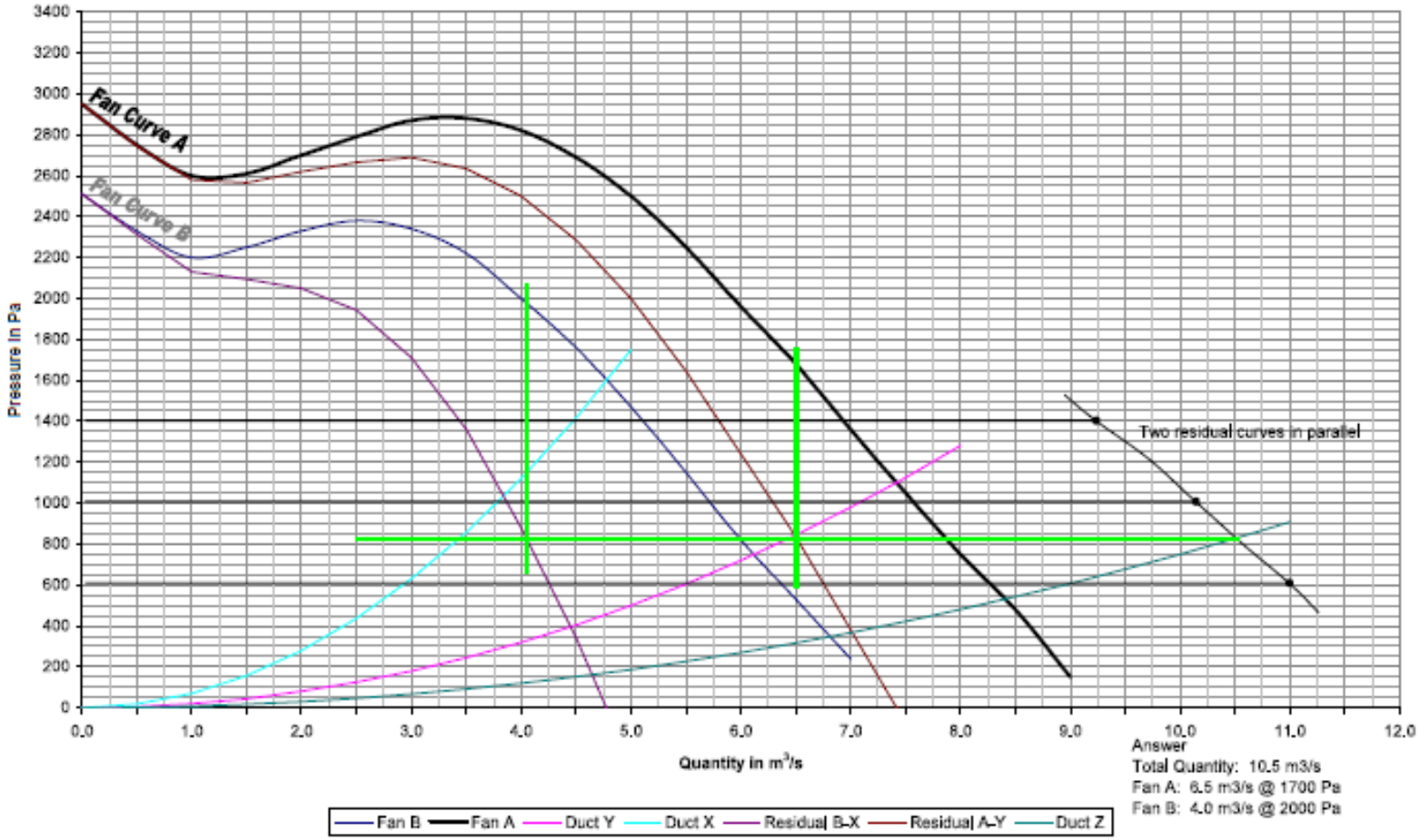
i) What is the air quantity flowing in each of the three ducts? (13)

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 (2)
8. Read Q from X-axis (2)
9. Read P from original fan curve (1)
10. Come back horizontally to Residual B. (2)
11. Read Q from X-axis (1)
12. Read P from original fan curve (1)

Answer

Question 1



Answer
Total Quantity: 10.5 m3/s
Fan A: 6.5 m3/s @ 1700 Pa
Fan B: 4.0 m3/s @ 2000 Pa

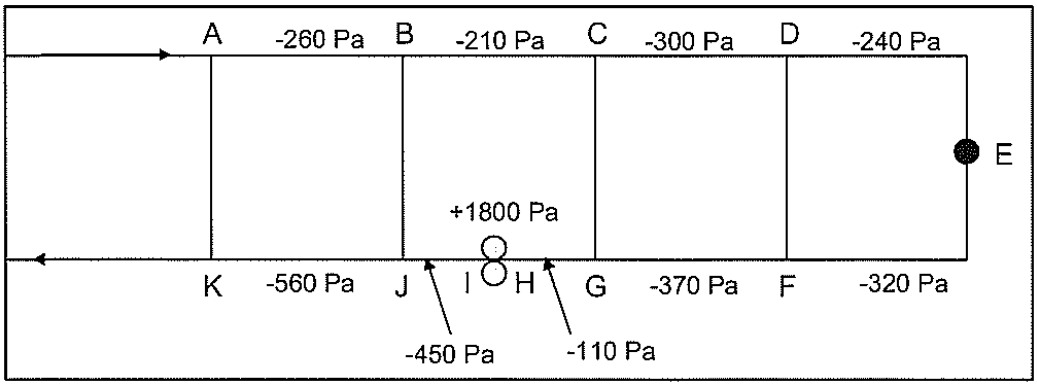
1.2 Mention four methods of controlling the output of a centrifugal fan. (4)

1 System dampers
2 Inlet-damper control
3 Inlet-vane control
4 Speed control

[25]

QUESTION 2

2.1 In a mine, it is necessary to open a new section (at E in the sketch below). It will be necessary to install a booster fan between H and I, and ventilation doors must be installed in all the connections between intake and return (i.e. in A-K, B-J, C-G, and D-F). The expected pressure drops along the airway segments are noted on the sketch and the booster fan will operate at a pressure of 1 800 Pa. The barometric pressure at A is 97.100 kPa.



2.2 Reproduce the diagram to indicate in which direction the doors must face in each connection, and calculate the expected pressure drop across all doors. (10)

Reproduce diagram (1)

Absolute pressure at A is 97 100 Pa, therefore:

Absolute pressure at B is 97 100 – 260 = 96 840 Pa

Absolute pressure at C is 96 840 – 210 = 96 630 Pa

Absolute pressure at D is 96 630 – 300 = 96 330 Pa (0.5 ea)

Absolute pressure at E is 96 330 – 240 = 96 090 Pa

Absolute pressure at F is 96 090 – 320 = 95 770 Pa

Absolute pressure at G is 97 770 – 370 = 95 400 Pa

Absolute pressure at H is 95 400 – 110 = 95 290 Pa

Absolute pressure at I is 95 290 + 1800 = 97 090 Pa

Absolute pressure at J is 97 090 – 450 = 96 640 Pa

Absolute pressure at K is 96 640 – 560 = 96 080 Pa

Doors

1. Door AK must open towards high pressure: Pressure across door will be 97 100 – 96080 = 1020 Pa.

2. Door BJ must open towards higher pressure: Pressure across door will be 96 840 – 96 640 = 200 Pa.

3. Door CG must open towards higher pressure: Pressure across door will be 96 630 – 95 400 = 1230 Pa.

4. Door must open towards higher pressure: Pressure across door will be 96 330 – 95770 = 560 Pa. (0.5 ea)

2.3 State the Reynolds Number and the units of measure in the equation (7).

$$\mathbf{Re} = \frac{VD\omega}{\mu}$$

(3)

Where Re = Reynolds Number

V = velocity (m/s) (1)

D = pipe diameter (m) (1)

ω = density (kg/m^3) (1)

μ = dynamic viscosity (Ns/m^2) (1)

2.4 Where is the Reynolds Number normally used? (1).

Scale model work

2.5 Discuss the difference between laminar and turbulent flows (2).

Laminar flow – Layers in the air stream flow smoothly over each other and the airway.

Turbulent flow – The airflow is restricted by eddies in the airflow that result in more energy being required to move the air.

2.6 Where would you expect to find laminar flow on a mine? (1)

A small volume of air moving through a large open stope.

2.7 Describe the method used to measure fan static pressure (FSP) for a fan in a ventilation column. (2)

Fan static pressure can be measured by taking the difference between a facing gauge at the inlet to the fan and a side gauge at the discharge side of the fan in a column.

[23]

QUESTION 3

3.1 100 l/s of water flows down a 1600m vertical shaft. The pipe diameter is 203mm and the temperature of the water entering the column is 4.6 0C.

Calculate:

I. The temperature of the water at the pipe discharge. (5)

Temperature increase = 2.34 x 1600/100 (1)

= 2.34 x 1.6 (1)

= 3.7 ^{0}C (1)

Temp at pipe discharge = 4.6 + 3.7 (1)

= 8.3 ^{0}C (1)

II. The temperature of the water at the turbine discharge if a 74% efficient turbine is installed. (6)

Head loss = 4.6/100 (from pipe friction chart)

= 4.6 x 1600/100

= 73.6m

Energy recovered $=\left(\frac{1600-73.6}{1000}\right)$ x 9.79 x 100 x 0.74

= 1106 Kw

Temp reduction $=\frac{1106}{4.187 \times 100}$

= 2.64 ^{0}C

Water temp at turbine discharge = (4.6 + 3.7) – 2.6

= 5.7 ^{0}C

(See other options in pages 356 & 7 of Workbook)

3.2 Describe five places where shock losses occur in a water reticulation system and give examples of how these losses can be avoided or reduced. (5)

1 Elbows – avoid sharp elbows completely
2 Number of valves – correct sizing of valves and proper maintenance
3 Number and type of bends – design with correct radius
4 Number and type of junctions – avoid T junctions completely
5 Number of orifice plates – correct design and installation.

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 Name the three types of alkalinity (3)

1 Total or “M” Alkalinity
2 “P” Alkalinity
3 Caustic, hydroxyl, or “O” alkalinity

3.5 Define the following terms with reference 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.

.

[24]

QUESTION 4

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

1 Identify the problem.
2 Find out about any legal requirements (TLV; OEL: etc)
3 Limit the dust at source by minimising generation of fines and preventing fine particles from becoming airborne.
4 Select the most efficient enclosure for the transfer points.
5 Select the most appropriate dust or fume extraction system.
6 Calculate the extraction rate from the open areas of each hood/extraction point and the design capture of the particular pollutant.
7 Select the most efficient filter or collector.
8 Assess the suitability of the location of the collector/filter.
9 Select the most appropriate exhaust stack height.
10 Dispose of the collected waste.

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 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.

Poor conditions can exist in the overlap section.

4.4 Briefly describe 4 issues to consider when designing ventilation for board-and-pillar mines. (4).

1 Ventilation circuits rely on large numbers of controls (walls, brattices, cross-overs).
2 Air utilization is typically low (50 -70%).
3 There are many large excavations requiring large volumes of air.
4 Low pressures are required to move air, thus small changes in the mine network can result in unexpected changes in the airflow.
5 Large walls and doors can be subjected to tremendous forces and must be suitable and robust.

[28]

TOTAL MARKS: 100