Chamber of Mines of South Africa

MEMORANDUM

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 3 PLANNING, APPLIED ECONOMICS AND TECHNICAL LITERATURE	**EXAMINER:** M. Coelho **MODERATOR:** M. Beukes
SUBJECT CODE: **COMMEC P3** **EXAMINATION DATE:** 11 MAY 2017 **TIME**: 14:30 – 17:30	**TOTAL MARKS:** 100 **PASS MARK:** 60%

NUMBER OF PAGES: 15
SPECIAL REQUIREMENTS: THIS IS NOT AN **OPEN BOOK EXAMINATION**.

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 and clearly state any assumptions you make.
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 **[20]**

The ventilation requirements for a coal mine with sparse methane must be determined. The following aspects should be considered:

- *Mining Method*: Bord and Pillar
- *Road width*: 7 m
- *Seam Height*: 3 m
- *Pillars sizes*: 10 x 10 m
- *Air velocity – conveyor belt*: 2 m/s
- *Air velocity – intake road*: 2,5 m/s
- *Air velocity – return road*: 5 m/s
- *Air velocity – downcast shaft*: 8 m/s
- *Air velocity – up cast shaft*: 10 m/s
- *Standard Panel length*: 1,2 km
- *Assume air utilisation*: 80 %
- *Air commitments*: 100 m^3/s
- *Design velocity in last through road*:1,5 m/s
- *Production ton/continuous miner/month*: 60 000 t
- *Production /year*: 4 320 000 t

1.1 Calculate the total area per road (1)

1.2 Calculate the volume required for the conveyor road (1)

1.3 Calculate the volume required for the return road (1)

1.4 Calculate the volume required for the intake road (1)

1.5 Calculate the volume required in the last through road? (1)

1.6 Number of continuous miner sections required? (2)

1.7 Calculate the total volume required for the mine? (4)

1.8 The diameter of the downcast shaft? (2)

1.9 The diameter of the up cast shaft? (2)

1.10 Calculate the friction pressure loss in the downcast shaft? (2)

1.11 Calculate the pressure loss in the intake roadways per km? (3)

Answer - EE pg 971

1.1 Total area per road = 3 x 7 = 21m²

1.2 Airflow volume on conveyor road (QB) = 21 x 2 = 42 m^3/s

1.3 Airflow volume return road (QRAW) = 21 x 5 = 105 m^3/s

1.4 Airflow volume intake road (QINTAKE) = 21 x 2,5 = 53 m^3/s

1.5 Minimum volume air in last through road (QR) = 21 x 1,5 = 31,5 m^3/s

1.6

Total tons/month = 4 320 000/12

= 360 000 tons/month

Sections required = 360 000/60 000

= 6

1.7

Minimum airflow volume (QP) = 31,5 m^3/s

Airflow volume for 6 sections = 6 x 31,5 = 189 m^3/s

Airflow volume for 6 sections (including utilisation factor) = 189/0.8 = 236.25 m^3/s

Total airflow volume required = (236.25 + 100)/0.8 = 420.31 m^3/s

1.8

420.31/8 = 52.53m^2

Diameter = ≈ 8.2 m

1.9

420.31/10 = 42.03m^2

Diameter = ≈ 7.32 m

1.10

$$\textit{Friction pressure loss} \quad = 2.5\,x\frac{wv^2}{2}$$

=2.5 x ((1 x8^2)/2) (Assume w =1)

= <u>80 Pa</u>

1.11

Rule of thumb EE pg 974 = velocity pressure loss of 1Pa for each pillar.

Therefore, a velocity pressure loss of 1 Pa = 17 m or 58.82 Pa per km

The pressure loss for intake roadways → 58.82 x 2.5^2/2 = 183.81 Pa (Assume w=1)

QUESTION 2 **[15]**

2.1 Define the following:

2.1.1 Simple Interest (1)

2.2.2 Compound interest (1)

2.2.3 Present value (1)

2.2 Compile a technical specification for a new main surface fan (10)

2.3 Considering the performance of the South African currency, what measures would you recommend if the fan you specified must be paid for in US $? (2)

Answer: **Workbook pg. 4**

2.1.1

Simple interest is a payment for money borrowed or lent or invested. A percentage is levied over a specified period, pertaining to the capital amount. The rate is usually applicable to a 12 month period. A = P (1 +i)

2.1.2

Compound interest is the interest earned in one year, added to the capital in the following year, and so on, so that the capital increases gradually. Compound interest is always implied in economic studies. A- P(1 + i)^n.

2.1.3

Present value is a lump sum cost of current or future expenditures or the lump sump sum value of current or future incomes now. It provides a ready means for comparing the cost of different schemes where each scheme comprises different kinds of cost or income such as capital expenditure, running cost and possible second hand resale value at some future date. ✓

2.2 – **Workbook pg 12** - Any 10 points for full marks ✓

A scheme for a new main surface fan should address the following aspects:

1. Specify costs of delivery, installation, commissioning and testing of the fan
2. Duties for fan required (fan pressure, quantity, and density)
    a. At time of commissioning
    b. Future needs and variations anticipated during service life
3. Testing
4. Performance curves
5. Volume
6. Fan pressure
7. Fan efficiency
8. Motors
9. General
10. Impellers
11. Shafts
12. Couplings and bearings
13. Safety devices
14. Maintenance
15. Sound levels
16. Drawings
17. Workmanship and material
18. Closing date

2.3

2016 saw a rally by the rand against the dollar starting the year of at R15.46 to the dollar end closing the year off at R 13.65 to the dollar, an almost 12% improvement.

However the 12 month period between now and delivery of the fan could result in a significant increase in rand terms, if the local currency devaluates in relation to the US dollar. ✓

Forward cover could be taken by insuring the sum (difference between the current rand price and a selected increase in the rate). This is like purchasing foreign currency now and paying for the item later. Cust be taken to remain within in the fiscal policy.

✓

The other option is to offer part payment of the contract at the time of placing the order and arranging for the monies to be pa trust account. Any interest accrued would pay towards the difference in the value at the time of the final invoice becoming due.

QUESTION 3 **[20]**

3.1 Mine management have decided to deepen its existing vertical shaft by 400 m to establish 4 additional production levels. For sinking the 7 m diameter shaft a force exhaust system will be used. A minimum air volume of 16 m^3/s will be required at shaft bottom to ensure a 30 minute re-entry period directly after the blast.

3.1.1 What is the maximum distance from the shaft bottom that the exhaust intake can be carried to ensure a 30-minute re-entry period? Discount over breaking of the rock in this calculation and assume 6 air changes. (7)

Question 3.1 – **Answer**

The fan discharge volume = 16 m^3/s

Diameter of shaft = 7,0 m

Number of air changes = 6

✓

$$\text{Shaftarea} = \frac{\pi D^2}{4}$$

$$= \sqrt{\frac{\pi \times (7)^2}{4}}$$

$$= 38{,}5 m^2$$

The total volume of air to be replaced in 30 minutes is:

Volume of air replaced = Q x re-entry time$_{(seconds)}$ ✓

=16 x (30 x60)

=28 800 m^3 ✓

The maximum distance between the force discharge and the exhaust intake must be determined, the shaft area has been determined as 38,5 m^2 and the air volume to be replaced as 28 800 m^3. The distance applicable to these values must now be determined and will therefore represent the maximum distance between the discharge and exhaust intake column

$$\text{length} = \frac{\text{Volume of air}}{\text{Area}} \checkmark$$

$$= \frac{28\,800}{38{,}5}$$

$$= 748{,}1 \text{ m (this is for one air change)} \checkmark$$

$$\text{for 6 air changes} = \frac{\text{total length}_{\text{one air change}}}{\text{number of air changes}} \checkmark$$

$$= \frac{748{,}1}{6}$$

$$= 124{,}7 \text{ say } 125 \text{ m (this is for six air changes)} \checkmark$$

3.2 The management of a mine plans to deepen its existing shaft system by 600 m to establish 5 new additional production levels to mine 150 000 tons per month from the deepened section.

Additional information:

- Sinking rate is 6 m per 24 hours

- Shaft diameter is 7 m plus 10% over break to accommodate the concrete lining.
- 24 day month
- The rock density is 2,78 kg/m^3
- Each level will be considered as a separate ventilation district.
- The planned production will split evenly from each production level.
- Average air density over the five levels is 1,2 kg/m^3

3.2.1 What average service water flow rate will be required during the development of
3.2.1.1 The shaft,
3.2.2.2 The production levels,
if the expected consumption is 1,77-ton water per ton of rock mined? (7)
3.2.2 If a design rate of 5,0 kg/s is planned, what size should the intake and return airways be designed to accommodate the desired flow rate? (6)

Question 3.2 – Answer – workbook pg 36-37 (resources)

3.2.1.1

$$\text{tons from shaft} = \frac{\pi D^2}{4} \text{ x advance per month x density}$$

$$= \frac{\pi[7 + (7 \text{ x } 0{,}1)]^2}{4} \text{ x } (6 \text{ x } 24) \text{ x } 2{,}78$$

$$= 18\,641 \text{ tons}$$

The total service water requirements during shaft sinking can now be established:

$$\text{service water needed} = \frac{\text{tons mined x water factor x } 1000_{\text{litres/ton}}}{\text{days in month x hours per day x } 3\,600}$$

$$= \frac{18\,641 \text{ x } 1{,}77 \text{ x } 1000}{24 \text{ x } 24 \text{ x } 3\,600}$$

$$= 15{,}9 \text{ say } 16 \text{ litres/second}$$

3.2.1.2 The total tons from production levels 150 000 tons, the total service water requirements for production can now be established:

$$\text{service water needed} = \frac{\text{tons mined x water factor x } 1000_{\text{litres/ton}}}{\text{days in month x hours per day x } 3\,600}$$

$$= \frac{150\,000 \times 1{,}77 \times 1000}{24 \times 24 \times 3\,600}$$

$$= 128 \text{ litres/second}$$

The additional service water requirements for production after shaft sinking, can now be established:

Service water required =128 – 16

=<u>112 litres/second</u>

Answer 3.2.2

The tons produced per level = 150 000 / 5

= 30 000 t

Air amount required per level = 30 000/1000 x 5

= 150 kg/s

The air density has been given as 1,2 kg/m^3, the air quantity can now be determined:

$$Q = \frac{m}{\rho} = \frac{150}{1,2} = 125 \text{ m}^3/\text{s}$$

$$\text{Intake airway area} = \frac{Q}{V} = \frac{125}{5} = 25 \text{ m}^2$$

$$\text{Return airway area} = \frac{Q}{V} = \frac{125}{7} = 17,8 \text{ say } 18 \text{ m}^2$$

Due to practical reasons the airway sizes per level should be as follows:

$$\left.\begin{array}{l}\text{Intake airways} = 2 \times 12,5 \text{ m}^2 \text{ ends} \\ \text{Return airways} = 2 \times 9,0 \text{ m}^2 \text{ ends}\end{array}\right\}$$

QUESTION 4 **[25]**

On a small mine the normal consumption of new 570 mm ventilation pipes is 150 m per year 760 mm pipes are not normally used.

To maintain current production levels, it is necessary to develop a 1 380 m long tunnel to intersect with the existing workings. This development will take 12 months to complete. It is to be exhaust ventilated. The fans and ventilation pipes required for this development will be purchased prior to the project commencement.

Two alternative options being considered for this project are the following:

- A - To use a 570 mm diameter column 76% of which can be reclaimed for normal mining use on completion of the project (the development phase).
- B - To use a 760 mm diameter column 75% of which can be sold on completion of the project at 28% of the initial purchase cost.

Determine which scheme would be the most economical over 8 years and make suitable recommendations to management, based on your practical experience. *(Hint calculate the total owning cost (TOC) for each scheme*)

Assume the following:

- The cost of a new 570 mm pipe is R 800/meter
- The cost of a new 760 mm pipe is R 1 100/meter
- The air quantity exhausted from the face of the tunnel must be 4,5 m^3/s
- There is no leakage
- The air density is 1,2 kg/m^3
- The capital cost of development fans is R 2 500/air kW
- The overall efficiency of these fans is 70%
- Annual electrical power costs are R 12 000/kW
- Friction factor of pipes is 0.0037 Ns^2/m^4
- The PV of R1/year over one year at 15% is R0,870
- The PV of R1/year over eight years at 15% is R4,487

Answer – workbook 20 -35

Scheme A

The capital cost for this scheme is = 1380 x 80 = **R1 104 000**

The annual consumption of 570 mm pipes = 150 m (given)

The annually cost normally for 150m 570mm pipes = 150 x 80 = **R120 000 per year**

Assume annual consumption remains constant:

Pipe length available after 1 year (76%) = 1380 x .76 = **1048.8 m**

The number of years that 570 mm pipes will be not be purchased = 1049/150 = **7 years**

This means that for the remainder of the project the mine will not have to buy 570 mm ventilation pipes

The PV of replacing 570 mm pipes over 8 years: = 12 000 x 4.487 = **R538 440** (cost if 8 years of pipes were to be purchased)

The PV of replacing 570 mm pipes over 1 year = 150 x 80 x .87 = **R104 400** (cost if 1 years of pipes were to be purchased)

The cost saving if 7 years of pipes were not to be purchased = 53 844 - 10 440 = **R434 040**

Therefore PV for 570 mm replacements over 8 years = 110 400 - 43 404 = **R669 960**

The pressure required for a fan must now be determined for a 570 mm leak less column:

$$\mathbf{P} = \frac{KCLQ^2}{A^3} \times \frac{w}{1.2}$$

$$= \frac{.0037 \times 3.14\,(pi) \times .570 \times 1380\,(4.5)^2}{[(pi \times 0.57)/4]3} \times \frac{1.2}{1.2}$$

= **11143 Pa**

$$\textbf{Total fan input power} = \frac{PQ/1000 \times efficiency}{1000 \times efficiency}$$

$$= \frac{11143 \times 4.5}{1000 \times .7}$$

= **71.6 kW**

The PV of the annual running cost (1 year) = 71.6 x 1200 x .87
= **R747 871**

The capital cost development fans = 250 x (11143 x 4.5)/1000
= **R125 362**

The total owning cost (TOC) scheme A = 66 966 + 74 787 + 12536
= **R1 543 193**

Scheme B				
The capital cost for scheme B is	=	1380 x 110	=	**R1 518 000**
570 mm pipes will be used continoisly				
The annual consumption of 570 mm pipes	=	150	m (given)	
The annual cost normally for 150 m 570 mm pipies	=	R120 000		calculated in Scheme A
The PV of replacing 570 mm pipes over 8 years:	=	12 000 x 4.487	=	R538 440 calculated in Scheme A
Assume annual consumption remains constant:				
Pipe length available after 1 year (76%)	=	1380 x .75	=	**1035 m**
The PV of 760mm pipes sold after 1 year (income)	=	1035 x 110 x .28 x .87	=	**R277 339 (income will be subtracted)**
The PV of the actual cost for this scheme must now be determined				
Therefore PV for 760 mm replacements over 8 years	=	151 800 - 27 734	=	**R1 240 661**

The pressure required for a fan must now be determined for a 570 mm leak less column:

$$P = \frac{KCLQ^2}{A^3} \times \frac{w}{1.2}$$

$$= \frac{.0037 \times 3.14\,(pi) \times .570 \times 1380\,(4.5)^2}{[(pi \times 0.57)/4]3} \times \frac{1.2}{1.2}$$

$$= \mathbf{2644\ Pa}$$

Total fan input power $= \dfrac{PQ/1000 \times efficiency}{1000 \times efficiency}$

$$= \frac{11143 \times 4.5}{1000 \times .7}$$

$$= \mathbf{17.0\ kW}$$

The PV of the annual running cost (1 year) = 71.6 x 1200 x .87
= **R177 473**

The capital cost development fans = 250 x (11143 x 4.5)/1000
= **R29 749**

The total owning cost (TOC) scheme B = 124 066 + 17 748 + 2975 + 53844
= **R1 986 324**

From the above Scheme A will be the more economical.

Comment: There is a difference in TOC's and various arguments can be given in favour of either scheme. Although the input power to the fan for scheme B is much lower than for scheme A, the initial capital outlay for 760 mm pipes are much higher. Depending on the type of development planned (conventional or trackless), the damage to 760 mm pipes can be severe and not warrant the savings in fan input power. If the development had to be done over a longer period then the choice of a 760 mm column could be warranted. The benefit of not having to buy 570 mm pipes in scheme A, is very much beneficial in the case of increase in pipe costs.

QUESTION 5 **[20]**

Comment on and discuss the content of the article related to mine environmental control and occupational hygiene, which have appeared in the following publications:

PLEASE NOTE - ADDRESS ONLY *ONE* OF THE FOLLOWING TWO TECHNICAL PUBLICATIONS:

5.1 An analysis of airflow patterns around a longwall shearer with a proposed modified spray system for dust control

(Y.P. Chugh, A. Chandna,H. Gurley- Southern Illinois University Carbondale ,October/December Volume 69 No 4)

Use the following headings in your answer:

1. Abstract
2. Introduction
3. Authors hypotheses and research goals
4. CFD modelling of a typical chassis spray block
5. Analysis of a typical single block chassis spray system
6. Analysis of the proposed spray system
7. Dust suppression studies
8. Summary observations
9. Concluding remarks

OR

5.2 XLP/ULP On-reef mechanised mining method by ventilation on demand as a concept

(J. Venter – BBE Consulting, M.B. Diedericks – Anglo American Platinum October/December Volume 69 No 4)

Use the following headings in your answer:

1. Abstract
2. Introduction
3. Extra low and ultra low profile (XLP/ULP) mining methodology
4. Ventilation design criteria and methodology
5. Ventilation on demand overview
6. Ventilation requirement comparison for a typical XLP mining stope block
7. Ventilation requirements applying ventilation on demand
8. Method comparison – conventional ventilation and ventilation on demand
9. Financial impact of ventilation on demand
10. Ventilation infrastructure
11. Operating cost
12. Discussion
13. Conclusion

Answer:

Using above headings, the student needs to produce 20 facts from the journal article to achieve full marks.

TOTAL MARKS: [100]