Minerals Council South Africa

MEMORANDUM

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 3 **SUBJECT CODE: COMMEC3– ECONOMICS, PLANNING AND TECHNICAL LITERATURE** **EXAMINATION DATE:** 11 OCTOBER 2018 **TIME**: 14:30 – 17:30	**EXAMINER:** M. Coelho **MODERATOR:** M. Beukes **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 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 **[25]**

A desktop study on a coal mine extension is underway. You are the ventilation engineer and are required to determine the ventilation requirements. The mine will produce 360 000t of coal per month and it is assumed that there will be 1 stone works (SW) and 2 abandoned panels (AP). (Density is assumed 1.2 kg/m^3)

The ventilations criteria as required by the mine are as follows:

Last through road (LTR) velocity for continuous miner (CM) sections	= 1.5 m/s
LTR velocity for stone works sections	= 1.0 m/s
LTR velocity for abandoned panel sections	= 0.5 m/s
Total number of CM sections	= 6
Bord width	= 7.2 m
Seam height	= 3.9 m
Air utilisation factor for CM, AW and AP sections	= 80 %
Downcast shaft velocity	= 10 m/s
Upcast shaft velocity	= 20 m/s

Assume an additional 20% quantity for commitments

Assume 30% overall mine leakage

1.1 Calculate the total CM section volume requirements (3)

CM section volume per LTR = 7.2 x 3.9 x 1.5 = 42.1 m^3/s

Volume per CM section = 42.1 /0.8 =52.7 m^3/s

Total volume required for CM sections = 52.7 x 6 =315.9 m^3/s

1.2 Calculate SW requirements (2)

SW section volume per LTR = 7.2 x 3.9 x 1.0 = 28.1 m^3/s

Volume per SW section = 28.1 /0.8 =35.1 m^3/s

1.3 Calculate AP requirements (3)

AP section volume per LTR = 7.2 x 3.9 x 0.5 = 14.04 m^3/s

Volume per AP section = 14.04 /0.8 =17.55 m^3/s

Total volume required for AP sections = 17.55 x 2 = 35.1 m^3/s

1.4 Calculate total mine volume requirements (3)

Total volume requirements (excluding leakages and commitments) = CM + AP +SW

315.9 + 35.1 + 35.1 = 386.1 m^3/s

Volume requirements including commitments = 386.1/0.8 = 482.6 m^3/s

Total mine volume requirements = 486.9/0.7 = 689.5 m^3/s

1.5 Calculate downcast shaft diameter (2)

Area required = 689.5/ 10 = 68.9 m^2

Diameter =√((69.55 x 4)/ ∏) = 9.38 m Ø

1.6 Due to ground conditions 2 upcast shaft are required calculate the diameter of each (3)

Area required = 689.5/ 20 = 34.5 m^2

Area per shaft = 34.5/2 = 17.23 m^2

Diameter =√((17.23 x 4)/ ∏) = 4.7 m Ø per shaft

1.7 What is the purpose of methane content and release sampling? (2)

Know the expected release rate

Determine adequacy of ventilation design for the content and release rate

1.8 What measures would you take if the methane content is 50% higher than the mines average? (3)

Direct more airflow to the face using scoop brattices and or use jet fans

Check return air concentrations

Increase volume flow to CM section

1.9 Indicate arithmetically and comment on the impact of increasing volume on air power (4)

System pressure is calculated by the following:

$$Pressure = RQ^2$$

Air power is calculated by the following:

$$Power_{air} = \mathrm{P.Q}$$

Therefore:

$$Power_{air} = R.Q^3$$

[R is the mine system resistance]

Thus, doubling the volume will result in 8 times the air power requirements

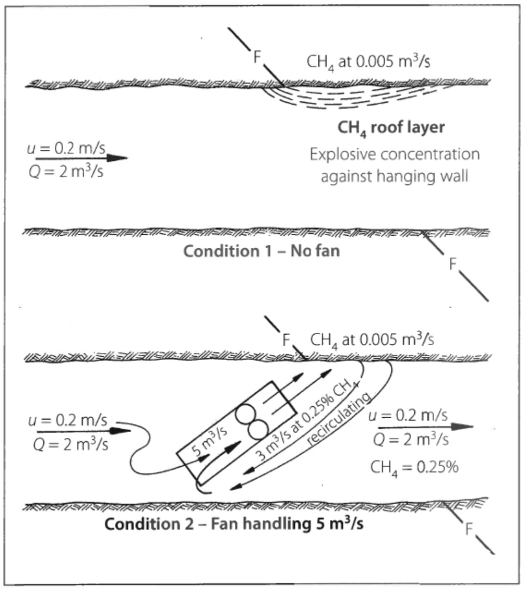
QUESTION 2 **[17]**

2.1 Define recirculation and provide four examples with a brief explanation of the undesirable and dangerous consequences of thereof? (9)

Recirculation can be defined as any portion of mine airflow that travels through the same area more than once. Recirculated air has a few undesirable and possibly dangerous consequences as follows

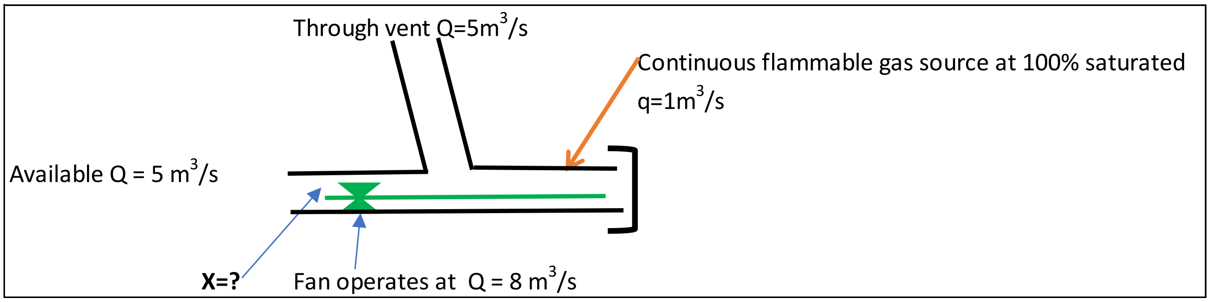
- **Build-up of heat and humidity** – As air recirculates, it repeatedly picks up increasing heat from machines, rock strata and ventilation fans. Moisture and humidity are increased by ground water and mining activities.
- **Build of fumes and dust** – Mining activities need fresh air to clear out noxious gases and dust. Recirculated air prevents this and allows fumes and dust to accumulate.
- **Recirculated blasting fumes** and dust may often prevent re-entry into blasted areas for extended periods of time, delaying production and other activities.
- **Gas build-up,** in coal mines can create a dangerous environment, prone to explosion or poisoning of personnel.

2.2 With reference to the figure below which depict methane layering in a coal mine explain why recirculation is a beneficial in the dispersion of methane layering with a high velocity air jet (4)



The through ventilation quantity through the haulage is 2m^3/s, the cross-sectional area of the haulage is 10m^2 and the velocity in the haulage is 0.2 m/s. This would not prevent methane roof layering. If a fan was installed to handle 5m^3/s blowing onto the methane layering discharge point, it would be recirculating some of the air. Without the fan, a methane roof layer with explosive concentrations of methane would exist against the hanging wall and extend over a considerable distance. The fan would break up the methane roof layer, and the concentration of methane in the general atmosphere beyond the fan discharge point would be 0.25%. The figure clearly shows that under this condition, if through ventilation is flowing and the fan is running, there is no danger of a methane build-up and mixing would be complete. In such a case, a methane monitor should be installed in such a way that if the methane concentration immediately past the methane discharge point increases to say 1% the fan is tripped automatically. Both the fan and switch should in this case be flameproof.

2.3 The figure below shows a fan recirculating in a development end and the presence of a continuous flammable gas source



2.3.1 Calculate the maximum concentration (%) of the flammable gas at point X (2)

Highest concentration that can be achieved anywhere is q/Q or 1/5 – what goes in comes out i.e. 0.2/20%

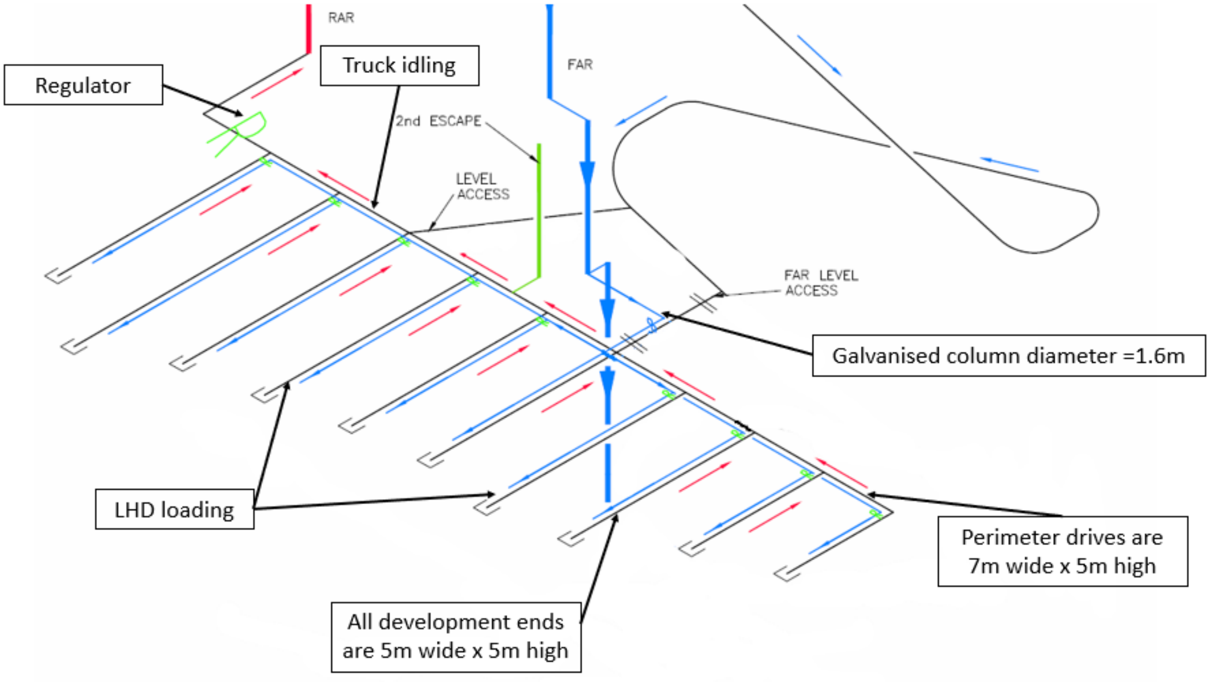
2.3.2 What is the gas concentration (%) in the recirculation portion after 2 air changes (2)

On fist pass through fan, conc is q/8, or 1/8, this becomes the conc in the recirc air =0.125 / 12.5%

On second pass you have ((3 x 1/8) returning + (5 x 1/5) approaching)/8 = 0.172 / 17.2% going through the fan

QUESTION 3 **[23]**

You are the consulting ventilation engineer for the extension of an existing mine to access a new 1500 m deep zinc deposit that will be exploited using the sub-level open stoping method accessed from a single decline. The figure below indicates a typical production section with a single fan and column supplying 10 development ends with air. Air is regulated to each development end using in-line regulators. Air intakes from the Fresh Air Raise (FAR) and decline which then returns via the Return Air Raise (RAR) (Density is = 1.2 kg/m^3 and assumed consistent throughout the mine)



A level will have 2 x 150 kW LHD operating in the development ends with a maximum of 1 per development end and 1 x 500 kW truck which will operate as far as the perimeter drive. It is required that a development end face should have a velocity of not less than 0.2 m/s.

3.1 Calculate the volume requirements at point of application for diesel dilution for the LHD and truck operating assuming a dilution factor of 0.06 m^3/s per rated kW. (2)

Q_{LHD} = 150 x 0.06 = 9 m^3/s

Q_{truck} = 500 x 0.06 = 30 m^3/s

3.2 Calculate the volume requirement per level that will need to be supplied by a fan in tight circuit positioned on each level, assume 10% column leakage (4)

Min Q_{dev} = 0.2 x 5 x 5 = 5m^3/s

2 LHDs required = 2 x 9 = 18 m^3/s

Q_{total} = 5m^3/s x 8 + 18m^3/s + 10% leakage= 64m^3/s

3.3 If the total airway lengths for a level is 389 m. Determine the fan duty? (4)

k-factor = 0.0037 Ns^2/m^8 typical for a galvanised steel column

P =kCLQ^2/A^3 =(0.0037 x 1.6x∏ x389 x (64)^2)/ ([∏(1.4)2/4])^3 = 3646 Pa

Fan duty = 64 m^3/s @ 3646 Pa

3.4 Calculate the total volume requirements if there are 4 production levels, 25% commitments and 15% leakage in the mine (4)

Total Q = 64 x 4 =256 /.75 = 341/.85 = 402 m^3/s

3.5 Calculate the diesel heat load components for the mine factoring in 20% additional heat added from the secondary fleet (i.e. drill-rigs, UV, graders, etc.), using a diesel heat factor of 1.5 x rated kW and a machine utilisation of 70% (5)

For LHDs per production section = 2 x 150 x 1.5 x 0.7 =315 kW

For Trucks = 1 x 500 x 1.5 x 0.7 = 525 kW

Total per level = 840 kW

Total diesel heat load for mine including secondary fleet = 4 levels x(840 /.8) = 4200 kW

3.6 Calculate the cooling capacity of the downcast air using a surface wet bulb temperature of 18 and a reject temp of 29°C (2)

From the graph attached = ±25 kJ/kg

Cooling capacity of air = 402 x 1.2 x 25 = 12060 kW

3.7 How much refrigeration is required if the following other heat loads exists (2)

- Broken and surrounding rock = 3100 kW
- Auto compression = 6300 kW
- Auxiliary fans = 836 kW
- Equipment (pumps, conveyors, sub-stations, etc.) = 3800 kW

Adding all heat loads = 3100 + 6300 + 836 +4200 +3800 = 18 236 kW

Cooling required = 18236 – 12060 = 6176 kW

QUESTION 4 **[20]**

4.1 Differentiate between primary and secondary ventilation systems (6)

Primary ventilation relates to the main ventilation and cooling infrastructure. It includes the main surface fans, main booster fans, up cast and downcast shafts. Ventilation raises, main airways, bulk air coolers, central refrigeration systems etc. The objective of primary system is to provide airflow to the sections and service zones in sufficient quantity and at appropriate temperatures and quality. Without this provision the secondary systems will never be able to create acceptable conditions in the workings.

Secondary ventilation relates to the control of ventilation in the actual sections and service zones. It includes all in stope and development auxiliary fans, ducting systems, secondary air cooling, etc., as well as requirements for service ventilation of pump stations, tips, workshops, hoist chambers, crusher stations, etc.

4.2 List 4 aspects that are typically form part of a design criteria document that is prepared early in the design process (4)

ANY 4

- Existing mine characteristics and constraints (for brownfields projects)
- Development and project schedule
- Mining method statement and production programme
- Main and secondary shaft requirements and infrastructure
- Inventory of all underground equipment and machinery and work cycles (electrical, diesel and other)
- Geothermal data
- Minerology of ore body and surrounding rock
- Expectations of fissure water and strata gas emissions
- Underground geothermal criteria and airborne contaminant design criteria
- Service ventilation requirements
- Service water usage
- Power cost data and expected project rate of return
- Surface weather data

4.3 Discuss the characteristics of the optimisation phase in mine project planning (5)

- Optimisation analysis of all subsystems
- Refinement of initial programme schedules
- Comparison of alternatives for different subsystems (main fan configuration, refrigeration machines, etc.)
- Design freeze on all concepts (preliminary specifications)
- Refinement of estimate and planning documentation

4.4 Discuss the considerations of the ventilation requirements for crusher station (5)

The service ventilation requirements for a crusher stations can generally be addressed in two ways either by allowing ventilation to pass through the crusher station and direct to the return system, or by filtering the air and reusing it in the intake system. The decision between these two alternatives must be considered for each individual case, bearing in mind the following:

- Amount of primary ventilation available (e.g. main shaft size constraints) and considerations of other priorities
- Cost of purchasing, installing, running and maintaining dust filtration systems
- Cost of establishing a return circuit
- Cost of primary ventilation 'losses' (e.g. main fan power, larger shafts)

QUESTION 5 **[15]**

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 Using continuous real time monitoring to monitor the effectiveness of manual and engineering controls for proactive management of airborne pollutants at Kopanang Mine (L. Kleyhans, L. Smith and M. Beukes – Anglo Gold Ashanti,April/June Volume 71 No 2)

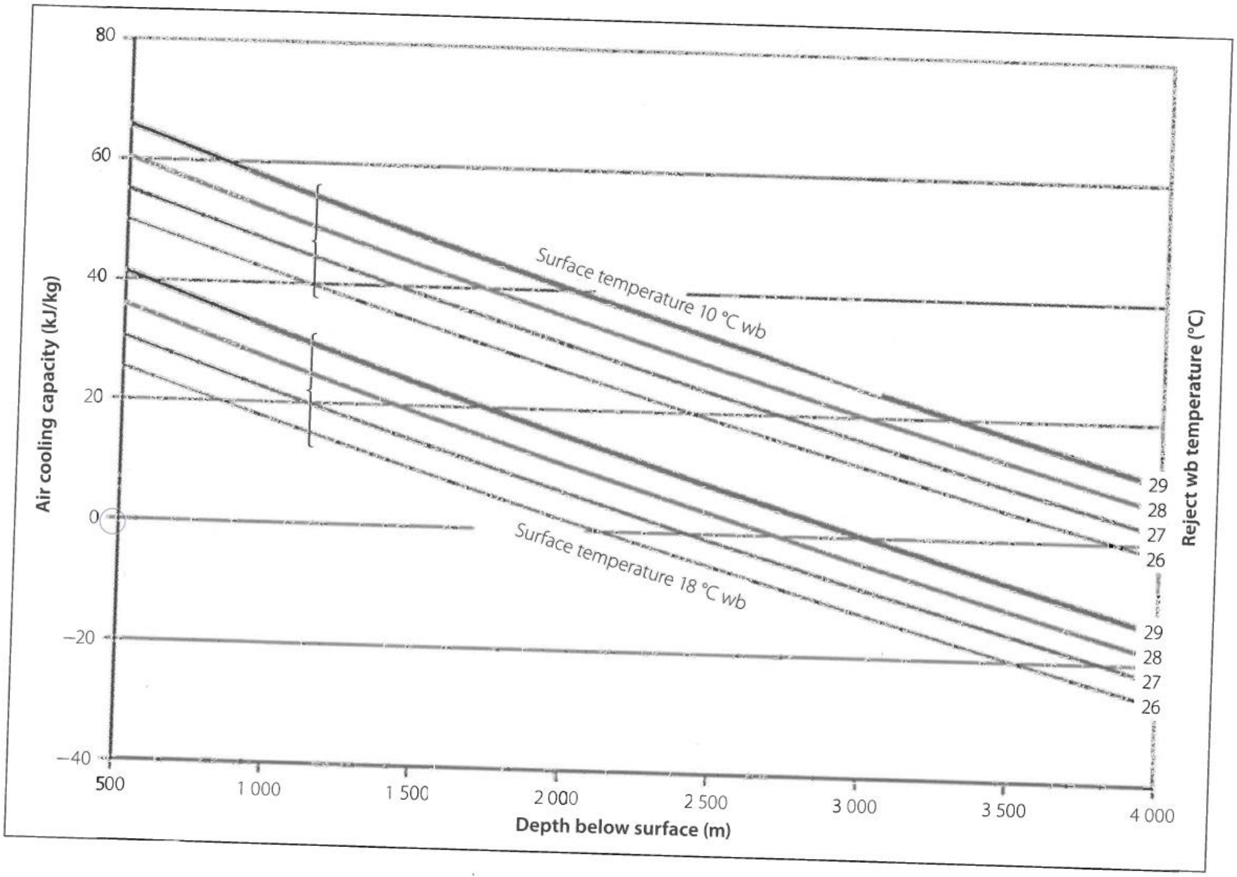
OR

5.2 Block cave mine ventilation optimisation techniques

(M. Hooman, W. Marx and F.H von Glehn – BBE Consulting, January/March Volume 71 No 1)

1 mark per fact = 15 facts = 15 marks

TOTAL MARKS: [100]


80
60
40
20
0
−20
−40
Air cooling capacity (kJ/kg)
Surface temperature 10 °C wb
Surface temperature 18 °C wb
29
28
27
26
29
28
27
26
Reject wb temperature (°C)
500
1 000
1 500
2 000
2 500
3 000
3 500
4 000
Depth below surface (m)