Minerals Council South Africa

EXAMINATION PAPER

SUBJECT:**CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL** **PAPER 2 – THERMAL ENGINEERING** SUBJECT CODE: **COMMEC2** EXAMINATION DATE: **09 October 2019** TIME: **14:00 – 17:30 (3½ HOURS)**	EXAMINER**: Marthinus v/d Bank** MODERATOR: **Marco Biffi** TOTAL MARKS: **[100]** PASS MARK: **(60%)**

NUMBER OF PAGES: **12**

SPECIAL REQUIREMENTS:

THIS IS **NOT** AN **OPEN BOOK EXAMINATION**. FORMULA HANDOUTS AVAILABLE

INSTRUCTIONS TO CANDIDATES:

1. Answer all 4 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) 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 your examiner or moderator regarding this examination.
9. Cell phones and any other electronic devices are **NOT** allowed in the examination room. **Only Calculator**
10. **The following charts to be included: Psychrometric charts: 85.0kPa, 95.0kPa, 97.5kPa, 100.0kPa, 105.0kPa, 115.0kPa and 120.0kPa.**

QUESTION 1.

1.1 300 m^3/s of air at a temperature of 13,6/20ºC enters a 1 800m deep downcast shaft. The barometric pressure is 85.0 kPa. During its passage down the shaft the air picks up heat from the surroundings at a rate of 1,15 kJ/kg per 300m and moisture from the surroundings at a rate of approximately 0,5 g/kg per 200m.

At the bottom of the shaft, where the barometric pressure is 105.0 kPa, the air passes through a haulage that is 1 600 m long (horizontal). In the horizontal airway the air picks up 2 890 kW of heat and 1,8 litres/second of water evaporates into the air. No air leakage takes place.

Assume the barometric pressure remains constant in the horizontal airway.

1.1.1 Determine the wet-bulb and dry-bulb temperature of the air at the end of the airway.

(5)

1.1.2 Determine the heat increase in the shaft due to auto compression in kW and what percentage does it make up of the total amount of heat added to the air in the shaft?

(10)

1.2 Give brief explanation for the following terms:

- Effective temperature
- Metabolic rate
- Heat Tolerance Screening (HTS)
- Natural Acclimatization
- Deterministic effects

(10)

(25)

QUESTION 2.

2.1 Use the Steady Flow Energy equation to discuss the heat that is added to the air by the use of electrical machinery underground, that perform thermodynamic work (e.g. Hoists) and those that do not (e.g. auxiliary fans)..

(6)

2.2 The following measurements were taken at an underground booster fan inlet:

Intake air volume 236 m³/s

Fan pressure 5 kPa

Temperature 24/27ºC

Barometric pressure 115 kPa

Power input to fan motor 1 775 kW

Motor efficiency 95%

2.2.1 Determine the conditions at the fan discharge.

2.2.2 What are the efficiency and overall efficiency of the fan.

(11)

2.3 The following measurements were taken at the inlet of an underground hoist chamber.

Temperature 26,3/29,5ºC

Barometric pressure 115 kPa

Hoist motor input power 2 170 kW

Motor efficiency 87%

How much air must be supplied to the hoist chamber to ensure that the wet-bulb temperature in the chamber does not exceed 28.5ºC? State any assumptions you make in giving your answer.

(8)

(25)

QUESTION 3.

3.1 You are the ventilation engineer on a shaft and you have to make an estimate of the heat load potential of a new kind of explosive to be tested on your shaft. The following technical details of the explosive are available.

- ANFO based explosives heat release 3 700 kJ/kg of explosives
- The charge density of ANFO explosives 0,8 kg/ton of rock blasted

It is known that the heat generated by the explosives will be removed in two stages, namely with the blasting fumes and some will be retained in the rock as heat. With high fragmentation it is assumed that 45% of the heat will be removed with the fumes. It is also estimated that 20% of the heat will be removed within the first hour after blasting. The amount of rock to be blasted is 2000 tons and assume the Cp of rock as 950 J/kg^{o}C.

Determine the following:

3.1.1 The total amount of heat produced by the explosives (kJ)

3.1.2 How much of the total heat produced remains in the rock and is not removed with the fumes (kJ)

3.1.3 The rate at which heat energy is removed with the fumes within the first hour after blasting

3.1.4 The rise in temperature of the rock blasted within the first hour

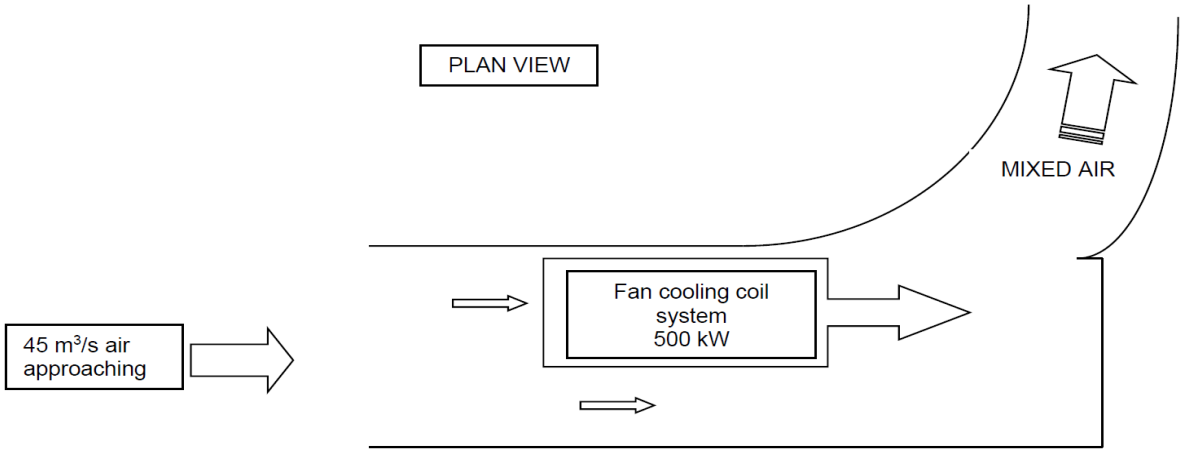
3.1.5 What would be the rise in temperature in the rock be (within the first hour) if the explosives used were a nitro glycerine based explosive with a heat release rate of 5800 kJ/kg explosive used assume same charge density.

(10)

3.2 A cooling unit has been suggested to improve the working conditions in a workplace at a mine. The current intake air temperature is 30.0/32.0^{o}C at a barometric pressure of 102.5 kPa. It is suggested that the cooling unit/cooling coil that is made up of the combination of a fan and chilled water reticulation system will be able to draw air through the system at an intake quantity of 20m^{3}/s and the duty of the cooling coil is 500 kW. A 45 kW fan is used for the cooling coil. The cooling coil will be installed in the main haulage and no recirculation is expected. The main airflow quantity in the haulage is 45 m^{3}/s.

Determine the exit conditions of the air after mixing of the air took place. Mine management expects that through this arrangement that they will be able to offer an intake wet-bulb temperature of 28.0^{o}C to the work place (ignore the increase pressure effect of the cooling coil fan). Use the 102.5 kPa psychrometric chart to help you to determine the various properties of the air for this scenario.

Comment on your answer based on the expectation. How can the conditions be improved further if need to. The drawing below will help to understand the problem.



(15)

(25)

QUESTION 4.

4.1 List at least 5 advantages and disadvantages of using ice as a medium for providing cooling in a deep mine (> 3000m).

(10)

4.2 A clerk in a metallurgical plant complains that the office in which she works is hot. One wall in particular appears to radiate heat into this office, this wall separates the office from an adjoining furnace room.

The wall adjoining with the furnace room measures 4m (W) x 2m (H). This wall comprises of a 200mm thick, double-brick wall with a 15mm thick layer of plaster on either side of the wall.

The surface temperature of this wall is measured to be 115ºC (on the furnace side of the wall) and 55ºC (on the office side of the wall). An air conditioner maintains the air temperature inside the office at a constant 26,5ºC. Given that:

- The thermal conductivity of brick is 0,7 W/mºC.
- The thermal conductivity of plaster is 0,93 W/mºC.
- The surface (skin and clothes) temperature of the clerk averages 28ºC.
- That side of the clerk's body facing the "hot" wall has a surface area of 0,8m².
- That side of the clerk's body facing the "hot" wall has an emissivity and view factor with the wall of 0,95

Determine the following:

4.2.1 At what rate does heat pass through the wall by means of conduction?

4.2.2 The convective heat transfer co-efficient for the wall

4.2.3 How much radiated heat is experienced by the clerk

(15)

(25)

Colin add psychrometric charts 85.0, 102.5, 105.0, 115.0 and 120.0