



MEMORANDUM

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 4 – RISK MANAGEMENT. INFORMATION MANAGEMENT, FIRES & EXPLOSIONS, GASES AND STATISTICS SUBJECT CODE: COMMEC EXAMINATION DATE: 12 MAY 2017 TIME: 14:30 – 17:30	EXAMINER: JC Maass MODERATOR: AR Nundlall TOTAL MARKS: [100] PASS MARK: 60%
NUMBER OF PAGES 10	
<u>Examination Instructions:</u> This examination question paper consists of 5 pages 1. Answer all 4 questions in <i>English</i>. 2. Put your identification 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 only. 5. Write in ink on the right hand page only – the left hand page <u>will not</u> 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 units 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. This is NOT an open book examination but the approved formula hand out may be used. 11. Cell phones are NOT allowed in the examination room	

Question 1. Risk Management

- 1.1. List **five** of the expected duties of employers with respect to Risk Management in terms of the Mine Health and Safety Act. (5)

(Workbook 4, Page 18)

- a) Providing equipment, materials and protective devices as prescribed by the legislative acts and regulations. (1)*
- b) Seeing that this equipment is maintained in good condition. (1)*
- c) Seeing that the equipment, materials and protective devices provided are used as prescribed. (1)*
- d) Providing information, training and supervisors to workers to protect their health and safety. (1)*
- e) Appointment of competent supervisors (managers). (1)*
- f) Acquainting the worker with any hazards in the workplace. (1)*
- g) Carrying out the procedures required by legislation. (1)*
- h) Assistance and co-operation to health and safety committees. (1)*
- i) Take every precaution reasonable to protect workers. (1)*

- 1.2. Briefly explain the meaning or definition of the following phrases or words used for Risk Management. (6)

(Workbook 4, Pages 21 & 48)

- a) Hazard: A hazard is a source of danger. (1)*
- b) Risk: Risk is the change of harm or loss. (1)*
- c) Incident: An undesired event that results in harm or loss. (1)*
- d) Legal Liability: Responsibility or accountability with regards to criminal or civil law. (1)*
- e) Occupational: All tasks and duties employees are paid / required to do in the lawful execution of the job they have been trained for. (1)*
- f) Consequence: The degree of harm, potential severity of the injuries or ill health and / or the number of people potentially affected. (1)*

- 1.3. Name the **four** fundamental steps of the Risk Management Process **and** give one example of an outcome of each step. (4)

(Workbook 4, Page 26)

- a) Risk Identification, e.g. inspections, internal & external audits, etc. (1)*
- b) Risk Evaluation, e.g. risk ranking, baseline or issue based risk assessments, investigations, etc. (1)*
- c) Risk Control, e.g. dust filters and water sprays, footwall treatment, noise silencers, fire prevention, protection and suppression, etc. (1)*
- d) Risk Financing, e.g. working cost budgets and capital application. (1)*

- 1.4. The approach to risk measurement should not be complicated and be sufficient so far as it is reasonable practicable. Briefly explain the approach to risk management by completing the sentence for the words below: (4)

(Workbook 4, Page 45)

- a) Allow: *Allow acceptable decision making.* (1)
- b) Have: *Have a high confidence level.* (1)
- c) Communicate: *Communicate easily to employees, inspectorate and other stakeholders.* (1)
- d) Demonstrate: *Demonstrate competent and responsible management.* (1)

- 1.5. You should consider the Risk Management principles of consequence and frequency when required to prioritise the Major Risks related to Environmental Engineering and Occupational Health at your mine. (6)

- a) Give **four** examples of Major risks that may seriously compromise the Health or Safety of the workforce almost immediately or **short term**:

(Workbook 4, Page 55)

- *Fire and / or Explosions.* (1)
- *Toxic or flammable gas accumulations.* (1)
- *Oxygen deficiency.* (1)
- *Ambient temperature Extremes (heat or cold stress).* (1)
- *Excessive workplace noise (distraction, no communication).* (1)
- *Poor visibility (accumulations of smoke, fumes or dust).* (1)

- b) Give **two** examples of Major risks that may seriously compromise the Health or Safety of the workforce in the medium to **long term**:

- *Heat related illness.* (1)
- *Noise induced hearing loss.* (1)
- *Respiratory illness due to respirable particulates.* (1)
- *Skin diseases due to the chemical compound contact.* (1)

[25]

Question 2. Information Management and Statistics

- 2.1. In business correspondence, as in the case for all good report writing, a simplistic and straightforward approach is the best way to go. The message or information you want to get across must however not be lost in too much simplicity. (5)

Briefly explain the concept of “Think before you write” by completing the sentences below:

(Workbook 4, Page 63)

- a) Think of the reader: *Is the reader a managing director, someone you know quite well or a total stranger? This will precondition your level of communication and allow you to be more relaxed when you start.* (1)
- b) Think of the reason: *What is the reason for writing the report? If there is more than one, be explicit.* (1)
- c) Think of the facts: *The facts you are communicating to the reader. Make a list and put these in a logical order.* (1)
- d) Think of the person: *What do you want the person receiving the correspondence should do for you? Again make a list and put the most important item first.* (1)
- e) Think of the follow-up: *Correspondence required if you get no reaction to your first communication. Think of what is required to get the reader to reply without further delay.* (1)

- 2.2. The Terms of Reference or Objectives dictate which types of report are required. Name **and** briefly explain the **four** types of reports: (4)

(Workbook 4, Page 64)

- a) *Investigation or examination reports – describes investigations carried out and the conclusions arrived at, and no more than this.* (1)
- b) *Recommendatory reports – only suggest courses of action.* (1)
- c) *Progress reports – only investigate and inform on the current status of a specific matter.* (1)
- d) *Comprehensive reports – reports that incorporates some or all of the above reports.* (1)

- 2.3. The objectives of reporting must also satisfy the reasons for reporting. A major task of the Environmental Engineering and/or Occupational Hygiene department is to collect, record, and report on the health and safety conditions that exist on their mines, in terms of section 12 of the MHSA. (6)

List **and** briefly explain **six** reasons for reports and reporting:

(Workbook 4, Page 79)

- a) *Provide information on current status of work and work conditions.* (1)
- b) *Act on sub-standard conditions and practices that can increase risk.* (1)

- c) *Formulate policy (standards) with regard to the work processes.* (1)
 - d) *For determining efficiencies and budgetary requirements.* (1)
 - e) *For legislation requirements.* (1)
 - f) *For Formal Risk management purposes.* (1)
 - g) *Provide a history of work and work conditions for record purposes.* (1)
 - h) *Create databases on environmental engineering, occupational hygiene and/or health.* (1)
- 2.4. Linking Occupational hygiene measurements to employee medical surveillance records are required in current legislation in terms of section 13 of the MSHA, a computerised database system is recommended. (5)
- List **and** briefly explain **five** duties required of the persons appointed, in terms of section 12 and 13 of the MSHA, to comply with legislation:
- (Workbook 4, Page 87)*
- a) *Establish and maintain a system of medical surveillance of employees exposed to health hazards.* (1)
 - b) *Keep record of such surveillance.* (1)
 - c) *Conduct occupational hygiene measurements.* (1)
 - d) *Keep record of such measurements.* (1)
 - e) *List these records to an employee's medical surveillance record.* (1)
 - f) *Safely keep all such records for a period of 40 years from the last date of the medical surveillance of that employee.* (1)
 - g) *Compile and submit an annual report to the Medical Inspector giving an analysis of medical surveillance, without employee names.* (1)
- 2.5. List **and** briefly explain the **five** actions to be taken by you as a mine official, if employees are working in or near a dangerous workplace and who can be immediately affected: (5)
- (Workbook 4, Page 93)*
- a) *Stop all work in affected area, including vehicles or tramming.* (1)
 - b) *Withdraw all persons who may be affected to a safe area.* (1)
 - c) *Take effective measures to prevent unauthorised entry to the unsafe area.* (1)
 - d) *Warn people at the other areas or workplaces that may also be affected.* (1)
 - e) *Inform management of the situation and wait for further instructions.* (1)

Question 3. Fires and Explosions

3.1. Define the following terms, briefly explain in your own words: (5)

(Workbook 4, Page 126)

- a) Products of combustion (pyrolysis): *The products of pyrolysis (chemical degeneration due to heat), are emitted from a substance in the form of gases, vapours and smokes throughout a range of heating and combustion temperatures.* (1)
- b) Heat contribution: *This is the radian heat output, in kilojoules (kJ), of a substance at a set combustion.* (1)
- c) Smoke density: *This the amount of hygroscopic nuclei emitted from a mass of a burning substance as smoke, at a set combustion temperature. The denser the nuclei are, the denser the smoke.* (1)
- d) Flash ignition temperature: *This is the lowest temperature that can ignite the vapour of a substance. It is the vapour that burns. It is the vapour that forms a flammable or explosive mixture with the air.* (1)
- e) Self-ignition temperature: *The temperature at which a substance will ignite spontaneously on exposure to air. This is normally given in °C for specific barometric and vapour pressures.* (1)

3.2. Fires are grouped into various classes to rationalise the choice between the extinguishing mediums and devices for fire-fighting purposes. (8)

Name the classes below, with at least **two** examples of each **and** the special precautions to be taken when extinguishing these types of fires.

(Workbook 4, Page 128 and 131)

- a) Class A: (2)
Combustible / flammable materials such as coal, paper, plastics, rubber, wood and textiles. (1)
These fires are often deep rooted and well below the material surface. Fires involving coal or rubber require sufficient water to penetrate and cool the burning material to below the ignition temperature. (1)
- b) Class B: (3)
Flammable liquids and grease such as alcohols, benzene, oils, paraffin, diesel and petrol. (1)
In dealing with flammable liquids two main hazards must be recognised:
 - *If the liquid floats on water and does not mix with it, the use of water may spread the fire into other areas.* (1)
 - *If the liquid has a low flash-point, its vapour may form an explosive mixture with air and spread a distance from the liquid itself.* (1)
- c) Class C: (3)
Class A, B, C or E in the presence of live electrical installations such as electrical cables, generators, drive motors, transformers, etc. (1)
With any fire involving electrical equipment the first step is to switch off the main current (lock-out):

- *Water or foam should not be used unless the electricity supply has been switched off and suitably locked out.* (1)
 - *Water should not be used if the fire also involves transformer or switchgear oil.* (1)
- 3.3. Give an approximate flash-point temperature of the following products **and** the approximate volumes of carbon monoxide (CO) and carbon dioxide (CO₂) gases produced when burning: (6)
- (Workbook 4, Page 133)*
- a) Wood: *FP > 200°C.* (1)
CO = 18-20% and CO₂ = 2-5% (1)
- b) High Density Polyethylene (HDPE): *FP > 250°C.* (1)
CO and CO₂ = 10-20% (1)
- c) Polyvinylchloride (PVC): *FP > 250°C.* (1)
CO = 10% (1)
- 3.4. Speed of response is essential during fire-fighting operations. Once a fire has been reported and confirmed, the organisation of the fire-fighting operations must be started immediately. (4)
- List **and** briefly explain the **four** primary duties of the first senior official (usually the manager) in the Emergency Control room:
- (Workbook 4, Page 175)*
- a) *To ensure that no persons are in danger and that everybody has been withdrawn from the return side of the fire.* (1)
- b) *To inform key personnel to report to the control room.* (1)
- c) *To ensure that warning has been given to all sections of the mine, as well as to neighbouring mines, that may be affected by the fire.* (1)
- d) *To initiate fire-fighting procedures as laid down in the mine code of practice and fire manual.* (1)
- 3.5. List **four** of the key personnel that should be in the Emergency Control room as part of the core control team, other than the Manager in charge, section manager and mine overseer: (2)
- (Workbook 4, Page 177)*
- a) *Mines Rescue Services liaison officer.* (½)
- b) *Senior Environmental Control officer.* (½)
- c) *Resident or section Engineer.* (½)
- d) *Scribe.* (½)

Question 4. Gases

- 4.1. List and briefly explain **five** of the main recognised methods to prevent a coal dust explosion in a mine. (5)

(Workbook 4, Page 212)

- a) As much as possible removal of fine coal spillage. (1)*
- b) Reduce / control dust creating sources. (1)*
- c) Effective ventilation to dilute or remove flammable gas emissions. (1)*
- d) Sufficient and effective application of incombustible stone dust in the workings. (1)*
- e) Sufficient, well designed and well-spaced flame quenching barriers. (1)*
- f) Prevent or control potential ignition and high temperature sources. (1)*

- 4.2. List and briefly explain **seven** precautions to be taken or the positions when testing for flammable gas in a force / exhaust overlap ventilation system. (7)

(Workbook 4, Page 274)

- a) Fans must be kept operating. (1)*
- b) Test at the return from the exhaust column (if not accessible, make a hole in the column and insert a probe for gas test purposes. (1)*
- c) Leave the gang about 10m from the intake of the force column in the charge of a responsible person. (1)*
- d) Take one person to assist. (1)*
- e) Test the intake to the force column. (1)*
- f) Test around the fan in the force column. (1)*
- g) Test at the fan switch. (1)*
- h) Test at the intake of the exhaust column. (1)*
- i) Test around the fan in the exhaust column. (1)*
- j) When proceeding to the face, test high places in the hanging, at faults, dykes and other places where flammable gas can accumulate. (1)*
- k) Test at the face (pilot holes, sockets, faults and fissures. (1)*
- l) Test all electrical equipment before initial starting of the motors. (1)*

- 4.3. The total volume of a sealed off section of a mine is 20 000 m³/s and consists of an atmosphere containing 80% methane. The pressure inside and outside the sealed area is 98 kPa. The starting of a nearby booster fan lowers the pressure outside the seal to 1.5 kPa. (8)

- a) If the resistance of the leakage path around the seal is 150 000 Ns²/m⁸, calculate at what rate the methane / air mixture inside the sealed section will start to flow around the seal? (2)
- b) If the airway alongside the seal has an airflow of 10 m³/s containing no

methane, what will be the methane percentage in the air stream on the return side of the seal immediately after starting up the fan? (3)

- c) Because the methane / air mixture flows out around the seal, the pressure inside the seal will eventually be equal to the new pressure outside the seal and the flow will stop. What total will be the volume of methane / air displaced from the sealed area, before the flow stops? (3)

(Exam Questions and Answers 4, Pages 19 and 20)

- a) *The rate of methane / air mixture through the sealed area has to be determined by using the known formula of $P = RQ^2$.*

$$\begin{aligned} Q &= \sqrt{(P / R)} \\ &= \sqrt{(1500 / 150\,000)} & (1) \\ &= \sqrt{(0.01)} \\ &= 0.1 \text{ m}^3/\text{s} & (1) \end{aligned}$$

(Note: this 0.1 m³/s is the mixture of methane and air – not separate).

- b) *80% of the 0.1 m³/s methane / air mixture is pure methane, the quantity of methane can now be determined.*

$$\begin{aligned} \text{Qty of CH}_4 &= \% \text{ CH}_4 \times Q_{\text{mix}} \\ &= 80 / 100 \times 0.1 \\ &= 0.08 \text{ m}^3/\text{s} & (1) \end{aligned}$$

After mixing with the fresh air, the percentage methane will be:

$$\begin{aligned} \% \text{ CH}_4 &= Q_{\text{CH}_4} / Q_{\text{mix}} \times 100 \% \\ &= \{0.08 / (10.0 + 0.1)\} \times 100 \% & (1) \\ &= 0.00792 \times 100 \% \\ &= 0.792 \% \text{ or } 7\,921 \text{ ppm} & (1) \end{aligned}$$

- c) *The total volume displaced from the sealed area must be determined, Boyle's law which states that $P_1V_1 = P_2V_2$ must be used.*

Initial pressure of mixture inside the seal = 98 kPa

Initial volume of mixture inside the seal = 20 000 m³

Final pressure of mixture inside seal = 96.5 kPa

$$\begin{aligned} V_2 &= (P_1V_1) / P_2 \\ &= (98 \times 20\,000) / 96.5 & (1) \\ &= 20\,311 \text{ m}^3 & (1) \end{aligned}$$

The initial and final volume inside the seal is 20 000 m³. The total volume of the mixture displaced to reach equilibrium:

$$\begin{aligned} &= 20\,311 - 20\,000 \\ &= 311 \text{ m}^3 \text{ of mixture displaced} & (1) \end{aligned}$$

- 4.4. You are requested by the engineering department on your mine to calculate the maximum carbon monoxide emission from the exhaust of a vehicle driven by a 72 kW compression ignition engine (diesel). The purpose is to ensure that the time weighted average exposure over an 8 hour shift (**TWA**), for CO is not exceeded, when operated in uncontaminated intake air. (5)
- The quantity of air used by the machine and released via the exhaust is 0.2 m³/s. Assume a clean airflow rate of 0.1 m³/s per kW of engine power.
- a) The required clean airflow rate for the operation of the engine. (1)
- b) The maximum CO release rate at the exhaust of the engine in m³/s. (4)

(Exam Questions and Answers 4, Pages 19 and 20)

a) *The required clean air airflow rate = rated kW x air Qty per rated kW*

$$= 72 \times 0.1$$

$$= 7.2 \text{ m}^3/\text{s} \quad (1)$$

b) *Maximum CO release rate allowed by the TWA = 30 ppm* (1)

$$= (30 / 1000000) \times 100\%$$

$$= 0.003 \% \text{ CO} \quad (1)$$

As a percentage of the total amount of fresh air supplied

$$= (0.003 / 100) \times 7.2 \text{ m}^3/\text{s}$$

$$= 0.00022 \text{ m}^3/\text{s} \quad (1)$$

$$\text{Concentration CO} = (Q_{\text{CO}} / Q_{\text{mix}}) \times 100\%$$

$$= (0.00022 / 0.2) \times 100$$

$$= 0.11 \%$$

$$= 1100 \text{ ppm} \quad (1)$$

This means that a maximum CO concentration of 1100 ppm can be released from the diesel engine into 7.2 m³/s of fresh air to ensure the required TWA of 30 ppm is not exceeded. (1)

[25]

TOTAL MARKS 100