mineral resources
& energy
Department:
Mineral Resources and Energy
REPUBLIC OF SOUTH AFRICA

MINE ENGINEER'S CERTIFICATE OF COMPETENCY EXAMINATION

MINES AND WORKS

PLANT ENGINEERING

DATE: 9 NOVEMBER 2023

TOTAL MARKS: 100
TO PASS: 50

TIME ALLOWED: 3 HOURS
(09H00 to 12H00)

INSTRUCTIONS:

- This question paper consists of **EIGHT (8)** pages including cover page.
- Questions 1 to 3 in SECTION A are **COMPULSORY** – answer all of them.
- Choose and answer **ANY** 2 questions in SECTION B. The examiner will only mark the first 2 questions you have answered.
- All answers are to be presented in a neat and readable manner. Answers will not be marked if not readable.
- Restrict the use of highlighters.
- Do not use a red pen.
- Read the instructions on the front page of your answer book carefully.
- No cellular phones and any other related devices shall be allowed in the examination venue.
- The use of computers, laptops and any other related devices is prohibited.

Section A: Compulsory Questions (Answer All 3 Questions)

Question 1

You are the Project Engineer on a shaft where decline winders are installed and the winder that is now running for 8 months is starting to give problems. You need to investigate.

During the investigation on a single-drum winder, it was found that the coupling bolts of the coupling between the gearbox and the drum were deformed in shear due to excessive torque. It was determined that the high acceleration rate of the winder caused the coupling bolts to be damaged. The design factor of safety for the coupling is 4.

Use the following information to determine the maximum allowed rope acceleration to ensure that the design factor of safety of the coupling is not exceeded. [20]

Mass of loaded conveyance and attachments	4 500 kg
Length of rope	1 500 m
Mass of rope per metre run	8 kg/m
Depth of shaft	1 200 m
Inertia of sheave wheel	1 200 kg.m^2
Mass of drum shaft	3 000 kg
Diameter of drum	2 m
Width of drum	1,3 m
Radius of gyration of empty drum	800 mm
Mass of solid shaft	2 000 kg
Diameter of shaft	450 mm
Mass of the drum shaft half coupling	312 kg
Radius of gyration of coupling	300 mm
Pitch circle diameter of coupling bolts	740 mm
Number of bolts	10
Diameter of bolts	50 mm
Ultimate shear stress of material of bolts	100 MPa
Frictional resistance of conveyance in guides	200 N

Question 2

You have been appointed on a trackless shaft within your company. You have several Trackless Mobile Machines (TMM) under your control. You had several incidents where machines were the root cause of serious injuries and incidents. You need to implement safety measures to prevent ongoing incidents. The Mining Industry Occupational Safety and Health (MOSH) issued a traffic management technical guide for underground trackless operations whereby minimum requirements are tabled for all mining groups to follow in order to mitigate the challenge. You need to analyse and implement the requirements to ensure compliance.

The Earth Moving Equipment Safety Round Table (EMESRT) adopted a nine-step hierarchy type model around design, operation and reaction which identifies areas of focus for the end user, mining companies, the original equipment manufacturers as well as third party for vehicles to provide a "one voice" of the industry approach.

1. List the nine "levels of control" to be used as a guideline as per the MOSH document (9)

Zoning provides the mine with a practical control to ensure that only authorized vehicles and pedestrians enter demarcated zones. This can be done either through physical controls or adherence to administrative controls. Specific management rules, other than the normal rules, as determined by the site-specific risk assessment, must be displayed at the entrance to the applicable area. Areas of the mine should be zoned in accordance with the risks (including interactions) specific to the area in order to differentiate risk areas and relevant controls.

2. List six risk areas that needs to be defined in accordance with demarcated zones. (6)

3. When determining the dimensions of the roadways, what must be taken into account or considered? List five considerations. (5)

[20]

Question 3

You have been appointed at your mine as the Services engineer responsible for all the services associated with the shaft. i.e. main pumps, compressors, electrical reticulation, main fans and refrigeration plants. For you to get acquainted with the equipment under your control, you have made several visits to sections of the mine. Your last visit was to a huge distribution substation mid-way through the shaft. During the visit, you observed the switchgear and substation are new and that all the protection relays are Intelligent electronic devices (IEDs). All breakers and the busbar rating are 1250 amp. All voltage transformers are busbar connected and all breakers are Magnetic Actuated Vacuum Breakers. The substation is fed from different utility transformers.

You consulted the single-line diagram, and you noted the following:

- Six incoming panels from the main substation
- Two 1000 kVA "dual" mini substations
- Four outgoing shaft feeder panels feeding to the next level substation.
- Four 1500 kW clear water pump panels
- Three 2 MVAr power factor panels
- Bus Section Panel
- All feeder cables to and from the substation are 185 mm^2 PILCSWA cables.

1. Redraw the single-line diagram to indicate the configuration of the substation (3)
2. With the new IED`s installed you can select various protection curves to be used. Name the various curves you can use. (5)
3. Looking at the configuration what will the input (available) current to the substation be and what risk do you see in this configuration? (4)
4. Looking at the specific protection relay placed in the Incomer panels what protection settings should be considered for the panel? (5)
5. Explain by means of a neat drawing the worming principle of differential protection? (3)

[20]

SECTION B – ANSWER ONLY TWO QUESTIONS

Question 4

4.1 You are an engineer in charge of machinery in a coal mine underground operation. Machines in your section are no longer safe to use, accidents are on the rise, as a result, and it is also becoming extremely un-economical to keep the machines in operation. The only other alternative available is to replace the machines.

The table below details costs and revenues associated with the project to replace the machines, and thus improve safety and operational performance in your section.

Cost of capital: 12%

Year	Costs	Revenue	Discount Factors
0	R 140,000,000		
1		R 80,000,000	1.12
2		R 70,000,000	1,2544
3		R 50,000,000	1,405
4		R 45,000,000	1,574
5		R 45,000,000	1,762
TOTAL			

Motivate your decision to replace the machines, using the above information. (10)

Hint: Calculate NPV and explain why the decision to replace the machines is right, given what the company is going through.

4.2 You are an engineer in charge of a boiler section. You have recently been experiencing a lot of priming with your boilers, which resulted in the cracking of your boiler cylinders and covers, which put the safety of employees at risk.

4.2.1 List 2 main causes of priming in boilers. (2)

4.2.2 List 2 indications of priming in boilers. (2)

4.2.3 List and describe the 3 ways in which corrosion occurs in steel boilers. (6)

[20]

Question 5

As the appointed engineer on a shaft, one of your responsibilities is overseeing the compressed air network. An important induction motor with unique insulation drives a compressor which is essential to production. The compressor is subjected to varying demands. It is thus important to avoid or minimize damage to the motor, which has the following particulars:

4 MW, 6,6 kV, 3 phase, 1 480 r/min with forced ventilation.
Squirrel cage, star connected, both ends of each phase winding accessible.
Locked rotor stall withstand time 10 s.
Starting direct online. Normal run-up time 20 s
With outboard white metal pedestal bearing with oil rings installed.

1. State SEVEN protective devices you would specify for the motor and its switchgear, briefly describing the purpose and function of the devices. (14)

2. Describe THREE non-destructive tests that can be done on the compressor components. Briefly describe how these tests are done. (6)

[20]

Question 6

6.1 The air intake to an air-conditioning plant is at the rate of 5 600 m^3/h, at a temperature of 28°C and a relative humidity of 78%. The air passes through a cooler where it is dehumidified by cooling to below the dew-point temperature and the condensate from the cooler leaves at the same temperature as the air.

Determine the air temperature required at exit from the cooler and the heat transfer in the heater if the air is next heated to 19°C and the relative humidity is 50%. (10)

For dry air:

C_p = 1,005 kJ/kg.K

R = 0,287 kJ/kg.K

For water pressure at low pressure, take R = 0,4615 kJ/kg.K

The pressure throughout the plant is constant at 101,325 kPa

Saturated pressure at 28°C = 3,778 kPa

Enthalpy of water vapour = 2552,1 kJ/kg

Saturated pressure at 19°C = 2,196 kPa

The dew-point temperature corresponding to 1,098 kPa = 8,3°C

Specific volume of air is 0,88 m^3/kg at 101,325 kPa.

6.2 Mention FIVE characteristics of fluids that are to be used as refrigerant to ensure health, safety and environmental consideration in refrigeration plants. (5)

6.3 Mention FIVE different methods of leak testing for refrigerant leaks. (5)

[20]

Question 7

(a) The maximum efficiency of a 500 kVA transformer occurs at 83% of full load. It has a full-load efficiency of 97,3% at unity power factor. The 24-hour load cycle is as follows:

No load .....9 hours

0,6 full load at 0,9 power factor .....5 hours

0,75 full load at 0,85 power factor .....3 hours

Full load at 0,8 power factor .....7 hours

Calculate for the 24 hour period:

(i) The total losses in kWh (6)

(ii) The energy efficiency (6)

(b) Explain why the operation of a plant at a low power factor results in power being "wasted". (4)

(c) What economic criteria apply when considering the extent to which the power factor of electrical plant may be raised? (4)

[20]

[Total: Section B = 40]

[Total Section A and Section B = 100 marks]

End