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: 31 MAY 2021

TOTAL MARKS: 100
TO PASS: 50

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

INSTRUCTIONS:

- This question paper consists of **TEN** pages including cover page.
- **ALL** questions must be answered.
- All answers are to be presented in a neat and readable manner. Papers 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.

Question 1

A second hand Koepe winder that winds minerals is to be installed in a sub-vertical shaft.

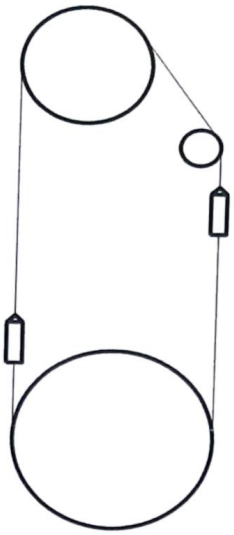
The driving sheave is too small for the width of the compartments, but the problem could be solved with a deflection sheave as shown in the sketch.

The tail rope runs in a free loop at the bottom and excessive sideways movement is contained with wooden blocks.

Data of installation:

Winding depth	1500 m
Maximum winding speed	5,25 m/s
Mineral load	18,15 t
Mass of each skip	17,18 t
Diameter of driving sheave	5,95 m
Contact angle of driving sheave	170°
Moment of inertia of rotating parts	120 000 kg.m2
Mass of head rope (4 x rope)	10,91 kg/m
Mass of tail rope (4 x rope)	0,91 kg/m
Total length of head and tail ropes	1 540 m
Coefficient of friction of driving sheave	0,2
Diameter of brake race	6,25 m
Braking force of each brake shoe (2 x shoes)	980 kN

Degree of protection (DOP) minimum 1,4 (Directive C2, Revision 1, 13 December 1996, Department of Mineral Resources and Energy)



Determine for a nominal winding cycle the available stopping distance – as required by Directive C2 – from the stopping point, where the emergency brake would come on if the speed controller fails at the end of the full speed zone. Ensure that the emergency deceleration would not cause slip at the driving sheave wheel. Assume a friction force of 10 kN for each conveyance. (20)

Question 2

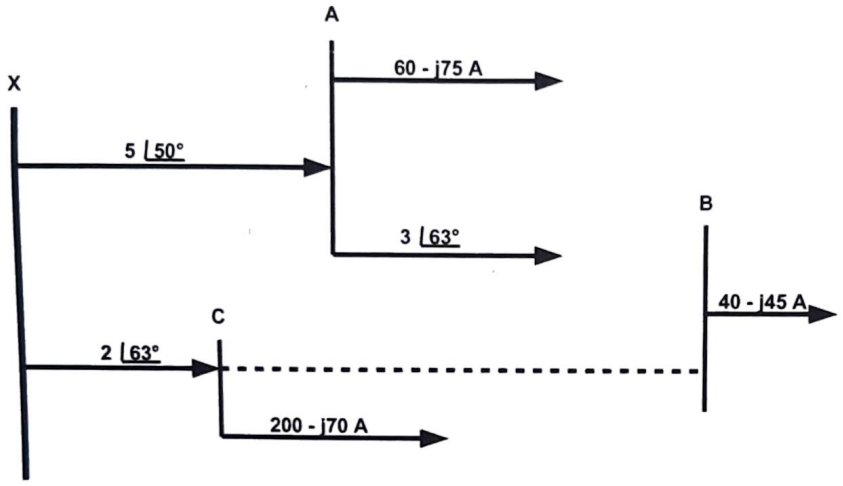
2.1 A Trackless Mobile Machinery(TMM) Operator was found to always having near miss collisions with the last near miss being a very high potential incident. You as the engineer in charge, have the responsibility to investigate the probability of recurrence and find reasons why this is the case. Describe the methodology you will follow to go about this and the probable causes that need to be investigated more closely. (15)

2.2 Describe ways and means to reduce derailment and re-railment accidents of trains in the underground transport section for which you are responsible. (5)

Question 3

3.1 Explain, using diagrams where necessary, the mechanism by which transient voltages are produced when a fault on a short line is cleared by a transmission line air circuit breaker. (6)

3.2 Three substations A, B and C are fed from a 66 kV main substation X. The line impedances per phase and the load currents from the individual substations are shown below. One of the options to improve the voltage at B is to install an interconnector with an impedance Z = 1.2 + j2 Ω/phase between B and C as indicated by the broken line. Calculate the improvement of the voltage which will be achieved if this option is exercised. (14)



Question 4

4.1 The following information was obtained for an underground mining area that is to be cooled by chilled service water and air heat exchangers.

Mass of rock mined	85 000 t/month
Mass ratio of service water to mined rock	2,5:1
Temperature difference of the chilled water across the refrigeration plant	19°C
Temperature difference of the chilled water across the heat exchangers	17°C
Quantity of refrigeration to cool the air	12 200 kW
Quantity of refrigeration to cool the mined rock	6 280 kW

Determine:

4.1.1 The quantity of chilled service water (3)

4.1.2 The quantity of chilled water to cool the air (3)

4.1.3 The total quantity of chilled water to be provided (3)

4.1.4 The capacity of the refrigeration plant (3)

4.2 The data below was taken from a pressure switch mounted on a feeder breaker in a hazardous location underground in a coal mine.

CERTEX
Ex ib I T3
IEC 60079-11

4.2.1 Explain the meaning of the above data. **(6)**

4.2.2 Motivate whether or not the pressure switch is suitable for use on the feeder breaker. **(2)**

Question 5

A 525 V, 3-phase, 45 kW, 1440 r/min motor is controlled with a star-delta starter. The power factor and efficiency are 0.85 and 0.92 respectively.

5.1 If the THREE windings are marked U1-U2, V1-V2, W1-W2, respectively, sketch the power and control circuits of the star-delta starter showing how the following components are connected:

Main isolator
Line contactor
Motor windings
Star contactor
Delta contactor (10)

5.2 When the motor is started in delta with a direct on line starter, the motor draws 6 times full load current and produces 2.2 times full load torque. What are the equivalent values when started with the star-delta starter? (5)

5.3 When the motor runs at full load in delta, calculate the phase and line currents. (5)

Question 6

6.1 State FOUR advantages of centrifugal air compressors. (4)

6.2 A new radial-flow centrifugal compressor is rated at 1 kg/s if the inlet pressure is 100 kPa and the temperature 15 ^{0}C. The delivery pressure is 238 kPa at 125 ^{0}C. Calculate the isentropic efficiency of the compressor and the power required to drive the compressor.

C p = 1,005 KJ/kg K and γ = 1,4
Isentropic efficiency = $\Delta Ts/\Delta T$ (6)

6.3 Steam for an autoclave is taken from the main at a pressure of 2 MPa and reduced to a pressure of 200 kPa. Determine the condition of the steam after the reducing valve if the steam in the main is 140 ^{0}C overheated. (10)

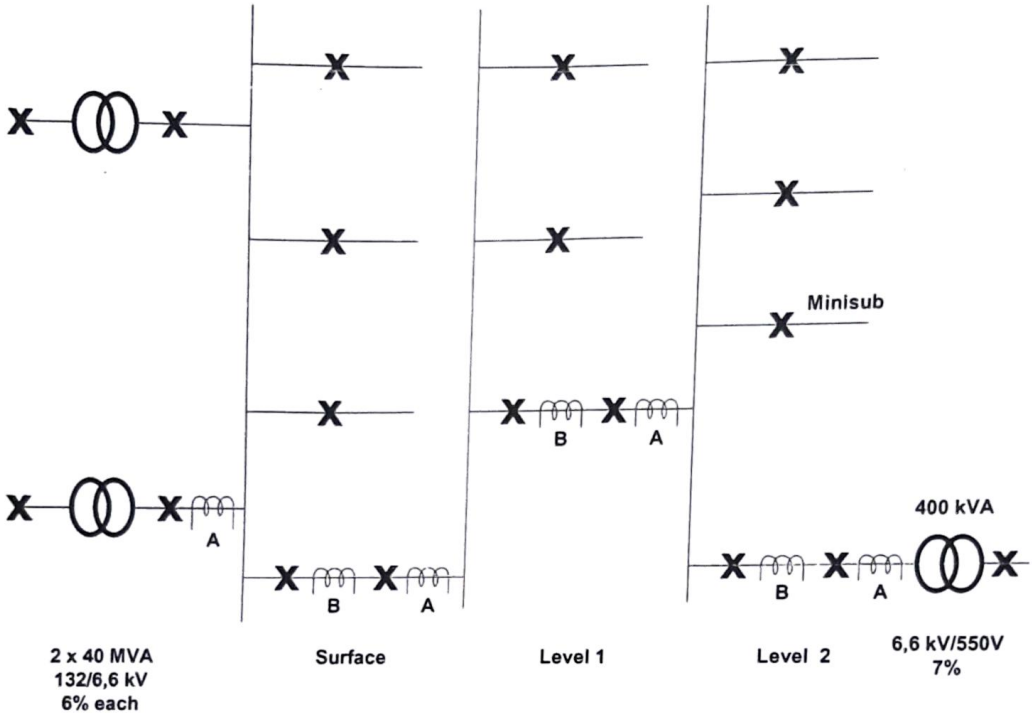
The specific heat of superheated steam is 2,09.

From steam tables:

ρ kPa	t_s ^{0}C	h_f kJ/kg	h_{fg} kJ/kg	h_g kJ/kg
200	120,2	505	2 202	2 707
2 000	212,4	908	1 889	2 797

Newly developed workings of a mine are to be equipped with electric power from the surface substation at the shaft head as shown in the diagram. The surface substation is equipped with two 40 MVA transformers and the high voltage side could be regarded as an infinite bus. The bus coupler between the transformers usually remains open.

The working of the mine consist of two levels, 150 m and 300 m below surface and an incline shaft of 12° used by rubber-tyred vehicles. The mine plans a multiple-shaft system.



Data available:

Horizontal distances of substations:

Surface substation to shaft head	60 m
Level 1 substation to shaft station	40 m
Level 2 substation to shaft station	50 m
Minisub to level 2 substation	200 m

Available current transformers at 10 VA:
25/1; 50/1; 100/1; 150/1; 200/1; 250/1; 300/1; 350/1; 400/1

Calculated loads at the incoming breakers of various sections:

	Average current	Load factor
Surface breaker A	800 A	0,90
Level 1 breaker A	280 A	0,85
Level 2 breaker A	90 A	0,80
Minisub	24 A	0,75

XLPE cable data:

Area (mm^2)	Full load current (A)	% R per km	% X per km
16	120	134	12,9
25	160	85,2	12
35	195	61,2	11,2
50	240	45,2	10,6
70	300	31,4	10,1
95	360	22,6	9,6

The %R and %X are based on 40 MVA and per km.

Current tappings available in the inverse definite minimum time relay are:
50%, 70%, 100%, 125%, 150%, 175%, and 200%.

Time/current relationship of the IDMT relay:
Operating time = $1{,}14(I^{0{,}12} - 1)$ where I = the current through the relay.

Fault values and tripping times of the high tension incoming breaker to surface substations are as follows: 250 MVA 21.8kA 2.5s

(a) Calculate:

i. The length and sizes of the cables required from surface to the minisub

ii. The three-phase symmetrical fault currents for:

- The level 2 feeder at the level 1 substation
- The minisub feeder at the level 2 substation
- The section feeder at the minisub (12)

(b) Select current transformers and plug settings and calculate the relay fault currents and tripping times for the protection relays of the breakers in the previous section.

Explain and show with calculations how the tripping times could be improved for successful discrimination. (8)

Total = 100

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