



Regional  
NSW

**CANDIDATE NUMBER:** \_\_\_\_\_ **(write in from your letter)**

**EXAMINATION:** ELECTRICAL ENGINEER

**EXAM PAPER:** CEE3 – Legislation, Australian Standards and electrical engineering applicable to open-cut mining

**DATE:** Wednesday 13th September 2023 – 12:50pm – 4:00pm

**DURATION:** 3 hours (excluding 10 minutes reading time)

**EXAMINATION FOR CERTIFICATE OF COMPETENCE TO BE AN ELECTRICAL ENGINEER OF COAL MINES OTHER THAN UNDERGROUND COAL MINES**

Issued under the *Work Health and Safety (Mines and Petroleum Sites) Regulation 2022*

**INSTRUCTIONS TO CANDIDATES:**

Unless otherwise stated all references to Act, Regulations and standards are to the *Work Health and Safety Act 2011*

*Work Health and Safety Regulation 2017*

*Work Health and Safety (Mines and Petroleum Sites) Act 2013*

*Work Health and Safety (Mines and Petroleum Sites) Regulation 2022*

*Australian/New Zealand Standards (the standards)*

Candidates shall be seated in the exam room no later than 1:00pm for exam instructions. 10 minutes reading time is allowed prior to the start of the examination. Candidates can use a **highlighter only** to mark points of importance during the reading time, but may not begin answering the questions. You must NOT use any other writing item during the reading time such as a pen.

After reading time is over place your identification number only, **NOT** your name, on the cover of this paper at the commencement of the exam. Electronic aids may not be used, apart from a non-programmable calculator.

It is expected that candidates will present their answers in an engineering manner, making full use of diagrams, tables, and schematics as appropriate, and showing full workings in calculations. **Poor legibility in diagrams and handwriting** may affect the candidate being deemed competent.

Provide answers in point form wherever appropriate. If you are unable to fit your answers in the available space use the two (2) blank pages included at the end of the paper. Ensure the question you are answering is clearly marked.

**All twelve (12) questions are to be attempted.** All questions are of equal value.

Candidates will be marked, and determined as competent, or not yet competent. If a question is identified as **ESSENTIAL**, then the candidate must get the set number of marks to pass the question. The candidate will be required to achieve at least **60%** and **pass** the **ESSENTIAL** questions to pass this paper.

This examination is a **closed book** examination and no reference material may be used during the exam. Reference material will be provided in the exam paper as applicable.

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## EXAMINATION BOOKLET

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Question Number	Essential	Candidate Score	Total Marks	Assessed by <i>Name</i>	Comments to justify, as necessary
1	A				
	B(i)				
	B(ii)				
	B(iii)				
	B(iv)				
	C(i)				
	C(ii)				
	C(iii)				
	D(i)				
	D(ii)				
	subtotal			<b>/ 10</b>	
2	A				
	B				
	C				
	D				
	E				

Question Number		Essential	Candidate Score	Total Marks	Assessed by <i>Name</i>	Comments to justify, as necessary
	F					
	<b>subtotal</b>			<b>/ 10</b>		
<b>3</b>	<b>subtotal</b>			<b>/ 10</b>		
4	A					
	B					
	C					
	D					
	<b>subtotal</b>	<b>Essential</b>			<b>/ 10</b>	
5	A					
	B					
	C					
	<b>subtotal</b>			<b>/ 10</b>		
6	A					
	B					
	<b>subtotal</b>			<b>/ 10</b>		
7	A	<b>Essential</b>				
	B(i)	<b>Essential</b>				
	B(ii)a	<b>Essential</b>				
	B(ii)b	<b>Essential</b>				
	B(iii)	<b>Essential</b>				

Question Number		Essential	Candidate Score	Total Marks	Assessed by <i>Name</i>	Comments to justify, as necessary
	C(i)	Essential				
	C(ii)	Essential				
	C(iii)	Essential				
	C(iv)	Essential				
	subtotal	Essential		/ 10		
8	A					
	B					
	C					
	subtotal			/ 10		
9	A	Essential				
	B	Essential				
	C	Essential				
	D	Essential				
	E	Essential				
	subtotal	Essential			/ 10	
10	A					
	B					
	C					
	subtotal				/ 10	
11	A					

Question Number		Essential	Candidate Score	Total Marks	Assessed by <i>Name</i>	Comments to justify, as necessary
	B					
	C					
	<b>subtotal</b>			<b>/ 10</b>		
12	A					
	B					
	C					
	D					
	E					
	<b>subtotal</b>			<b>/ 10</b>		
<b>PAPER</b>	<b>Verdict</b>		<b>TOTAL</b>	<b>/ 120</b>		<i>Marks checked by:</i>

### Question 1 – ASNZS 2081

A. AS/NZ 2081:2011- Electrical Protection devices for Mines and Quarries. What are the key objectives of this standard? 2 marks

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B. The standard provides definitions of key protection terms. According to the standard, what is the definition of

i. Back-up protection 1 mark

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ii. Earth fault current 1 mark

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iii. Earth leakage current 1 mark

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iv. Operating time

1 mark

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C. The time current curve TCC below represents the protection coordination between two CB's Q1 and Q2

i. Nominate the expected operating times for Q1 for a load of 75 Amps. 0.5 mark

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ii. Nominate the expected operating times for Q2 for a load of 250. 0.5 mark

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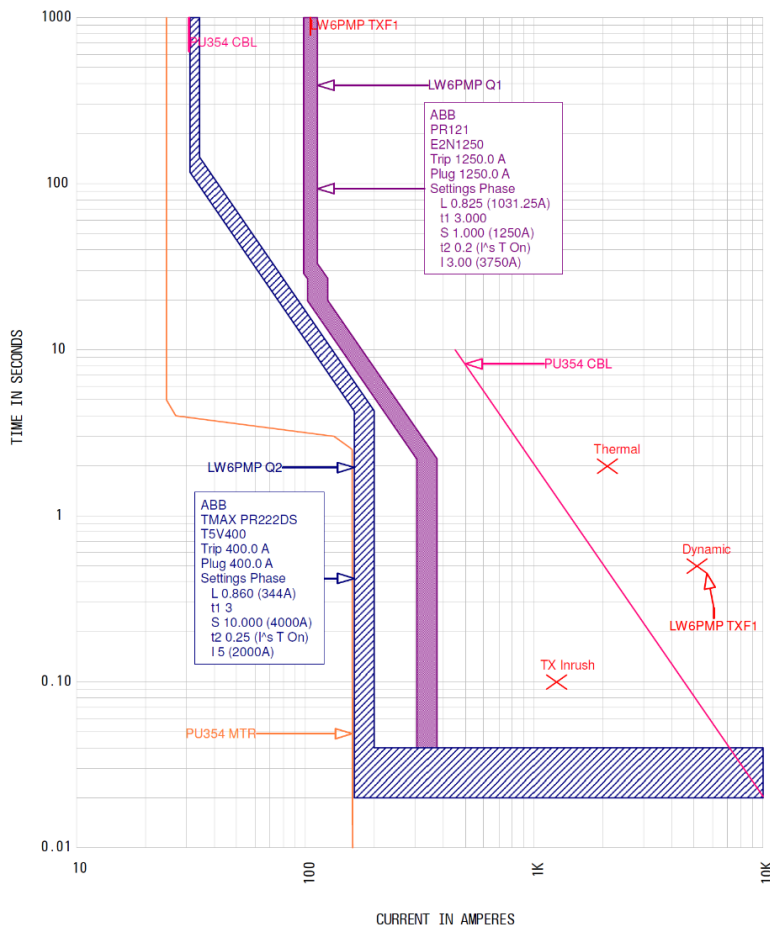
iii. What does the pink line (PU345 CBL) represent in the TCC below? 1 mark

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D. Over time the connected loads have changed from the original design, Q1 and Q2 circuit breakers are now simultaneously seeing a current flow of 140A.

i. What does the protection system rely on at this load for protection grading? 1 mark

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ii. What would you do to address the new load case? 1 mark

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## Question 2 – Power transformer and oil sampling

A. Regarding transformer oil sampling, what is a SOT?

1 mark

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B. Regarding transformer oil sampling, what is a DGA?

1 mark

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C. Hydrogen, Oxygen, Methane, Acetylene are examples of gases typically identified in a DGA, list 2 other common gases that may be identified.

1 mark

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D. Briefly describe what Furan Analysis on transformer oil is used to indicate:

2 marks

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E. Briefly describe how the typical Buchholz transformer protection device operates:

2 marks

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F. List eight (8) items that you require to be listed on a power transformer nameplate.

3 marks

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### Question 3 – Multiple Choice Question

Circle the correct answer for the following questions and fill the designated table for question 10 (1 mark for each question)

1. AS2081 specifies performance requirements for protection devices intended for use with electrical supply networks utilising:
  - a) IT Networks
  - b) MEN Networks
  - c) IT and MEN Networks
  - d) TT networks
  
2. Which protection device is not covered by AS2081?
  - a) Instantaneous overcurrent
  - b) Earth fault current limiting devices.
  - c) Earth continuity protection devices.
  - d) Earth fault protection devices.
  - e) Earth fault lockout protection devices.
  - f) NER integrity protection devices.

3) Resistive Earth Fault Current Limiting devices shall comply with the following temperature ratings “For all other installations, the maximum temperature rise shall not exceed \_\_\_?\_\_\_ after the application of rated phase-to-earth voltage for rated time.”

- a) 150 C
- b) 200 C
- c) 300 C
- d) 350 C

4) If the resistance between a pilot core and the earth falls below what value will the device initiate the tripping or prevent the closure of the circuit interrupting device?

- a) 45Ω
- b) 100Ω
- c) 500Ω
- d) 1000Ω

5) What is the maximum delay between the detection of an earth continuity fault (open circuit or short circuit) and the disconnection of power from the circuit?

- a) 20mS
- b) 50mS
- c) 100mS
- d) 500mS

6) The protection device shall be designed to ensure that the thermal ratings of its components and assemblies are not exceeded during an earth fault current equal to \_\_\_?\_\_\_ times the maximum earth fault tripping set point of the device maintained for a duration of at least 2.5 s.

- a) two
- b) five
- c) ten
- d) twenty

7) Earth fault lockout protection devices shall be designed to prevent energisation of the circuit interrupting device when the insulation resistance of any active conductor to earth is below:

- a) 10 k $\Omega$
- b) 100 k $\Omega$
- c) 1 M $\Omega$
- d) 2 M $\Omega$

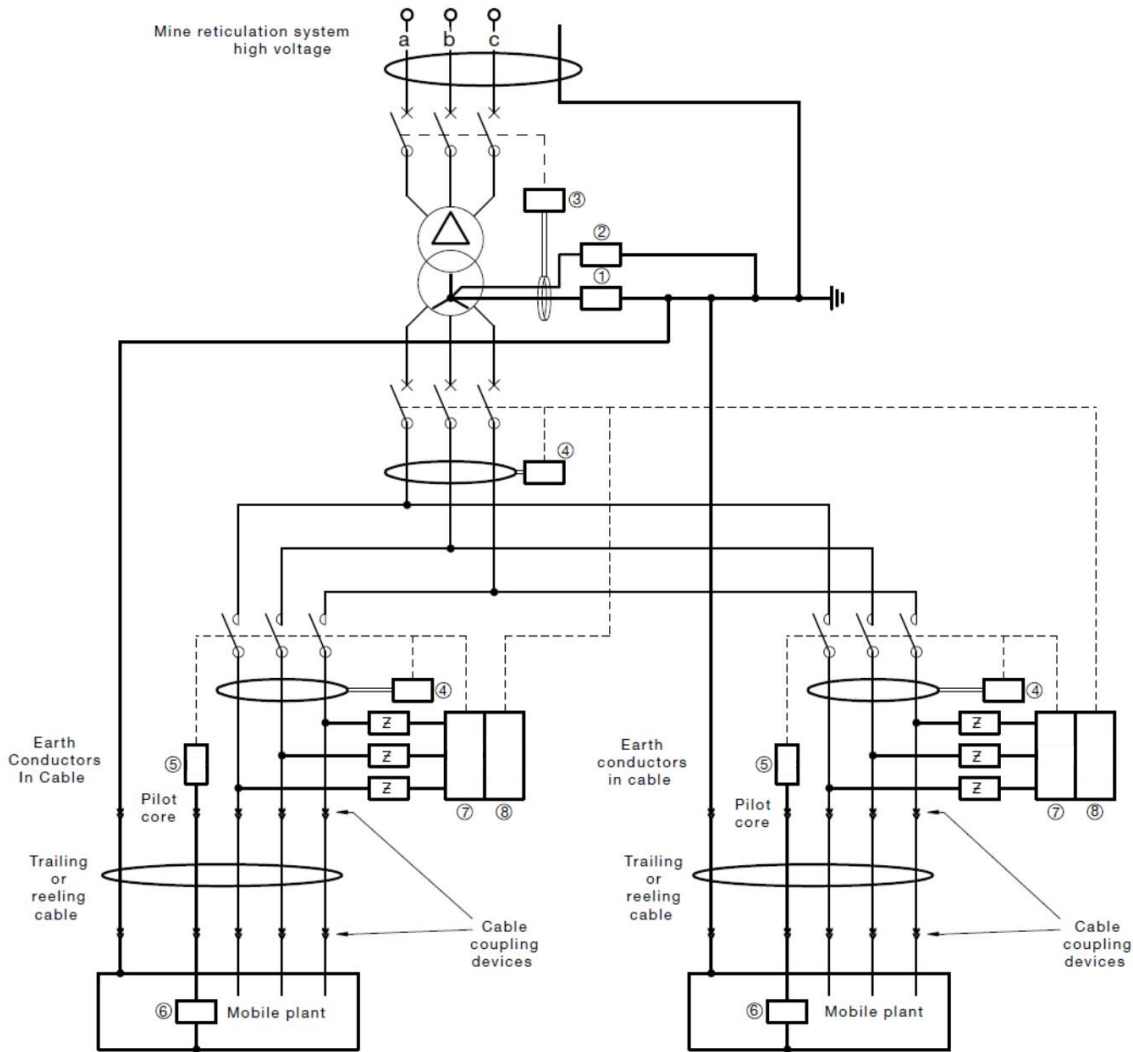
8) The protection device shall be designed to initiate a trip of an \_\_\_\_\_ circuit interrupting device if a voltage exceeding 25 V a.c. or 60 V d.c. is detected on any phase on the load side of the circuit interrupting device when it is expected to be in the \_\_\_\_\_ position.

- a) upstream, closed
- b) upstream, open
- c) downstream, closed
- d) downstream, open

9) A \_\_\_\_\_?\_\_\_\_\_ in the resistance of the NER will result in an increase in the earth fault current. This will result in a corresponding \_\_\_\_\_?\_\_\_\_\_ in prospective touch or step potentials under fault conditions.

- a) decrease, increase
- b) decrease, decrease
- c) increase, increase

10) Match the numbers from (1) to (8) with the labels



	Letter that corresponds to the number above		
1)		a)	Frozen Contact Protection
2)		b)	Earth Continuity Protection
3)		c)	Earth Fault Lockout protection
4)		d)	Series neutral earth leakage protection
5)		e)	Core Balance earth leakage protection
6)		f)	Neutral connected Impedance (NER)
7)		g)	Pilot (Earth Continuity) termination unit
8)		h)	NER integrity protection

## Question 4 – Work Health and Safety (Mines and Petroleum Sites) Regulation 2022

### Principal Hazards

There is a risk of fatalities and serious injury in all parts of the mining sector that requires everyone to be vigilant and proactive in meeting their responsibilities. Learning from experience, preventing devastating reoccurrences, and improving the health and safety of all people working in the industry is a profound way of acknowledging and recognising all those that have been affected by mining safety incidents throughout history.

A. What is the meaning of a “Principal Hazard”?

2 marks

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B. List seven (7) of the Principal Hazards (mining).

3 marks

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C. Name two (2) PHMPs that would require input from the site Electrical Engineering Manager during development to ensure a comprehensive evaluation of risk. 2 marks

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D. Explain why the electrical engineering manager is required during development to ensure a comprehensive evaluation of risk. 3 marks

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**Question 5 – WHS Act – Consultation**

Work Health and Safety Act Part 5 Division 2 Consultation with workers places duties on the Operator (PCBU) of a coal mine to engage in consultation, and includes the following sections:

- 46. Duty to consult with other duty holders
- 47. Duty to consult with workers
- 48. Nature of consultation
- 49. When consultation is required

A. What requirements are placed on the PCBU to consult with workers? 4 marks

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B. What requirements are placed on the nature of consultation?

4 marks

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C. When is consultation required?

2 marks

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## Question 6 – WHS Act – Duty of care, Duty of workers

A. Fill in the missing words for Section 19 Primary duty of care

6 marks

(1) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of—

(a) workers engaged, or caused to be engaged by the person, and

(b) workers whose activities in carrying out work are influenced or directed by the person, while the workers are at work in the business or undertaking.

(2) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking.

(3) Without limiting subsections (1) and (2), a person conducting a business or undertaking must ensure, so far as is reasonably practicable—

(a) the provision and maintenance of \_\_\_\_\_ without risks to health and safety, and

(b) the provision and maintenance of safe \_\_\_\_\_, and

(c) the provision and maintenance of safe \_\_\_\_\_, and

(d) the safe use, handling, and storage of \_\_\_\_\_, and

(e) the provision of adequate \_\_\_\_\_ for the welfare at work of workers in carrying out work for the business or undertaking, including ensuring access to those \_\_\_\_\_, and

(f) the provision of any \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_ or \_\_\_\_\_ that is necessary to protect all persons from risks to their health and safety arising from work carried out as part of the conduct of the business or undertaking, and

(g) that the health of workers and the conditions at the workplace are monitored for the purpose of preventing \_\_\_\_\_ or \_\_\_\_\_ of workers arising from the conduct of the business or undertaking.

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B. Fill in the missing words for Section 28 Duties of workers

4 marks

While at work, a worker must—

(a) take \_\_\_\_\_ for his or her own health and safety, and

(b) take \_\_\_\_\_ that his or her  
\_\_\_\_\_ or \_\_\_\_\_ do not adversely affect the  
health and safety of \_\_\_\_\_, and

(c) comply, so far as the worker is reasonably able, with any  
\_\_\_\_\_ that is given by the  
person conducting the business or undertaking to allow the person to comply with this Act,  
and

(d) co-operate with any \_\_\_\_\_ or \_\_\_\_\_ of the person  
conducting the business or undertaking relating to health or safety at the workplace that has  
been notified to workers.

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## Question 7 – Earthing and lightning

**Essential**

Candidates must get 6 out of 10 marks to pass this question

You are the Electrical Engineer for an open-cut coal mine, which is located in an area that is known to have high lightning activity during storm seasons.

Your site is required to establish a new surface infrastructure area which incorporates the following infrastructure:

- Administration Buildings, Bathhouse, Workshop and Carpark.
- 66/11kV Substation
  - 66kV Supply: Overhead Power Lines
  - 11kV Supply: XLPE Cables
  - Transformers: 2 x 20/25MVA KNAF DYN11 Transformers
  - Earthing: IT (10A NER per transformer)
- Additional supply infrastructure
  - 11KV /415Kv- 1.5MVA transformer for administration, bathhouse supply
  - 11KV /415Kv- 2MVA transformer for Workshop
  - Area lighting for Carpark and delivery area

### A. General

List Australian Standards that are relevant to this installation:

1 mark

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B. Earthing

- i. What are the two (2) key requirements for an effective earthing system? (*WHS (Mines & Petroleum Sites) Regulation 2022 – Sec. 34*) 1 Mark

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- ii. The project team has lead time issues on your preferred cable supplier for the 11kV supply cables and has found an alternative brand of cable with a shorter lead time. You review the cable and find that it is XLPE 11/6.35kV SWA.  
a) What would be your concerns about using the cable and why? 1 mark

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- b) What considerations would you need to include in your testing standards regarding insulation testing of XLPE cables? 1 mark

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- iii. Assume that the two transformers can be connected in parallel on the secondary side using a bus-tie circuit breaker. In the event that this bus-tie is closed, what is the impact to your earth fault current limitation? 1 mark

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C. Lightning

i. List three (3) risks you are concerned about associated with lightning: 2 marks

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ii. What steps would you undertake over the lifecycle of this project in order to satisfy your concerns and your obligations in regard to the risks associated with lightning?  
1 mark

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iii. What controls could you implement in your earthing system to mitigate the risks (for both personnel and equipment) associated with lightning? 1 mark

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iv. What is the maximum best practice earth impedance of a lightning down-conductor as required under AS/NZS 1768? 1 mark

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## Question 8 – Power Calculation

The mine you are working at has had an electrical fault on one of the main conveyor motors. This conveyor is a dual-drive configuration with 2 X 500kW 415v motors. The spare motor onsite was found in an unserviceable condition and will require a week to be turned around at the motor workshop before it can be reinstalled.

One formula for calculating the power needed for the conveyor is:

$$\text{Power to move the load horizontally (kW)} = 2.72 \times L \times F \times (C+46) / 1000$$

$$\text{Power to move empty belt (kW)} = 14.6 \times F \times G \times (C+46) \times S / 1000$$

$$\text{Power to elevate or lower the load (kW)} = 2.72 \times L \times H / 1000$$

where:

Maximum loading (L)	4,500 tph
Conveyor length (centre distance) (C)	1000 m
Belt width (W)	1,400 mm
Idler friction factor (F)	0.02
Inertial Factor (G)	68
Nett change in elevation (H)	+ 30 m
Belt Speed (S)	5 m/sec

- A. Calculate the power required to operate the conveyor at full load 3 marks

B. With the remaining 500kw motor on the conveyor, the production department has recommended that the reduced coal transfer 3000tph coal that can be transported until the spare motor is returned to site, is this possible? 4 marks

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C. Draw a vector diagram showing apparent power, true power and reactive power at full load for the single conveyor motor. 3 marks

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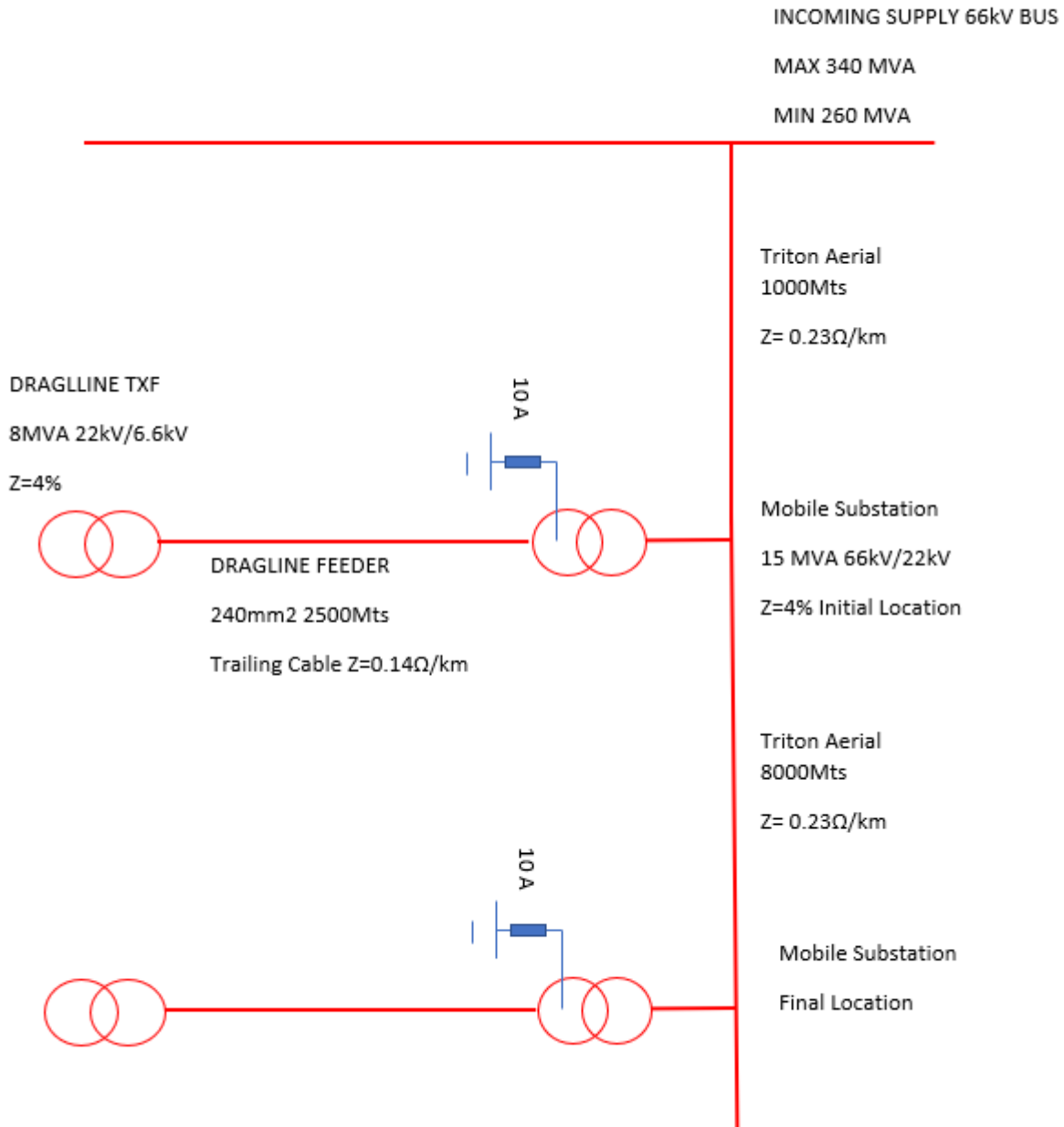
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## Question 9 – Protection

**Essential**

Candidates must get 6 out of 10 marks to pass this question



You are the Statutory Electrical Engineer at a Surface Mining Operation that wishes to expand its operation to a new area.

There is an aerial service that runs from the switchboard to the Mobile Substation. The cable is Triton and is 1000 metres long.

The expansion would require an additional 8000 metres of Triton.

The Dragline on Board Transformer is 8MVA 22kV / 6.6kV 4% Z with an inrush of 10 x FLC. Impedance of Triton can be assumed as 0.23 Ω/km.

The Dragline is supplied by a trailing cable 240mm<sup>2</sup> 2500 metres long.

The impedance of the trailing cable can be assumed to be 0.14Ω/km

A. What is the maximum prospective earth fault on the 22kV system at the Dragline?

1 mark

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B. Calculate the maximum fault level at the dragline transformer.

3 marks

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C. Calculate the minimum fault level at the dragline transformer.

2 marks

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D. What rating does the High Tension end of the transformer need to be designed to?

1 mark

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E. Nominate the protection settings for dragline feeder at the mobile substation CB ANSI Code 51P..... ANSI Code 50P.....

Justify your answer.

3 marks

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## Question 10 – Switchboards

You are required to install a number of low-voltage switchboards for a new project that is supplied by a TN earthing system.

- A. Detail the Australian Standards you would use within the specification along with a short summary of their relevance to switchboard specification. 4 marks

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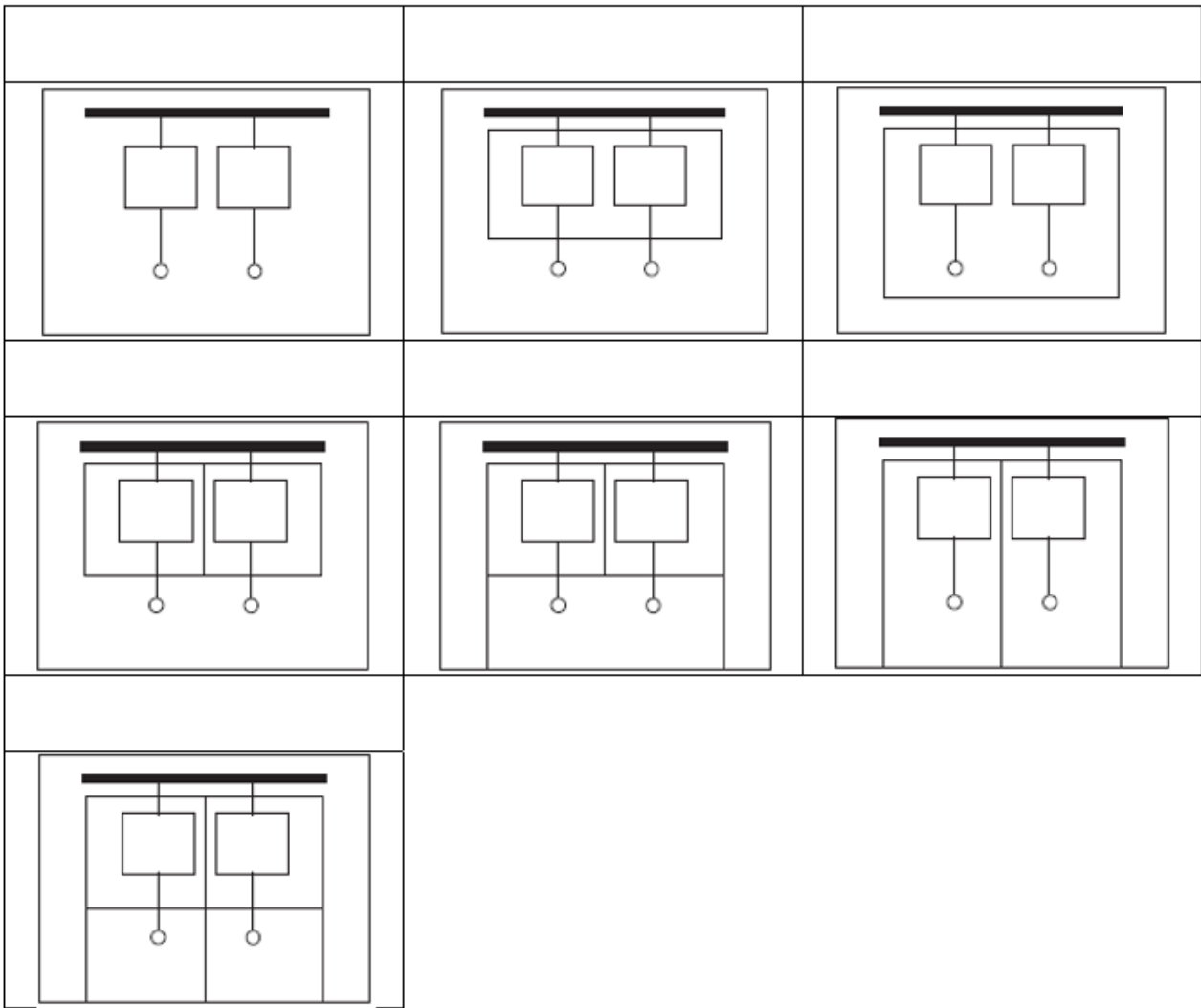
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- B. The AS/NZS 61439 series describes forms of internal separation for switchboards. Label the form of separation as described in the AS/NZS 61439 series against each of the below diagrams. 3.5 marks



/ 3.5

C. Can you describe three differences between a Form 1 and Form 4b board? 2.5 marks

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/ 2.5

## Question 11 – Arc Flash

You have just attained your Practising Certificate and have accepted an offer as Electrical Engineer at a Surface Coal Mine in another district.

On your first field inspection at your new mine, you visit a water storage area.

The dam has a pumping system consisting of an underground type substation obtained from an auction and a submersible pump.

The substation is supplying a separate Pump Starter Enclosure, a local isolator and a 5kW submersible pump.

### **Substation.**

*2.5MVA 11kV / 1/05kV Z= 3.8% IP55 rated.*

### **Pump Starter Enclosure.**

*Supplied by 35mm<sup>2</sup> Trailing type cable 15mts.*

*Enclosure has two compartments, an isolator compartment housing a circuit breaker and a second compartment housing the contactor, overload and control circuits.*

*Each compartment is fitted with a single door, Form 1 and hinged on one side. There is a Tee style handle on the other.*

*The Circuit Breaker is a small frame but does not have a visible label.*

- A. What steps would you need to perform to confirm that the pump starter equipment is suitable for the power supply? Explain your answer. 4 marks

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You identify that the power system exceeds the breaking capacity of the pump starter circuit breaker.

B. What steps can you take to enable the equipment to operate within its rating? 3 marks

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You have a concern over the effects of an internal arcing event in the Pump Starter enclosure.

C. In terms of an arcing event inside of the enclosure, what risks exist for operators of the Pump starter panel and what steps would you take to address these risks? 3 marks

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**Question 12 – Introduction to site**

You have taken up the role of statutory electrical engineer at an old coal mining operation and it has been brought to your attention that there is no process for introducing equipment to your site.

You have been provided with an estimation that there are 50 items that have gone through no process of introduction to site before being put into operation. The equipment ranges from heavy earth-moving equipment to battery-powered welders and many things in between.

A. Explain the steps you would take to address the current situation with the legacy plant.

3 marks

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B. Explain what process you would implement to rectify the identified failure. 2 marks

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C. The WHS(M&Ps) Regulation 2022 Schedule 2 part 3 – Electrical engineering control plan lists 5 risks that the control plan must set out the control measures for. Name four (4) that are relevant for the introduction of plant. 2 marks

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D. From an electrical perspective, list five (5) items on the mobile plant you would focus on in the development of the introduction to plant inspection plan. 2 marks

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E. What standard will provide guidance on the electrical installations on mobile plant? 1 mark

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**END OF QUESTIONS**

**BLANK PAPER TO WRITE ANSWERS THAT YOU COULD FIT INTO THE SPACE  
PROVIDED – INDICATE QUESTION NUMBER AT START OF ANSWER**

**END OF PAPER**