

EXAMINATION PAPER

Electrical engineering manager of underground coal mines certificate of competence

Written examination 24 July 2019

Instructions to candidates

Unless otherwise stated all references to the 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 2014
- Australian Standards.

CEE 1 – Application of electrical engineering to mining

Question 1

You are the electrical engineering manager at an underground coal mine and you have a contract company working with your electrical team completing repairs to a conveyor starter in your workshop.

You have been alerted that one of the tradesmen has received an electric shock while attempting to open the door to the starter enclosure with power on.

At the time of the incident 690-volt power was being supplied to the starter panel, which is also transformed to lower voltages within the starter.

- a) What first aid protocols should be in place to ensure the person receives the appropriate care? (2 marks)
- b) Identify four engineering controls that should have prevented this incident from occurring. (4 marks)
- c) You are initially unaware of the electric shock voltage level the person received in the incident. What steps could you take to identify the source of the electric shock? (4 marks)

Question 2

You have recently been appointed to the position of electrical engineering manager at a coal mine, and you have been informed that the mine is two weeks away from commissioning a new surface substation providing electrical power to critical infrastructure including workshop, fuel farm, compressors and pumps etc.

The network supplier has nominated two fault levels at the point of supply. They have defined these as normal supply and alternate supply. This is due to the two possible configurations of the network distribution to allow emergency supply in case of network faults or maintenance events. The alternate supply has a lower fault level than the normal supply and does not provide a stable incoming supply as it can fluctuate between 0.85 to 1.1 per unit. The alternate supply is only in place for short periods typically 8-10 hours during planned maintenance windows and emergency repairs.

- a) What should be considered in managing two different declared fault levels at the point of connection? (2 marks).
- b) Explain how you would manage the two different declared fault levels. (2 marks)
- c) What concerns would you have with the incoming fluctuating supply voltage? (2 marks)
- d) What engineering controls could you introduce to manage the fluctuating supply voltage? (2 marks)
- e) What documentation would you review to verify the surface substation design addresses the varying fault level and fluctuating supply voltage? (2 marks)

Question 3

You have recently been appointed to the position of electrical engineering manager at a longwall coal mine and you have been informed that the mine is two weeks away from a longwall relocation.

With this longwall relocation, there will be a number of contract electricians employed short term and any number of short term hired mobile machines being deployed underground to cater for this event.

You are responsible for the electrical labour on site and ensuring that all electrical equipment brought to site is fit for purpose and duty.

- a) Nominate the documented system at your site which will manage the requirements for supplementary electricians. (1 mark)
- b) Nominate the documented system at your site which will manage the requirements for the additional mobile plant. (1 mark)
- c) For each of the documented systems you have nominated, identify four key areas that should be addressed. (8 marks)

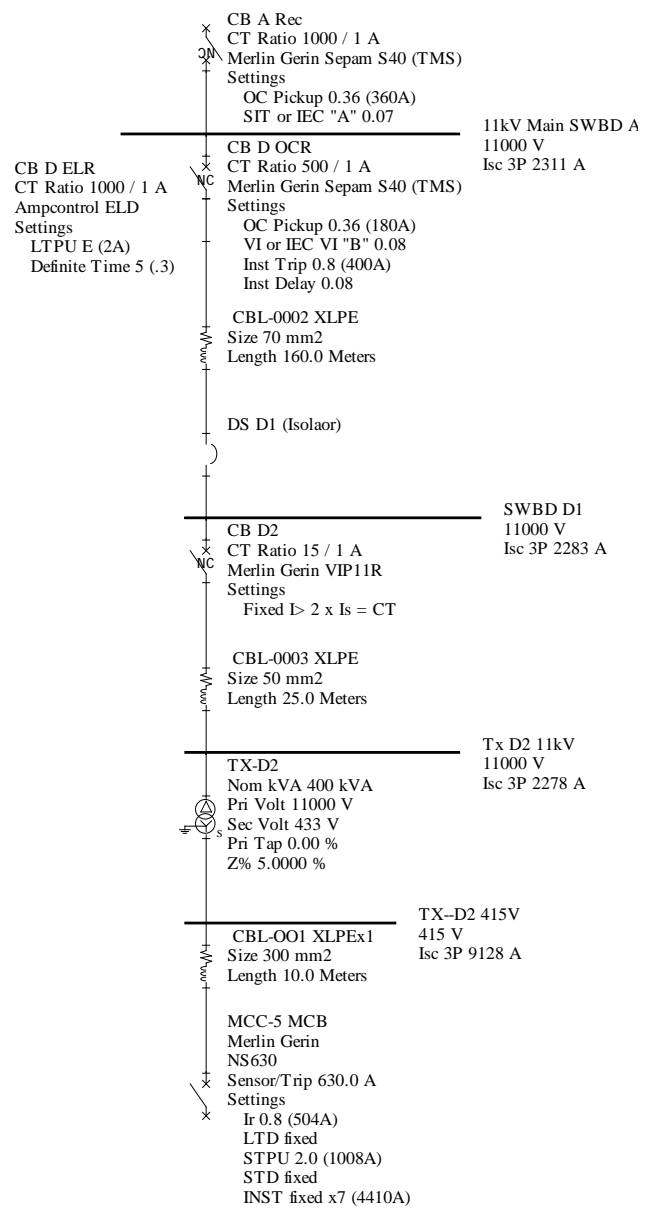
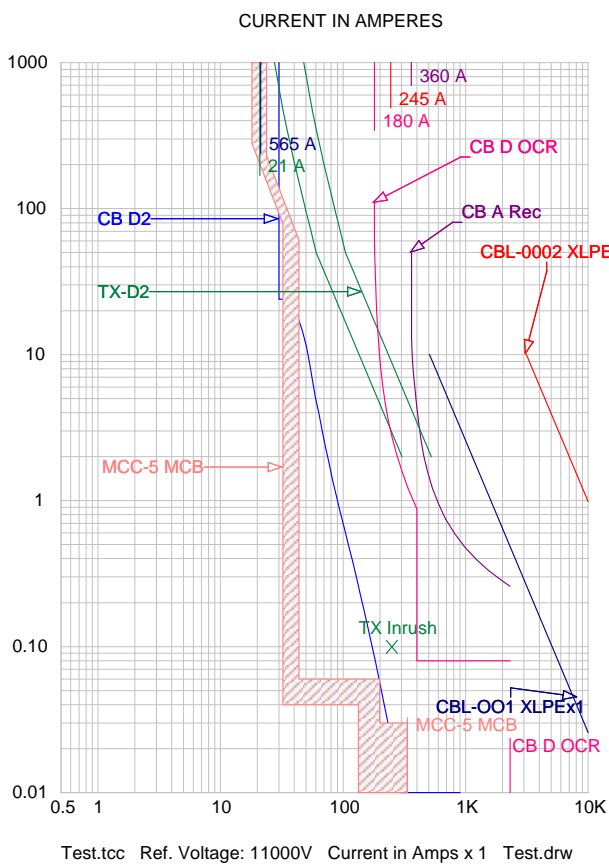
Question 4

AS/NZ 2081:2011- Electrical Protection devices for Mines and Quarries is a recognised standard in coal mines.

- a) What are the key objectives of this standard? (3 marks)
- b) How does the standard define the following?
 - i. Back-up protection (1 mark)
 - ii. Earth fault current (1 mark)
 - iii. Earth leakage current (1 mark)
 - iv. Operating time (1 mark)

c) On the time current curve below, nominate the operating times for the following protection devices to operate at a fault current of 1000 amps at 11kV. (3 marks)

- i. CB D2
- ii. CB D OCR
- iii. CB A Rec



Question 5

AS/NZS 3800:2012: Electrical equipment for explosive atmospheres - Repair and overhaul (the standard) provides guidance on the repair, overhaul, reclamation and modification of equipment for use in explosive atmospheres.

The standard refers to “Repair Facilities” and states that the facility involved in the repair, overhaul and/or modification of explosion-protected electrical equipment must have their capabilities for compliance with this standard independently verified.

- a) Name one of the certification bodies that can complete this verification. (1 mark)
- b) What documentation is required to overhaul flameproof Exd Group I equipment? (2 marks)
- c) The standard specifies that personnel directly concerned with repairs and overhaul shall be competent or supervised by a responsible person. How does the standard define a responsible person? (2 marks)
- d) What are the requirements nominated in the standard for the sourcing of “spare parts”? (2 marks)
- e) If the repair and overhaul is completed in accordance with the certification documents, what symbol must be included in the overhaul label? (1 marks)
- f) What are the minimum requirements for the repair facility that will overhaul your explosion protected electrical equipment? (2 marks)

Question 6

Your mine is supplied from the energy provider at 66kv. The energy provider has advised you they are changing your electricity supply agreement to include penalties for poor power factor. The mine is running at a power factor of 0.65 at a recorded maximum demand of 20 MVA.

- a) Nominate the size of an 11kV connected capacitor bank to correct the power factor to 0.98 lag. Note: Power factor correction units are available in 500kVAr increments. (4 marks)
- b) From your calculation, how many capacitor banks would you specify and why? (2 marks)
- c) Calculate the resultant power factor if the capacitor bank you selected remained connected when the demand dropped to 10 MVA at 0.65 lag power factor and explain any issues you see with this. (2 marks)
- d) List the relative merits of high voltage verses low voltage connected power factor correction units. (2 marks)

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CEE2 – Legislation and standards applicable to underground coal mines

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- *Work Health and Safety (Mines and Petroleum Sites) Act 2013*
- Work Health and Safety (Mines and Petroleum Sites) Regulation 2014
- Australian Standards.

Question 1

As the electrical engineering manager, you have identified a requirement to improve welding practices on site. You have engaged a training company to develop a welding training package for your site.

- a) Nominate four key areas to be addressed within the training package. (4 marks)
- b) Provide examples of the welding environment categories as defined in *AS1674.2 Safety in welding and allied processes*. (3 marks)
Category A
Category B
Category C
- c) What are the control measures required in a Category C environment by *AS1674.2 Safety in welding and allied processes*? (3 marks)

Question 2

Work Health and Safety (Mines and Petroleum Sites) Regulation 2014, Schedule 2 Principal control plans—matters to be addressed. States the following. Fill in the missing words. (1/2 mark each. Note each _____ Number _____ is one word).

- (1) The operator of a mine or petroleum site must, in preparing an electrical engineering control plan, take the following into account in determining the means by which the operator will manage the risks to health and safety from electricity at the mine or petroleum site:
- the overall _____ 1 _____ cycle of the electrical aspects of plant and electrical installations at the mine or petroleum site,
 - the reliability of electrical _____ 2 _____ used at the mine or petroleum site to protect persons from electrical or other hazards,
 - the electrical engineering and electrical work practices to be employed at the mine or petroleum site,
 - the _____ 3 _____ required by workers to safely work on electrical plant or electrical installations at the mine or petroleum site.
- (2) An electrical engineering control plan must set out the control measures for the following risks to health and safety associated with electricity at the mine or petroleum site taking into account the matters set out in subclause (3):
- injury to persons caused by direct or indirect contact with electricity,
 - injury to persons caused by working on electrical plant or electrical installations,
 - the unintended initiation of gas or dust explosions,
 - the unintended operation of plant,
 - the occurrence of _____ 4 _____ _____ 5 _____ .
- (3) The following matters must be taken into account when developing a control measure referred to in subclause (2):
- the location of the electrical plant and electrical installations at the mine or petroleum site,
 - the rating and design of plant for the _____ 6 _____
_____ 7 _____ _____ 8 _____ _____ 9 _____
electrical load, operating frequency, operating voltages and arc fault control,
 - the design and operation of any electrical plant that contains flammable liquid,
 - the carrying out of the selection, installation and use of electrical cables and electrical cable accessories at the mine or petroleum site,

- (e) the control of _____ 10 _____ 11 _____ at the mine or petroleum site, including preventing the ignition of flammable gas,
- (f) the impact of lightning on the mine or petroleum site (especially on an underground mine) including the effect on electrical systems,
- (g) the need for reliable circuit interruption for all points in the electrical distribution system at the mine or petroleum site when faults occur taking into account the operating time and tripping current of circuit protection devices,
- (h) the type of _____ 12 _____ 13 _____ used, including levels of earth fault limitation,
- (i) the potential for persons to contact electricity indirectly,
- (j) the prospective touch, step and _____ 14 _____ voltage,
- (k) variations in operating conditions,
- (l) preventing persons inadvertently contacting energised parts of electrical plant and electrical installations,
- (m) the consultation, co-operation and co-ordination of activities between persons conducting businesses or undertakings at the mine or petroleum site (including the operator) and persons conducting businesses or undertakings installing, maintaining or carrying out work on an electricity supply authority's infrastructure,
- (n) the procedures for the following:
- (i) the use of electrical _____ 15 _____ 16 _____ ,
 - (ii) the use of electrical test instruments,
 - (iii) work near overhead power lines and cables,
 - (iv) the treatment of electric shocks and electric burns,
 - (v) accessing and working on high voltage electrical installations,
- (o) signage and notices in relation to the risks arising in relation to particular electrical plant and electrical installations such as electrical switchgear,
- (p) the security and maintenance of the electrical control system software and control circuits at the mine or petroleum site,
- (q) the use of _____ 17 _____ and fibre optic equipment at the mine or petroleum site,
- (r) the construction, installation and maintenance of battery-powered vehicles and battery charging stations at the mine or petroleum site,

- (s) the supply of electricity in hazardous atmospheres and, in the case of underground coal mines, in hazardous zones,
- (t) the use of _____ 18 _____ 19 _____ in hazardous atmospheres and, in the case of underground coal mines, in hazardous zones,
- (u) safe work systems for persons dealing with electrical plant and electrical installations including the isolation, dissipation and control of all electrical energy sources from the electrical plant or electrical installation,
- (v) the use of switchgear and electrical protection devices that can _____ 20 _____ detect an electrical fault in a circuit and disconnect the supply of power to the circuit.

Question 3

With respect to *AS/NZS 60079.11:2011 Explosive atmospheres - Equipment protection by intrinsic safety 'I'*, answer the following questions:

- a) Explain the principle of intrinsic safety. (2 marks)
- b) Intrinsically safe equipment has a level of protection as 'ia' and 'ib'. Explain your understanding of the differences between the two levels of protection. (4 marks)

In a simple intrinsically safe system:

- c) What is the relationship between C_o and C_i ? (1 mark)
- d) What is the allowable cable capacitance (C_c) with respect to C_o and C_i ? (1 mark)
- e) What is "simple apparatus"? (1 mark)
- f) What is "associated apparatus"? (1 mark)

Question 4

Your mine has voltage drop problems on the longwall. The solution that you have chosen is to run a new overhead power line, purchase and install a new surface 10 MVA mobile substation, and supply the longwall via a borehole cable.

- a) With respect to the purchase of the mobile substation only, list the life cycle stages between Design to Decommissioning along with four items that are required to be considered at each stage. (7 marks)
- b) As part of the new mobile substation, you need to select a cable that is suitable for the borehole. Nominate the type of cable you would select and any special requirements. The borehole will be 150 mts deep. (3 marks)

Question 5

Cables conforming to *AS/ NZS 1802:2003 Electric cables—Reeling and trailing—For underground coal mining purposes*, are suitable for use in a hazardous zone where the concentration of methane in the general body of the air is less than 1.25% by volume.

- a) With the use of the area below draw a typical cross-sectional diagram of a “Type 245 Trailing Cable” and label each of the components (conductors, screens, etc). (4 marks)
- b) Describe where the Type 245 cable design may be utilised in an underground coal mine, and why it may be chosen over other cable types. (3 marks)
- c) Explain what is meant by a “Type Test” as per AS1747:2003. (2 marks)
- d) Explain what voltage range this type of cable is designed to operate within, as per AS/ANZ 1802:2003. (1 mark)

Question 6

With respect to *AS2290.3 2018 - Electrical Equipment for coal mines – Introduction, Inspection and Maintenance Part 3: Gas Detecting and Monitoring equipment*:

- a) *Table 3.1 – Schedule of Inspections and Tests*, identifies gas testing equipment types. Identify four gas detecting equipment types. (2 marks)
- b) At what frequency should a handheld gas detector used by a mining official be span tested? (2 marks)

With user servicing of gas detectors:

- c) What is referred to as “User Serviceable Items”? (2 marks)
- d) A remote carbon monoxide gas monitor is used for the early detection of an underground conveyor fire and is connected to the mines control room SCADA system via an isolation barrier, telemetry link and PLC. What commissioning checks should be carried out for this system? (4 marks)

Question 7

Clause 72 of the *Work Health and Safety (Mines and Petroleum site) Regulations 2014* states requirements on the “Control and Monitoring of Methane levels” for an underground coal mine.

- a) Clause 72 (3) states “*The mine operator of an underground coal mine must ensure that methane monitoring plant is provided at the mine that:...*”
There are five requirements, please identify at least four of (a), (b), (c), (d) and (e). (4 marks)

- b) Clause 72 (6) states “*the mine operator of an underground coal mine must ensure that each face machine in use at the mine is equipped with a continuous methane monitor that...*”.
- Please identify what is referred to as a “face machine”, as defined in the *Work Health and Safety (Mines and Petroleum site) Regulations 2014*? (3 marks)
- c) Please state the requirements for the above clause. (3 marks)
- The gas level for an audible or visual alarm “general body”
 - The gas level to cut the supply of power “general body”?
 - The gas level to cut the supply of power “close to the heads of the face machine”?

Question 8

AS2290.1 – *Electrical Equipment for coal mines – Introduction, inspection and maintenance Part 1: For hazardous areas* refers to the effective life cycle management of equipment, and the importance that all appropriate documentation needed to comply with the standard, is in place prior to the introduction and commissioning of equipment in a hazardous area.

- What is the principle document being referred to in this standard? (2 marks)
- There are fifteen (15) separate documents which need to be included in this principle document. Identify at least five (5) of these associated documents. (5 marks)
- List at least three (3) “additional documentation” which can be added. (3 marks)

Question 9

Increased Safety (Ex e) is a form of explosion protection technique commonly used throughout the underground coal industry.

The following questions are related to this form of protection:

- In your own words, what is the definition of “Increased Safety”? (3 marks)
- List at least four (4) techniques used in the design of Exe equipment. (4 marks)
- When an inspection of an Exe CH₄ enclosure on a face machine was carried out, it was identified that the external cable glands entering the enclosure were standard ‘off the shelf’ PVC glands. Are these allowed for use in this type of enclosure? Explain your answer. (3 marks)

Question 10

With respect to *AS/NZS 60079.1:2015: Explosive atmospheres - Equipment protection by flameproof enclosures ‘d’*. Answer the following questions.

- Explain the principle a Flameproof enclosure. (2 marks)
- Explain what is meant by the term ‘L’ (often referred to as big L). (1 mark)

When reviewing an equipment certificate number of a flameproof enclosure, certificate number - IEC Ex SIM 05.0008X Type Ex d It6:

- c) What does the 'X' mean (1 mark)
- d) What is your understanding of the first three letter of the certificate, in this case, IEC? (1 mark)
- e) Draw and label a flameproof group I spigot joint that you would expect to find on a headlight. Nominate the minimum 'L' for a 0.4mm gap. (4 marks)
- f) Explain how you would confirm that the gap of a spigot joint is compliant to the certificate of conformity. (1 mark)

Question 11

You have received a safety alert describing an incident where an electrician received an electric shock and an electrical burn to his hand whilst carrying out routine maintenance in a withdrawable 415 Volt 37kW pump cell in a motor control centre (MCC). The MCC has a design fault rating of 65kA and the modelled maximum fault level of the installation is 25kA.

- a) List three design features you may find on the 37kW pump cell to prevent contact with live conductors. (3 marks)
- b) List two design features you may find on the 37kW pump cell to eliminate or mitigate arcing faults. (2 marks)
- c) List three administrative controls you would expect to see in place to manage the risks associated with this type of incident. (3 marks)
- d) The following warning is provided in the manufacturer's installation manual:



ATTENTION: De-energize, lock out, and tag out all sources of power to the MCC when you install or remove MCC units. If MCC units are installed or removed with power applied to the main power bus, follow established electrical safety work practices.

List two key conditions you would include in a procedure for the withdrawal of an MCC unit with the main power bus energised. (2 marks)

Question 12

Faulty batteries and charging units have been attributed to numerous fires associated with lithium batteries worldwide. Your mine has committed to the introduction of battery-operated loaders for underground use.

With respect to the lifecycle management of the batteries; list five key areas that would need to be addressed in your risk assessment to ensure safe operation. Briefly explain why each of your nominated key areas needs to be assessed. (10 marks)

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