(CEE1)

NSW Coal Competence Board

EXAMINATION FOR CERTIFICATE OF COMPETENCE AS Mine Electrical Engineer

(Coal Mine Health and Safety Act 2002)

Wednesday 21 August 2013

9.30am – 12.30pm

Application of Electrical Engineering to Mining

INSTRUCTIONS TO CANDIDATES:

It is expected that candidates will present their answers in an engineering manner making full use of diagrams, tables, and relevant circuits where applicable and showing full working in calculations. Neatness in diagrams is essential and will be considered in the allocation of marks. Questions are to be answered as a prospective manager of electrical engineering at a NSW mine.

- Examination time **3 hours**
- **Each** whole question is designed for a **30 minute** answer
- Candidates should attempt **all** questions
- Candidates must mark this paper with their **Candidate Number only**
- All questions and parts are allocated their respective marking value
- During the reading time candidates may use a highlighter to mark the key parts of questions.

Question 1 (10 marks)

You are the Manager of Electrical Engineering at a mine producing 4 million tonnes per year. You have recently taken over the position and have identified that over the past 3 years your mine has reported 36 failures of Ex, as per the following table:

Year	Incident
2013	• 2 events of longwall lights with lenses smashed after shot firing stone off the shearer • 2 events of man transporter head lights having smashed lenses found in crib room • 1 event of bolts found missing in fan starters after maintenance • 4 events of damaged shuttle car cables showing evidence of arcing • 3 events of cable arcs in other type of cables being evident
2012	• 3 events of cables pulled out of head lights on diesels • 1 event of incorrect bolts found in shuttle car cable reel • 4 events of IS telephones found to have hand sets missing • 4 events of damaged shuttle car cables showing evidence of arcing
2011	• 4 events of damaged shuttle car cables showing evidence of arcing • 2 events of damaged glands found on Exd enclosures • 4 reports from cable repairers of evidence of arcing • 2 events where plastic blanks were found in a shuttle car panel

a) On identifying these results what would be your initial course of action? (4 marks)

b) Who would be involved in any action you take? (2 marks)

c) Draft the executive summary section of your report, outlining your long-term strategies to fix the high number of incidents. Your report should be suitable to send to the Electrical Inspector. (4 marks)

Question 2 (10 marks)

You have been appointed the Electrical Engineer at a “greenfield” coal mine construction site. On commencement of mining-related activities you are to be appointed as the Mine Electrical Engineering Manager. As a consequence you will be responsible for developing the Mine’s Electrical Engineering Management Plan and the Standards of Engineering Practice.

When considering Electrical Protection Systems:

a) With regard to the requirements of Clause 19 of the CMHSR 2006, what provisions must be in place with regard to electrical protection on all electrical circuits? (1 mark)

b) What information should be included in your Power System Single Line Diagram? (2 marks)

c) In considering the content of Section 2 of AS3007:2013, *Electrical Installations – Surface Mines and Associated Processing Plant*, and industry best-practice, what general requirements and information would you incorporate into your equipment technical specifications with regard to the protection of personnel from Arc Flash? (2 marks)

d) In managing the Fault Study for the mine power system, what would be considered as triggers for a review of the study to ensure it is kept up to date? (3 marks)

e) The primary fundamental principle that should be applied to the design, selection and installation of electrical protection and earthing systems at your mine is that the first fault to be detected and cleared is always what type of fault? Why? (2 marks)

Question 3 (10 marks)

You have recently taken over as the Manager of Electrical Engineering and you have identified that your mine has taken no action concerning the recommendations of Safety Bulletin *SB11-04 - Electrical Hazards Associated with Variable Speed Drives and Earth Fault Current Limited Systems* (Attached pages 4,5,6)

You have brought this to the attention of the Mine Manager who as asked you to develop a strategy and identify what further actions the mine should take.

Your mine currently has:

- A new longwall on order with the shearer fitted with VVVF drive traction control
- Three development sections each with a continuous miner and 2 shuttle cars all fitted with VSD's

Your answer should include:

- An action plan with anticipated time frames
- Who you will involve in the process
- In relation to the recommendations in the Safety Bulletin, what the identified issues are likely to be
- Identification of the risks associated with this type of technology when used with an "IT" earthing system in an underground coal mine
- How you intend to communicate the issues and outcomes, and to whom these will be communicated

(10 marks)

NSW GOVERNMENT | Trade & Investment

SAFETY BULLETIN

Electrical hazards associated with variable speed drives and earth fault current limited systems

BACKGROUND

Variable Speed Drives (VSDs), also known as Variable Voltage Variable Frequency (VVVF) drives, often cause relatively large capacitively coupled currents to flow in the earthing systems of the associated drive motors, plant and machinery during normal operation. These capacitive currents are associated with the switching frequencies of the output of the VVVF drives.

These high frequency currents are a source of electro-magnetic interference (EMI or noise) that can cause unreliable and sporadic operation of electronic control equipment. To minimise the impact of this noise on surrounding plant and equipment, it is common practice to use filter circuits to localise the currents to a specific area of the electrical network.

However, the use of VSDs and associated EMI mitigation techniques may (in certain circumstances) have a detrimental impact on the effectiveness of the current limitation system as used in underground mines. This phenomenon appears to be amplified when two or more machines fitted with VSDs and EMI filters are supplied from the one substation/transformer which utilises a neutral earthing resistor (NER).

Recent incidents at an underground mine involving earth faults on motor cables fed from VSD drives have drawn this issue to the Department's notice. Investigations into these incidents have identified high frequency currents flowing to earth during these fault conditions which were significantly higher than the value of the current limitation of the NER for the supply system.

Computer modelling has indicated that when powered from a common supply, the combined effects of multiple VSDs and EMI filters during fault conditions on the load side of the VSD can excite resonances that cause large circulating currents to flow between the EMI filters. Elements of this modelling have been verified in actual tests of equipment presently in service. Modelling also suggests that currents of several times the maximum value of the limitation device can flow at the substation NER.

Therefore, during an earth fault on the output side of an operating VSD higher fault currents could also have the effect of generating higher than expected prospective touch potentials at machinery associated with the supply system, not just at the location of the earth fault.

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www.dpi.nsw.gov.au/minesafety
Comet Ref. No. 317598180001

Mine Safety Bulletin No: SB11-04
Prepared by:B Gittins
Phone: 02 6360 5351
Date Issued: 21/12/2011

There is also an increased risk of sparking between machines, if machines are in close proximity to each other at the time an earth fault occurs on the VSD supplied motor or cable.

Notes:

1. It should be noted, that the duration of these high current earth faults on the equipment tested so far is typically very short. Tests on this equipment have demonstrated clearance times of about of 1 mS, due to the operation of an EMI filter fuse utilised with this system. However, different variable speed drives should be modelled according to their unique fault level and/or clearance time characteristics, where interactions with other VSDs and their associated EMI filters is possible.

2. Where a machine is fitted with its own isolation transformer eg the VSD traction drives on a longwall shearer the EMI filter on these drives will not interact with any other VSD drives in the longwall panel.

RECOMMENDATIONS

Whilst the following recommendations are good engineering practice, additional emphasis should be placed on them until a permanent engineering solution(s) is provided.

1. The values for the earth continuity of machinery fed via reeling and trailing cables, where VSD drives are utilised, need to be maintained at a minimum value. This is the primary protection against excessive touch potentials and should also be considered best practice in normal mining environments.

   Note: The normal value for tripping of earth continuity relays is 45Ω. This upper value of possible earth resistance, allowing for known pilot resistance of the cables, may result in potentially dangerous voltages appearing at a machine. Measures should be used to ensure that the machine cable's earthing resistance remains as low as practical rather than potentially operating at the upper limits of the pilot relay.

2. Equipment fed via reeling or trailing cables should be protected with earth leakage units set for no intentional time delay ie 'instantaneous' initiation of fault detection.

3. The length of all reeling and trailing cables, including those supplying DCBs and Distribution Boxes should be kept as short as possible. Relocation of transformers should be undertaken where possible, in preference to the use of extension cables to machinery.

4. Effective mechanical protection should be provided to all cables fed from a VSD drive to minimise the likelihood of damage to the cables.

5. Where possible rearrange the VSD operated machinery at the mine to minimise the number of VVVF drives and associated EMI filters with any single substation/transformer eg distribute VSD operated equipment evenly between underground panels where such equipment does not have its own onboard isolation transformer.

6. Where a mine utilises VSD drives supplied through trailing cables it is suggested that the operator of the mine consider having professional software modelling of their applications undertaken to determine the extent to which the safety at the mine may be affected by this issue and how the risks can be managed. This recommendation therefore extends beyond the face areas of a mine eg VSD operated conveyor drives and pumps whose drives are powered through trailing cables supplied from fault current limited supplies.
7. Reference should be made to the following documents for more information
    a. VVVF Drives and Electrical Protection in the Mining Environment, presentation by Tim Wylie at the 2011 Electrical Engineering Safety Seminar at Sydney Olympic Park, Homebush. http://www.dpi.nsw.gov.au/minerals/safety/publications/seminar-presentations/2011-electrical-engineering-safety-seminar
    b. AS/NZS 4871.1:2010 Electrical equipment for mines and Quarries Appendix E Variable speed drive - guidance for identification of potential risks
    c. AS/NZS 60479 Parts 1 & 2 Effects of current on human beings and livestock

NOTE: Please ensure all relevant people in your organisation receive a copy of this safety bulletin, and are informed of its content and recommendations. This safety bulletin should be processed in a systematic manner through the mine's information and communication process. It should also be placed on the mine's notice board.

Signed

Rob Regan
DIRECTOR
MINE SAFETY OPERATIONS BRANCH
NSW TRADE & INVESTMENT

Question 4 (10 marks)

AS/NZS2290.1:2005 Electrical equipment for coal mines—Introduction and maintenance.

This Standard sets out requirements for the introduction; examination; maintenance; in-situ repair and allowable modifications to electrical equipment designed for use in hazardous areas in underground coal mines.

It also details commissioning; testing and documentation requirements to ensure safety; and compliance with relevant Standards for different types of explosion protection apparatus, and reliable operation of the equipment while in service. It also makes reference to pre-overhaul equipment audits

a) How would you identify when Exd equipment should be overhauled? (1 mark)

b) What is the purpose of the pre overhaul inspection? (1 mark)

c) When should the initial pre overhaul inspection be carried out? (1 mark)

d) When should a second pre overhaul audit be carried out? (1 mark)

e) What is the expected period between pre-overhaul audits? (1 mark)

f) Who should conduct a pre-overhaul audit of Exd equipment? (1 mark)

g) Whilst undertaking a pre-overhaul audit, a competent person identifies ‘L’ and ‘l’ dimensions that do not comply with the certification drawings. Outline your possible options to resolve the problem. (4 marks)

Question 5 (10 marks)

Mining cables used for underground coal operations in reeling and trailing applications are designed to be “fit for purpose” for their duty in a particularly harsh environment.

The following questions are related to this design requirement:

a) With the use of the area below draw a typical cross sectional diagram of a “type 245.3 Trailing Cable” and identify the critical design features of the cables internal cores, insulation and screening (4 marks).

b) Describe how and where the Type 245.3 cable design is utilised in the underground mining industry, and why it may be chosen over other cable types? (2 marks)

c) Explain what a “symmetrical load test” is on a trailing type cable for underground use and why this test is important. With the use of a diagram show how this test would be carried out in a licensed workshop, as per AS1747:2003 (4 marks)

Question 6 (10 marks)

A project for a new underground mine involves driving roadways from an existing box cut; however, due to recent rain the box cut has had to be utilised as water storage. The mine surveyor has estimated there is 600 million litres of water within the box cut and work is well on the way of installing pump lines to dewater the area.

The project manager has sourced an electric pump that will pump 7500 litres of water per minute at a maximum 300m of head. The calculated maximum head will be approximately 120m with a flow of 10000 litres per minute derived from the pump curve.

The pump is driven by a three-phase induction motor running at 1440rpm, has an efficiency of 85% and a power factor of 0.88.

Assume the density of the mine water to be the same as that of pure water

Document any assumptions made in your calculations.

Formula Power = qgHQ

Where: q = density of water (kg\m^3)

g = acceleration due to gravity

H = vertical height (m)

Q = flow rate (m^3\sec)

Using the information given, calculate the following:

a) The power requirements to drive the pump at the nominated maximum head and flow-rate (3 marks)

b) The expected time frame to de-water the area, also allowing for maintenance and breakdowns (2 marks)

c) The approximate power consumed to de-water the area (2 marks)

d) The size of generator that you would require to run the pump (2 marks)

e) What contingencies would you put in place for this installation? (1 mark)

END OF QUESTIONS

END OF PAPER

(CEE2)

NSW Coal Competence Board

EXAMINATION FOR CERTIFICATE OF COMPETENCE AS Mine Electrical Engineer

(Coal Mine Health and Safety Act 2002)

Wednesday 21 August 2013

1.30pm – 4.30pm

Legislation and standards applicable to underground coal mines

INSTRUCTIONS TO CANDIDATES:

Unless otherwise stated all references to Regulations are to the
Coal Mine Health and Safety Regulation 2006
or
Work Health and Safety Regulation 2011

It is expected that candidates will present their answers in an engineering manner making full use of diagrams, tables, and relevant circuits where applicable and showing full working in calculations. Neatness in diagrams is essential and will be considered in the allocation of marks. Questions are to be answered as a prospective manager of electrical engineering at a NSW mine.

- Examination time **3 hours**.
- **Each** whole question is designed for a **15 minute** answer.
- Candidates should attempt **all** questions.
- Candidates must mark this paper with their **Candidate Number only**.
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QUESTION 1 (10 marks)

You are the Manager of Electrical Engineering of an underground coal operation in NSW. Incidents have occurred around Remote Controlled Mining machines which have been identified as "Unintended Activations", when the machine has functioned in a manner which may place operators at risk.

a) Identify the clause in the *CMHS Regulation* which this type of incident falls under, and give details of the clause wording and requirements (2 marks)

b) Australian Standard AS4240.3:2013 details the requirements for Remote Control systems. Explain in some detail the scope of this standard. (3 marks)

c) Identify at least two types of equipment to which this standard (AS4240.3:2013) does **not apply**. (2 marks)

d) With the use of a diagram identify what "Exclusion Zones" refer to for a continuous miner in this standard. (AS4240.3:2013) (3 marks)

QUESTION 2 (10 marks)

As the Manager of Electrical Engineering at an underground coal mine you attend daily and weekly mine review meetings. Recent meetings have highlighted an apparent increase in the number of cable damage incidents.

You have researched these incidents and identified the primary areas of damage are from:

- Miner cable damage during machine flits, and
- Shuttle car cable damage from sheath wear on the ribs, and
- Longwall inter-chock connecting cables, trapped between supports.

a) In your Electrical Engineering Management Plan, what systems and standards should be in place to deal with these types of issues? (4 marks)

b) With respect to the management systems and plans outlined in your previous answer, what are some of the specific rules you would have in place to help ensure that the risk of cable damage is minimised at your mine? (6 marks)

QUESTION 3 (10 marks)

As the Qualified Electrical Engineer you are required to develop guidance to your electrical personnel for instances when electrical personnel may be required to "test" on energised low voltage circuits commonly found in fixed plant in surface operations.

a) What are the specific requirements listed in *Work Health and Safety Legislation* in this regard. (2 marks)

b) AS4836 – "Safe working on or near low voltage electrical installations and equipment" requires a number of safety precautions to be undertaken or considered before and during testing. List 6 of these requirements (3 marks)

c) AS4836 mentions the following terms. In your own words describe your understanding of these terms, in relation to the standard.

- On or Near (1 mark)
- Safety Observer (1 mark)
- Competent Person (1 mark)

d) List two (2) risk control methodologies identified in the Hierarchy of Controls listed in AS4836 and give practical examples of how these would be applied in the management of risks associated with live low voltage testing. (2 marks)

QUESTION 4 (10 marks)

You are the Manager of Electrical Engineering at an underground coal mine, and an incident has occurred involving a Shuttle Car Cable crushing a cable against the rib line.

Initial investigations by the tradesman have identified major burning at the crush point on the cable; the supply circuit breaker in the DCB has a welded set of contacts; and the supply transformer has tripped on the back-up earth leakage protection.

a) On being made aware of the incident, what would be your initial concerns with respect to the operation of the electrical protection? (3 marks)

b) What systems or processes need to be in place at your operation to assist in preventing the apparent failure of the protection system in this instance? (2 marks)

c) With regard to the operation of the protection system, what would your investigation cover? (2 marks)

d) Draw a simple single line diagram as an example of how these systems may operate with respect to your operation. (3 marks)

QUESTION 5 (10 marks)

AS/NZ 2081:2011 *Electrical Protection devices for Mines and Quarries*

a) What is the difference between an *Earth Fault* and *Earth Leakage*? (1 mark)

b) For the purposes of this standard, what is the difference between *type* testing and *routine* testing by a manufacturer? (1 mark)

c) The Standard nominates a typical maximum EC resistance setting of 45ohms. In determining the relay setting – what are the crucial parameters that need to be considered? (2 marks)

d) For Earth Fault Protection Devices installed on IT systems, what is the minimum recommended trip ratio between the earth fault limitation device and earth fault trip value? (1 mark)

e) For an Earth Fault Lockout device, what is the minimum permissible insulation resistance between a phase conductor and earth? (1 mark)

f) For Frozen Contactor Protection, a trip time of up to 20 secs is permitted for detection of voltage on the load side of a contactor after it is expected to be in the open position. Under what circumstances would such a long trip time be required? (2 marks)

g) The standard recommends a maximum time delay for an earth fault should not exceed 500mSec. Under what circumstances may this value have to be exceeded? What would be your main consideration in exceeding this value? (2 marks)

QUESTION 6 (10 marks)

The Mine Operator has asked for your assistance in developing rules to be used for the restoration of power at the mine.

Develop a checklist of your expectations for your site personnel to follow in the event of:

a) An earth fault on a 10km overhead power line energised at 11kV to a remote dam site. (4 marks)

b) What differences would you have in your procedure in the event that the previous situation in ‘a)’ was an instantaneous overcurrent fault?(2 marks)

c) Who would you allow to conduct any fault finding/switching on site and why?(2 marks)

d) Would you consider a competent 4th year electrical apprentice to undertake this work if they are the only resource available at the time? (1 mark)

e) Explain how an insulation test would or would not be beneficial in fault finding the aerial system? (1 mark)

QUESTION 7 (10 marks)

Your General Manager has been made aware of an increase in arc flash and electric shock incidents in switch-rooms in the industry.

He has asked you as the Manager of Electrical Engineering on site to prepare a report of all areas on the surface of your mine site where there is a risk of arc-flash or electric shock incidents involving non-electrical and electrical personnel.

In this report he wants recommendations on how to control any hazards identified.

Using the *WH&SA 2011* and the *WH&SR 2011* as a guide:

a) What measures, under the hierarchy of controls, would be appropriate in assisting to control the hazards identified on your site? (3 marks)

b) Further to above in 'a)', what specific controls could be put in place to eliminate or minimize the hazards of arc flash and electric shock? (2 marks)

c) Typically, what type of duties would a non-electrical person be undertaking in an area that has electrical hazards identified? (1 mark)

d) Further to (c) what are your recommendations to protect these personnel from the hazards identified? (2 marks)

e) What are your recommendations to protect electrical persons from the hazards identified? (2 marks)

QUESTION 8 (10 marks)

The *NSW Work Health and Safety Regulation 2011* contains provisions relating to electrical safety in the workplace.

The Safe Work Australia Code of Practice, *Managing Electrical Risks in the Workplace,* provides guidance and information on how the provisions of the Regulation can be met.

a) The Code outlines the requirements for a *safe system of work* to deal with potentially unsafe electrical equipment. What are the key elements of this system? (2 marks)

b) According to the Code, what are the competency requirements for personnel undertaking testing under AS3760? (2 marks)

c) What is the definition of electrical work, according to the Code? (2 marks)

d) For the purposes of this Code, is automotive electrical work undertaken on earth-moving plant considered "electrical work"? (2 marks)

e) The *WH&S Regulation 2011* details the circumstances under which work on "energized electrical equipment" is permitted. What are these? (2 marks)

QUESTION 9 (10 marks)

As the sites Manager of Electrical Engineering you have been asked to provide input into your sites induction training requirements for portable electrical equipment being brought onto site.

a) List three (3) items of plant or equipment that you would want specifically addressed in your induction training? (2 marks)

b) What are your individual site requirements for the items listed above? (4 marks)

c) What would be your inspection regime for portable electrical tools and appliances in the surface workshop at your operation? (1 mark)

d) Explain how your inspection and test frequency may differ from the requirements of AS3760 – In service safety inspection and testing of electrical equipment (2 marks)

e) How could some of these risks be eliminated altogether? (1 mark)

QUESTION 10 (10 marks)

Increased Safety (Exe) is a form of Explosion Protection technique increasingly used in underground coal mines.

a) In your own words, what is the definition of “Increased Safety”? (1 mark)

b) List at least four (4) concepts used in the design of Exe equipment (2 marks)

c) Give examples of typical Increased Safety equipment currently used in the industry (1 mark)

d) When an inspection of an Exe lighting box enclosure on a Longwall face 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 this type of enclosure? Justify your answer. (3 marks)

e) On inspecting an Exe conveyor motor operating in a hazardous zone it is apparent that, at some previous time, the motor terminal block has been removed (for reasons unknown), and the motor leads have been directly bolted to the motor supply cable conductors. These connections appear to have been taped up utilising an appropriately rated insulation tape. Is this permitted? Justify your answer. (3 marks)

QUESTION 11 (10 marks)

As Manager of Electrical Engineering at a coal operation you need to provide a system that ensures all your electrical contractors are aware of your standards of Engineering Practice

Describe a system you would put in place to manage the risks associated with the use of electricity that will:

a) Provide appropriate information and training to your contractors, including non-electrical personnel, prior to undertaking work on your site. (3 marks)

b) How would you confirm the requirements detailed in the information and training you provide, are understood? (3 marks)

c) What processes could you utilise to measure the effectiveness of your training system? (2 marks)

d) What systems could you utilise to ensure support information was available to personnel as required? (2 marks)

QUESTION 12 (10 marks)

Intrinsic Safety Concepts
AS60079:11 – Equipment protection by Intrinsic Safety
AS60079:25 – Assessment of simple IS systems.

a) You have an ongoing issue with spurious CH4 trips on your Longwall face. The supplier of the methanometer considers that voltage drop is the issue and has recommended a replacement cable with larger conductor cross sectional area. In terms of the integrity of the IS protection, what would be your main concern? (1 mark)

b) According to AS60079.11, what is the minimum segregation distance between IS and non-IS terminals on equipment? (1 mark)

c) According to AS60079.11, what are the minimum clearance distances between the bare conducting parts of separate IS circuits? (1 mark)

d) What is the fundamental requirement of the design and construction of an infallible transformer? (1 mark)

e) Draw a sample block diagram for the following simple IS system (6 marks):

Pressure Transducer located in a hazardous area connected to a PLC analogue input in a safe area via a IS transmitter. Include all key parameters utilising typical expected values. In your diagram, the relationship between all input and output parameters (eg *Um; Uo; Ii; Io; Co; Ci; Lo; Lr*) should demonstrate that the circuit is compliant

END OF QUESTIONS

END OF PAPER

(CEE3)

NSW Coal Competence Board

EXAMINATION FOR CERTIFICATE OF COMPETENCE AS Mine Electrical Engineer

(Coal Mine Health and Safety Act 2002)

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1.30pm – 4.30pm

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QUESTION 1 (10 marks)

Mining cables used for surface operations in reeling and trailing applications are designed to be "fit for purpose" for their duty in a particularly harsh environment. The following questions are related to this design requirement:

a) With the use of the area below draw a typical cross sectional diagram of a "type 409 Trailing Cable" and identify the critical design features of the cables internal cores, insulation and screening. (4 marks)

b) Describe the primary engineering reasons for this particular design and layout of the cable construction. (2 marks)

c) List a minimum of five of the eight pre-repair tests which need to be carried out on every mining cable when sent to a licenced repair workshop. (4 marks)

QUESTION 2 (10 marks)

You have been appointed the Electrical Engineer at a "greenfield" coal mine construction site. On commencement of mining-related activities you are to be appointed as the Mine Electrical Engineering Manager. As a consequence you will be responsible for developing the Mine's Electrical Engineering Management Plan, and Standards of Engineering Practice.

When considering Electrical Protection Systems:

a) According to the *CMHS Regulation*, in your EEMP, what provisions should be made for electrical protection? (1 mark)

b) In developing your Standard of Engineering Practice for Electrical Protection Systems, nominate your key requirements for the management of protection settings. (4 marks)

c) With reference to AS3007:2, in considering the design and construction of electrical installations on the surface of the mine, what general requirements should be outlined in your EEMP and Technical Specifications to ensure the protection of personnel against direct contact with live electrical conductors? (2 marks)

d) After construction of your Main Substation, the Supply Authority contacts you to advise that due to alterations to their network configuration the incoming fault level at your substation has risen by 30MVA. What are the potential issues associated with this, and what would be your first action? (2 marks)

e) The primary fundamental principle that should be applied to the design, selection and installation of electrical protection and earthing systems at your mine is that the first fault to be detected and cleared is always what type of fault? (1 mark)

QUESTION 3 (10 marks)

AS3000:2007 *Wiring Rules Clause 7.7 – Hazardous Areas (Explosive Gas or Combustible Dusts)*

Your mine has a project to install a new 10000 tonne ROM bin. Approval Conditions stipulate the ROM conveyor from the loading point to the top of the bin (800m long) and the top of the bin itself must be fully enclosed to minimise dust. Due to operational sequencing the bin will typically run at about 75% of capacity. The ROM coal is typically dry; the in-situ gas content of the mined coal is very high ($5m^3$/tonne) with a low desorption rate, and has a high propensity for spontaneous combustion.

a) Given the information above, outline what should be done at the design stage to establish requirements for the electrical installation at the top of the bin (3 marks)

b) Whose responsibility is it to classify the hazardous area? (1 mark)

For each of the following clauses describe how you would incorporate the requirements of each into the Technical Specifications and Electrical Engineering Management Plan for your Mine. (2 marks each)

d) *Clause 1.5.4.1 - Protection shall be provided against dangers that may arise from contact with parts of the electrical installation that are live in normal service.*

e) *Clause 1.5.5.1 - Protection shall be provided against dangers that may arise from contact with exposed conductive parts that may become live under fault conditions.*

f) *Clause 1.8 – All electrical installations and any alterations additions and repairs to electrical installations shall, prior to being placed into service or use, be inspected as far as practicable and tested to verify that the installation meets the requirements of this standard as applicable.*

QUESTION 4 (10 marks)

The electrical supply to a coal mine is via two 33kV / 11kV transformers. The maximum demand has been recorded as 20MVA at a 0.65 lagging power factor.

a) Nominate the size of a 11kV connected capacitor bank to correct the power factor to 0.98 lag. (2 marks)
Power factor correction units are available in 500kVAr increments.

b) What is the power factor achieved with the power factor unit you selected, at the nominated maximum demand? (2 marks)

c) What is the kVAr of each phase if the capacitor bank is delta connected? (2 marks)

d) Calculate the resultant power factor if the capacitor bank you selected remained connected when the demand dropped to 10MVA at 0.65 lag power factor. (2 marks)

e) List the relative merits of high voltage verse low voltage connected power factor correction units (2 marks)

QUESTION 5 (10 marks)

AS/NZ 2081:2011 Electrical Protection devices for Mines and Quarries.

a) What are the key objectives of AS2081? (4 marks)

b) According to the Standard, what is the maximum permissible operating time for an Earth Continuity Protection Device? Why is this maximum time important? (2 marks)

c) Earth continuity protection devices shall be designed to operate if the shunt resistance between the pilot and earth falls below a nominated value. What is this value? (1 mark)

d) For Earth Fault Protection Devices installed on IT systems, what is the minimum recommended trip ratio between the earth fault limitation device and earth fault trip value? (1 mark)

e) For an Earth Fault Lockout device, what is the minimum permissible insulation resistance between a phase conductor and earth? (1 mark)

f) For Frozen Contactor Protection, a trip time of up to 20 secs is permitted for detection of voltage on the load side of a contactor after it is expected to be in the open position. Under what circumstances would such a long trip time be required? (1 mark)

QUESTION 6 (10 marks)

You have taken on the role of Mine Electrical Engineer at a green-field site.

During your first day on the job you take particular note of the following:

- There is a Construction Camp on the main access road, consisting of a large number of demountable buildings and containers;
- The mine Administration Area is located separately and also comprises a large number of demountable buildings with 2 large rural sheds being used as "temporary" workshop facilities.
- The Administration Area is supplied via a 250KVA Generator, with a number of Distribution Boards secured to the buildings.

Over the coming days you establish that:-

- The Construction Camp is not part of the mine lease, however
- Both the Camp and Administration Area were installed by the same company, and
- The company is a large organisation and has extensive construction experience, but has not worked on coal mine sites in NSW previously, and
- There appear to be no test reports available

Considering the Administration Area installation:-

a) What key Standards and other documentation would you refer to or consider when assessing the installation? (2 marks)

b) When undertaking an inspection, what would be your particular concerns with regard to the safety and compliance of the generator installation? (3 marks)

c) You observe that power cables are installed via a combination of being buried directly; on cable trays; and suspended via catenary wires. Outline the earthing requirements for the installation. (3 marks)

d) What would you require to see provided in the testing documentation? (2 marks)

QUESTION 7 (10 marks)

A company Project Manager has been put in charge of a 16 week project for the construction of a new ROM Surface bin at an underground coal mine.

The Project Manager has been informed that welding incidents have been identified as occurring at a high frequency throughout the industry and he has asked you for advice on how to manage safe welding processes during the shutdown.

a) What Australian Standards will you advise him to comply with to assist in his management of safe welding processes (2 marks)

b) What is your advice on the category to be used on this project and designate the control measures for the category you have chosen? (2 marks)

c) Name the tests that need to be carried out on the electrically supplied welding machine and the frequency required. (3 marks)

d) Who can do work inside a welding power source? (1 mark)

e) What are the added requirements if you are welding in a confined space? Some of these are specified but are there any other safety improvements you would recommend to the Project manager? (2 marks)

QUESTION 8 (10 marks)

The *NSW Work Health and Safety Regulation 2011* contains provisions relating to electrical safety in the workplace. The Code of Practice, 'Managing Electrical Risks in the Workplace' *(*Safe Work Australia*),* provides guidance and information on how the provisions of the Regulation can be met.

a) Provide three examples of types of electrical work where the Code of Practice **does not** apply. (2 marks)

b) AS3760 sets out indicative inspection and testing frequencies for electrical equipment. The Code of Practice for 'Managing Electrical Risks in the Workplace' *(*Safe Work Australia) provides guidance on when testing should be undertaken in addition to the testing frequencies recommended in the Standard. When should such additional testing on electrical equipment be undertaken? (2 marks)

c) In relation to construction work, according to the *WH&S Regulation 2011*, when should RCD's be used? (2 marks)

d) You are performing in inspection at your mine, and find a fitter removing a coupling-half from the shaft of a 110kW pump motor. You note the motor is still connected to the cable (with the terminal box cover in place) however he has isolated the pump in accordance with site isolation procedures.
Under the *WH&S Regulation 2011* is this considered "electrical work"? Support your answer. (2 marks)

e) *The WH&S Regulation 2011* details the circumstances under which work on "energized electrical equipment" is permitted. What are these? (2 marks)

QUESTION 9 (10 marks)

As the Qualified Electrical Engineer (QEE) for a mine site, you have been asked to provide a Technical Specification for mobile and transportable plant to be operated on the surface.

a) List any specific standards / guidelines that you would reference in your specification. (1 mark)

b) What would be some of your specific requirements in point form for your specification? (4 marks)

c) What would you consider to be safety critical that you would not compromise on in your specification? (1 mark)

d) Where would you install any emergency stops and what specific requirements would you ask for from the supplier? (2 marks)

e) What documentation would you insist on being provided prior to accepting the machine? (2 marks)

QUESTION 10 (10 marks)

You are the Qualified Electrical Engineer (QEE) for a large Open Cut facility which has been on “care and maintenance” mode for a period of time, and has just been given a new life with operations about to start up again.

With the commencement of operations a series of new machinery will be coming to site:

a) What are some of the issues which may be encountered when bringing new equipment to site? (2 marks)

b) What process needs to be in place to handle this new equipment? (4 marks)

c) Draw a basic flow diagram of the process, and how you can ensure that the equipment is suitable for service at your site? (4 marks)

QUESTION 11 (10 marks)

As Qualified Electrical Engineering at a coal operation you need to provide a system that ensure all your electrical contractors are aware of your standards of Engineering Practice

Describe a system you would put in place to manage the risk of electricity that will:

a) Provide training to your contractors prior to commencing work on your site. This would include non-electrical people (3 marks)

b) How would you confirm your requirements are understood? (3 marks)

c) Describe how you will measure the effectiveness of your standard. (2 marks)

d) Describe how you will ensure that supporting information is available (2 marks)

QUESTION 12 (10 marks)
Explain in your own words your understanding of the following

a) To reverse a 3 ph induction motor, any 2 phase are reversed. What is the reason why the motor will reverse? (1 mark)

b) What is meant by the term “Corona” with regards to electrical engineering? (1 mark)

c) What is meant by the term “Partial discharge” with regards to electrical engineering? (1 mark)

d) What is the purpose of a circuit breaker? (1 mark)

e) What is meant by the impedance of a transformer? eg Z= 4% (1mark)

f) Why would you specify a high impedance transformer as opposed to a low impendence transformer? (1 mark)

g) What is the purpose of a Buckholz relay on a transformer? (1 mark)

h) Where would you find the “I^2t rating”? (1 mark)

i) What is meant by the term “HRC”? (1 mark)

j) What gases are produced during an arcing fault within an oil filled transformer? (1 mark)

END OF QUESTIONS
END OF PAPER