



Mine Safety

EXAM PAPER | CERTIFICATE OF COMPETENCE

Electrical engineering manager of underground coal mines

SEPTEMBER 2015

CEE1 Application of electrical engineering to mining

- Examination date:** 16 September 2015
- Examination times:** 9.30am to 12.30pm
- Examination venue:** Hunter TAFE, Kurri Kurri.
- Instructions to candidates:** Unless otherwise stated all references to Act and Regulations are to the:
*Work Health and Safety
(Mines) Regulation 2014
Work Health and Safety Regulation 2011
Work Health and Safety (Mines) Act 2013
Work Health and Safety Act 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 workings in calculations. Credit marks will be given for such work in assessing marks for these questions. If you unable to fit your answer in the allocated space provided please utilise the blank page opposite the question.

Neatness in diagrams is essential and will be considered in the allocation of marks. Provide answers in point form wherever appropriate. State any assumptions you make in order to answer the question.

Questions are to be answered from the perspective of an electrical engineer nominated to exercise the statutory function of electrical engineering manager by a mine operator at a NSW mine.

Electronic aids may not be used, apart from calculators.

All questions are compulsory and candidates must attempt each question.

All questions are of equal value, but parts of questions may vary in value. The marks applicable to each part of a question will be indicated adjacent to the question.

Place your identification number only, NOT your name, on your paper.

10 minutes reading time is allowed prior to the start of the examination. Candidates can use a highlighter to mark points of importance during the reading time, but may not begin answering the questions. The examination time is three (3) hours. Each whole question is intended to be able to be answered in 30 minutes.

This examination is a **closed book** examination.

Question 1 (10 marks)

You were the electrical engineer at an underground coal operation, on 1 February 2015, when the new *Work Health and Safety (Mines) Act 2013* and *Work Health and Safety (Mines) Regulation 2014* came into effect. You have been asked by the mine operator to advise what effect this new legislative framework will have on the operation.

Draft a short report advising of key areas specific to electrical engineering safety that he should be made aware of.

The report should include:

- Any key dates or times specified in the *Work Health and Safety (Mines) Act 2013* and *Work Health and Safety (Mines) Regulation 2014*, for electrical engineering (2 marks)
- The prescribed statutory functions specific to electrical engineering and the requirements for each (4 marks)
- Any items from the *Work Health and Safety (Mines) Regulation 2014* you consider important to bring to the attention of the mine operator (2 marks)
- Any changes to notifications to the regulator you consider important (1 mark)
- Report clarity (1 mark)

Question 2 (10 marks)

You are the electrical engineer nominated to exercise the statutory function of electrical engineering manager at a NSW underground coal mine and you have a contract company working with your own electrical team on repairs to a conveyor starter and drive 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.

- a) What process needs to be initiated directly after the site electric shock protocols have been followed? (2 marks)
- b) You are initially unaware of the potential of the shock the tradesman received in the incident – Please identify the process that would be followed at your mine in this situation? (2 marks)
- c) Is this a “notifiable incident” in terms of the *Work Health and Safety (Mines) Regulation 2014* and if so explain why? (1 mark)
- d) If you believe this incident is a reportable incident, under what clause of the *Work Health and Safety (Mines) Regulation 2014* is this type of incident identified? (2 marks)
- e) If you believe this incident is a reportable incident, what is the time period for notification? (1 mark)
- f) After investigation, it has been identified that a 48 volt AC control supply had inadvertently contacted the enclosure door – does this affect the management of the incident? Please explain your answer. (2 marks)

Question 3 (10 marks)

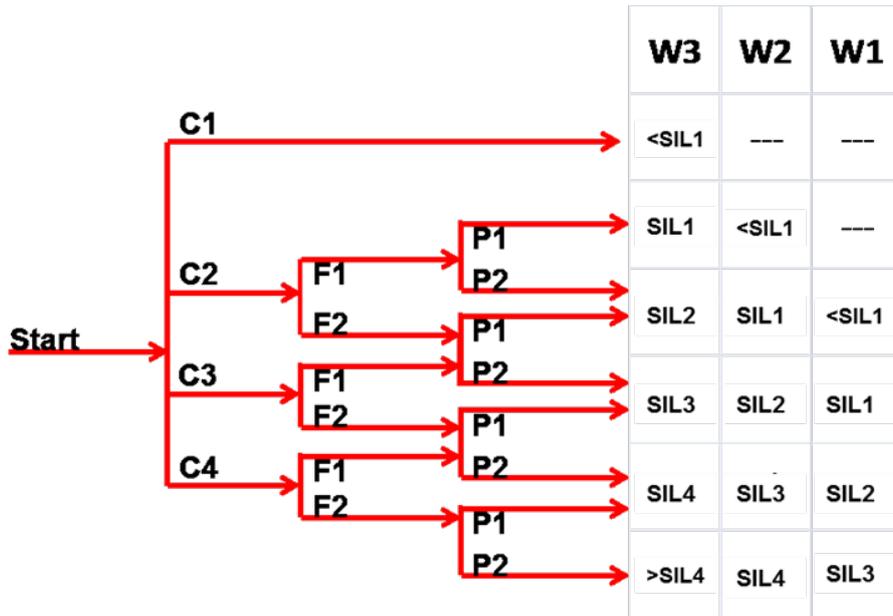
An over-pressure protection system is to be installed on a longwall pump station at your mine. Over-pressurising of the hydraulic system due to malfunction of the pump control system is seen as a hazardous event with the potential for serious injury and/or death to workers if not adequately controlled.

- a) Use the risk graph method of AS61508.5 - 1999 *Examples of methods for the determination of safety integrity levels* to determine the Safety Integrity Level (SIL) required of the over-pressure protection system for the longwall pump station at your mine. (2 marks)

You may assume that:

- Over-pressurisation due to a malfunction of the pump control system is an infrequent event. Only one (1) such event has been recorded across the company’s five (5) mines in the last year.
- Workers are infrequently in proximity of the pump station and hydraulic system and when they are, it is only for short durations.

- Pressure relief valves are also installed on the pump station and hydraulic system as an additional layer of protection. Many of the hydraulic parts and lines are also guarded.



C (Consequence) Parameter	Description
C1	Minor injury (non-permanent).
C2	Serious injury (non-permanent).
C3	Permanent disability or fatality.
C4	Multiple fatalities.
F (Exposure) Parameter	Description
F1	Rare to frequent exposure.
F2	Permanent exposure or almost permanent exposure.
P (Avoidance) Parameter	Description
P1	Avoidance is possible under certain conditions (eg. independent facilities are provided to alert exposed persons, independent facilities are provided to shut-down the plant, danger is easily recognised and there is sufficient time for persons to escape the hazard, or actual safety experience indicates that avoidance is possible.).
P2	Avoidance is not possible or is almost impossible.
W (Demand) Parameter	Description
W3	Function is demanded more than once per year.
W2	Function is demanded less than once per year but more than once per 10 years.
W1	Function is demanded less than once per 10 years.

- Is the over-pressure protection system a “low demand” or “high demand” safety function? Explain your reasoning. (2 marks)
- Should the over-pressure protection system be designed to be independent of the pump control system? Explain why, or why not. (2 marks)
- Sometime after the over-pressure protection system is installed the Longwall Superintendent wants to increase its proof-testing interval (the interval at which a test is done to confirm that the system is operating correctly and that no hidden failures are present that would prevent its correct operation when demanded).

Explain briefly to him the potential effect of this on the safety integrity of the over-pressure protection system and overall plant safety.

How would you determine if his proposed increase in proof-testing interval is allowable, given the original SIL allocation? (4 marks)

Question 4 (10 marks)

The following questions relate to the Work Health and Safety Regulation 2011 (the "Regulation").

Part 4.7 of the Regulation places specific obligations on a person conducting a business or undertaking (PCBU) with regard to electrical safety in workplaces.

With regard to this part of the Regulation:

- Would the AC drive system in an off-road electric-drive dump truck be considered electrical equipment? (1 mark)
- Is installing conduits for power cables into trenches considered electrical work? Is mounting a switchboard onto a brick wall considered electrical work? (1 mark)
- What conditions prescribe when a PCBU must ensure inspection and testing of equipment supplied through a socket-outlet is undertaken? (3 marks)
- According to the Regulation, what steps must be taken prior to undertaking electrical work on energised electrical equipment? (4 marks)
- What are the key requirements for the tools and testing equipment employed when undertaking electrical work on energised electrical equipment? (1 mark)

Question 5 (10 marks)

The following questions relate to AS/NZS3800:2012 Electrical equipment for explosive atmospheres - Repair and overhaul (the "Standard") and the Work Health and Safety (Mines) Regulation 2014 (the "Regulation"). Draw a typical cross sectional diagram of a type 245.1 Trailing Cable and identify the critical design features of the cables; including internal cores, insulation and screening.

Explain why it is designed in this manner. (4 marks)

- When considering explosion-protected electrical equipment installed in a surface gas drainage plant, must this equipment be overhauled or repaired only by a licenced workshop? (1 mark)
- Who is responsible for ensuring an underground coal mine only uses a workshop licenced to undertake overhauls of explosion-protected electrical equipment? (1 mark)
- According to the Standard, when should overpressure testing be undertaken? (1 mark)
- According to the Standard, is it permissible for Group I equipment be overhauled to the standard against which the equipment was certified? (1 mark)
- According to the Standard, where an overhaul facility is intending to omit tests on overhauled equipment that are required under the Standard, what should the facility do? (2 marks)
- According to the Standard, what documentation is required to be obtained from the end-user or manufacturer for the repair or overhaul of the equipment? (2 marks)
- According to the Standard, what should be included in the job report prepared for the end user? (2 marks)

Question 6 (10 marks)

You are in the process of designing a new power supply to three buildings on your site. The supply will be 11kV to a 1MVA (11kV/415V) transformer with an impedance of 6%. The design has considered additional loads from this transformer in the future with only one building being constructed now and two more in future years.

- Determine what the maximum possible fault level at the 11kV transformer would be. (2 marks)
- What would be the short circuit current on the secondary side of the transformer? (2 marks)
- The 415V secondary supply will be via a 240mm² PVC/PVC cable 80m from the building. Given that (V_c) for this cable is 0.210 mV/Am, calculate the expected voltage drop over this length of run. (2 marks)
- Will the voltage drop calculated in part (c) above, be within the guidelines of the requirements of AS/NZS 3000:2007 – Electrical installations (Australian/New Zealand Wiring Rules) giving reasons to support your answer? (2 marks)

- e) What in this installation would you consider to dictate the circuit breaker rating on the secondary side of the transformer for the building supply? (1 mark)
- f) What electrical protection would you specify (as a minimum) on the supply to the building? (1 mark)

CEE2 Legislation and standards applicable to underground coal mines

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Question 1 (10 marks)

The following questions relate to AS/NZS 60079.1:2007 – *Explosive atmospheres - Equipment protection by flameproof enclosures 'd'* (the "Standard").

- a) With reference to the Standard, explain your understanding of the following terms:
 - i. Flameproof enclosures "d" (2 marks)
 - ii. Width "L" of a flameproof joint (1 mark)
 - iii. The distance "I" of a flamepath (1 mark)
 - iv. Gap "i" of a flamepath (1 mark)
- b) With reference to part (b)(iv) above, how is the gap "i" of a flamepath different for cylindrical joints? (2 marks)
- c) With reference to the Standard, explain "pressure piling" and what the effects of it are. (2 marks)
- d) Explain the "over-pressure test" and what it is made up of. (1 mark)

Question 2 (10 marks)

As the electrical engineer nominated to perform the statutory function of electrical engineering manager by a mine operator of an underground coal mine in NSW, you are required to manage the electrical systems attached to diesel engine powered machines used within your operation.

The Plant Design Registration Diesel Engine System (DES) of these machines contains "Conditions of Registration" which include electrical requirements for the machine operation.

- a) Identify the type of electrical equipment referred to under this registration? (4 marks)
- b) Identify the operating requirements for this equipment under this registration. (6 marks)

Question 3 (10 marks)

The following questions relate to the *Work Health and Safety Act 2011* (the “Act”)

- a) With regard to the management of risk, section 17 of the Act imposes what duty? (2 marks)
- b) According to section 18 of the Act, what matters should be weighed up in determining what is “reasonably practicable”? (4 marks)
- c) According to section 19(3) of the Act, which relates to “primary duty of care”, what must a person conducting a business or undertaking (PCBU) ensure? (4 marks)

Question 4 (10 marks)

Life cycle management of electrical explosion-protected equipment is a requirement for all underground coal operations within NSW, as identified in *Work Health and Safety (Mines) Regulation 2014*, schedule 2, “Principal control plans – matters to be addressed”.

As the electrical engineer nominated to perform the statutory function of electrical engineering manager by a mine operator of an underground coal mine you have this requirement high on the priority list for your operation.

NSW Department of Primary Industries (DPI) Technical Reference EES003 – “Practices for the Life Cycle Management of Explosion Protected Equipment” identifies guidance for aspects of life cycle management of electrical explosion-protected equipment in a mining environment. The following questions relate to this industry reference document.

- a) In the “Purpose” section of the reference document, there are eight (8) risks that the practices are designed to protect. State six (6) of these risks. (3 marks)
- b) Chapter two (2) of the reference document identifies a number of areas, which when followed, will ensure compliance with the *Work Health and Safety (Mines) Regulation 2014*. Section 2.10 relates to the “Maintenance of electrical explosion protected equipment at the mine”. There are nine (9) control measures within that part that need to be considered when specifying site maintenance requirements. State six (6) of these measures. (3 marks)
- c) The reference document identifies “Portable electrical apparatus”. Identify the critical controls in place at your mine for the use of this type of equipment underground or in a “hazardous zone”. (4 marks)

Question 5 (10 marks)

The following questions relate to AS/NZS 2290.1:2014 – *Electrical equipment for coal mines – Introduction, inspection and maintenance for hazardous areas* (the “Standard”).

- a) Does the *Work Health and Safety (Mines) Regulation 2014* require compliance with the Standard? (1 mark)
- b) According to the Standard:
 - i. What processes should be followed to determine the accessibility of components in determining an inspection strategy for equipment? (1 mark)
 - ii. What processes should be followed to determine the frequency of periodic inspections on electrical equipment installed in “hazardous areas”? (1 mark)
 - iii. What is the purpose of a pre-overhaul audit? (1 mark)
 - iv. For Exd electrical equipment, what checks should be included in an external inspection? (3 marks)
 - v. For Exe electrical equipment, what checks should be included in an internal inspection? (3 marks)

Question 6 (10 marks)

The following questions relate to the *Work Health and Safety (Mines) Regulation 2014* (the “Regulation”).

Clause 72 of the Regulation states the requirements for “Control and monitoring of methane levels” for an underground coal mine.

- a) Clause 72 (3) requires a mine operator to ensure particular methane monitoring plant is provided at the mine.
There are five (5) requirements of this clause, identify four (4) of them. (4 marks)
- b) Clause 72 (6) requires the mine operator to ensure face machines in use at the mine to be equipped with a continuous methane monitor.
- i. Describe what a “face machine” is in terms of the Regulation. (2 marks)
 - ii. State the requirements for this clause (1 mark)
 - iii. This clause requires the continuous methane monitor to give an audible or visual alarm if the concentration of methane in the “general body of air” reaches a particular level. State this level. (1 mark)
 - iv. This clause requires the continuous methane monitor to cut the supply of power to the face machine if the concentration of methane in the “general body of air” reaches a particular level. State this level. (1 mark)
 - v. This clause requires the continuous methane monitor to cut the supply of power to the face machine if the concentration of methane “in the air close to the heads of the face machine” reaches a particular level. State this level. (1 mark)

Question 7 (10 marks)

The following questions relate to AS/NZS 3800 – *Electrical equipment for explosive atmospheres - Repair and overhaul* (the “Standard”).

This “scope” of the Standard is described as follows:

“(a) specifies requirements for and gives instructions, principally of a technical nature, on the repair, overhaul, reclamation and modification of equipment designed for use in explosive atmospheres;

(b) is not applicable to maintenance, other than when repair and overhaul cannot be disassociated from maintenance, neither does it give advice on cable entry systems which may require a renewal when the equipment is re-installed;

(c) prevents overhaul without manufacturer and certificate documentation to types of protection ‘i’ and ‘m’; and

(d) assumes that good engineering practices are adopted throughout.”

- a) List two circumstances where a flameproof enclosure must be over-pressure tested. (2 marks)
- b) When over-pressure tests are required for group 1 (coal mines), what pressure is used and for how long? (2 marks)
- c) The standard defines a “responsible person” associated with an overhaul workshop. Explain your understanding of the role of this person. (2 marks)
- d) What does the symbol “X” mean on a certificate of conformity? (1 mark)
- e) Before sending an Ex d enclosure to an overhaul workshop, what would you confirm? (1 mark)
- f) What does the Standard discuss when after repair, overhaul, alteration, or modification, the equipment is changed such that it no longer conforms with the type of protection standards or certificate documentation? (2 marks)

Question 8 (10 marks)

The following questions relate to AS/NZS 4871:1 – 2012 *Electrical equipment for mines and quarries* (the “Standard”).

The Standard discusses the need for interlocking to be fitted in certain circumstances. As the electrical engineer nominated to perform the statutory function of electrical engineering manager by a mine operator:

- a) How would you determine when interlocking would be required on your site? (1 mark)
- b) What factors should be considered when determining if, and when, interlocking is required? (4 marks)
- c) What specifically, should be covered in the design of covers giving access to live conductors above extra low voltage? (2 marks)
- d) Name three (3) types of acceptable interlocking methods. (3 marks)

Question 9 (10 marks)

Schedule 2 of the *Work Health and Safety (Mines) Regulation 2014*, "Principle control plans- matters to be addressed", outlines the requirements of the electrical control plan.

Within the extract of Schedule 2 below, fill in the missing words in the spaces.

(10 marks in total, with ½ mark per missing word).

3 Electrical engineering control plan

- (1) The mine _____ must, in preparing an electrical engineering control plan, take the following into account in determining the means by which the mine operator will manage the risks to health and safety from electricity at the mine:
 - (a) the overall _____ of the electrical aspects of plant and electrical installations at the mine,
 - (b) the _____ of electrical safeguards used at the mine to protect persons from electrical or other hazards,
 - (c) the electrical engineering and electrical work practices to be employed at the mine,
 - (d) the _____ required by workers to safely work on electrical plant or electrical installations at the mine.
- (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 taking into account the matters set out in subclause (3):
 - (a) injury to persons caused by _____ or _____ contact with electricity,
 - (b) injury to persons caused by working on electrical plant or electrical installations,
 - (c) the unintended initiation of _____ or _____ explosions,
 - (d) the _____ operation of plant,
 - (e) the occurrence of uncontrolled fires.
- (3) The following matters must be taken into account when developing a control measure referred to in subclause (2):
 - (a) the _____ of the electrical plant and electrical installations at the mine,
 - (b) (b) the _____ and _____ of plant for the prospective electrical fault level, electrical load, operating frequency, operating voltages and arc fault control,
 - (c) the design and operation of any electrical plant that contains flammable liquid,
 - (d) (d) the carrying out of the _____, installation and use of electrical cables and electrical cable accessories at the mine,
 - (e) the control of static electricity at the mine, including preventing the ignition of flammable gas,
 - (f) the impact of lightning on the mine (especially on an underground mine) including the effect on electrical systems,

- (g) the need for _____ circuit interruption for all points in the mine's electrical distribution system when faults occur taking into account the operating time and tripping current of circuit protection devices,
- (h) the type of _____ system used, including levels of earth fault limitation,
- (i) the potential for persons to contact electricity indirectly,
- (j) the prospective _____, step and transfer 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 (including the mine 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 welding plant,
 - ii. (ii) the use of electrical _____ instruments,
 - iii. work near overhead power lines and cables,
 - iv. the treatment of electric shocks and electric burns,
 - v. accessing and working on _____ 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 _____ and maintenance of the mine's electrical control system software and control circuits,
- (q) the use of lasers and fibre optic equipment at the mine,
- (r) the construction, installation and maintenance of battery powered vehicles and battery charging stations at the mine,
- (s) the supply of electricity in hazardous atmospheres and, in the case of underground coal mines, in hazardous zones,
- (t) the use of electrical plant 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 automatically detect an electrical fault in a circuit and disconnect the supply of power to the circuit.

Question 10 (10 marks)

The following questions relate to AS3012:2010 – *Electrical installations – Construction and demolition sites* (the "Standard").

- a) How is compliance with the Standard required? (1 mark)
- b) What are the specific installation requirements relating to the use of switchboards installed for the purpose of construction and demolition sites? (3 marks)
- c) Produce an electrical drawing for a single-phase generator installation with integral RCD-protected multiple socket outlets. Show the necessary protection devices. (5 marks)
- d) What is different about the construction wiring in relation to the installed permanent wiring? (1 mark)

Question 11 (10 marks)

The following questions relate to AS/NZS 3000:2007 – *Electrical installations (Australian/New Zealand Wiring Rules)* (the “Standard”).

The Standard describes the requirements for the protection of overcurrent in electrical installations.

- Draw a simple time-current curve showing the typical characteristics of a circuit breaker, fuse, as well as the damage curve of a cable on the one graph. (4 marks)
- What is the principle of “Automatic disconnection of supply” as described in Appendix B Circuit Protection Guide of the Standard? (2marks)
- What is the maximum touch voltage that may be sustained by a person indefinitely? (2 marks)
- What are the mean tripping currents for Type B, C and D circuit breakers as described in Appendix B Circuit Protection Guide of the Standard when discussing automatic operation of the protective device? (2 marks)

Question 12 (10 marks)

The following questions relate to Intrinsic safety concepts and AS/NZS 60079.11: 2011: *Explosive atmospheres – Equipment protection by intrinsic safety ‘i’* (the “Standard”).

In a NSW underground coal mine, can a Group II IS device be used in a hazardous zone? Justify your answer. (1 mark)

- In a NSW underground coal mine, can a Group II IS device be used in a hazardous zone? Justify your answer. (1 mark)
- What is the definition of “associated apparatus”, and what would be an example of “associated apparatus” as defined in the Standard? (2 mark)
- Further to part (b) above, what issues must be addressed with the use of “associated apparatus” in a hazardous zone? (1 mark)
- According to the Standard, what is considered to be a “simple apparatus”? (2 marks)
- Considering the following table, can the IS field device be connected and used with the IS interface in a hazardous zone of a NSW underground coal mine? Provide a detailed justification of your decision (2 marks)

Item	IS interface	IS Field Device	Connecting Cable
Equipment Group	I/IIC	I/IIB	
Level of Protection	ia	ia	
Temp Classification		T3	
Ambient Temp	45deg	45deg	
Voltage	$U_o = 12V$	$U_i = 13.2V$	
Current	$I_o = 90mA$	$I_i = 120mA$	
Power	$P_o = 900mW$	$P_i = 1.2W$	
Capacitance	$C_o = 100nF$	$C_i = 1nF$	$C_c = 1nF/m$
Inductance	$L_o = 10mH$	$L_i = 4uH$	$L_c = 10uH/m$
L/R Ratio	$L_o/R_o = 54uH/ohm$		$L_c/R_c = 100uH/ohm$

- When considering *only* the inductance and capacitance parameters of the devices and the interconnecting cable, what would be the maximum length of cable? (2 marks)

END OF QUESTIONS

END OF EXAM

More information

Business Processes & Authorisations

Phone: 4931 6625

Acknowledgments

Electrical engineering manager/Electrical engineer examination panel

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