Electrical Workers Registration Board
SAFETY | COMPETENCY | COMPLIANCE

Teaching Guidelines for Electrician

Examination Prescriptions for Theory and Regulations Tuition and Practical Skill Assessments

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government
Te Kāwanatanga o Aotearoa

Electrical Workers Registration Board
SAFETY | COMPETENCY | COMPLIANCE

More information

Information, examples and answers to your questions about the topics covered here can be found on our website: **www.mbie.govt.nz**

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1. Introduction

Under the Electricity Act the Electrical Workers Registration Board (the Board) has a responsibility to set the registration criterion and ensure that all persons applying for electrical registration are competent.

Electrician examination prescriptions in these teaching guidelines are structured around the agreed essential capabilities. This document has been prepared to assist tutors in the development and delivery of courses for trainees and candidates who need to complete any or all of the requirements to be eligible to apply for registration as an Electrician.

- capstone testing – pass the Electrician Theory Examination and the Electricians Regulations Examination
- the electrician three-stage practical skill assessment programme or an electrician practical examination.

Tuition provided for theory or Regulations or the practical skill assessment must cover **all** of the subject matter in the relevant part of this document.

2. Scope

Theory and Regulations prescriptions are for capstone examination purposes and incorporate the essential capabilities for electrician registration.

Candidates undergoing tuition in accordance with these prescriptions should receive the full range of theory and regulations tuition either by:

- completing a Board-approved competency-based training programme, or
- completing training under an experience pathway in New Zealand; or
- completing registration requirements as an overseas-trained electrical worker

3. Electrician Registration Requirements

To be eligible for registration as an Electrician, an applicant must provide evidence that they have:

(a) passed a Board-approved Electrician theoretical written examination; and

(b) passed a Board-approved Electrician regulatory written examination; and

(c) passed a Board-approved Electrician practical examination; and

(d) **either**

- completed 4 years practical work experience and on job training in carrying out PEW that is satisfactory to the Board; **or**
- held registration as an Electrical Installer for a period not less than one year and completed not less than one year practical experience in the PEW of an Electrical Installer;

(e) **or**, in place of (a) to (d) inclusive:

- completed a Board-approved Electrician competency-based training programme (if available).

4. Limits of work

An Electrician may, subject to the limitations set out below, carry out the following:

- Carry out PEW on installations, works and appliances.
- Test any PEW of the type they are authorised to carry out.
- Certify any PEW of the type they are authorised to carry out.
- Supervise one or two persons at one time to carry out PEW.

Limitations

An Electrician must **not**:

- Inspect PEW
- Carry out PEW in a mining operation, hazardous area, medical cardiac protected area or mains parallel generation system
- Supervise more than two persons at one time to carry out PEW.

5. Examination Prescriptions

5.1 Electrician Theory Examination

The Electrician theory examination will cover any aspect of the theory prescription allocated with A or B knowledge designations and may also contain elements with C or D designations.

In addition, theory examination questions will contain aspects of the regulations prescription that a candidate is expected to know without the need to directly access references from Regulations or Standards.

For example, the minimum acceptable insulation resistance values for an electrical installation (as required in section 8 of AS/NZS 3000) may be incorporated into a theory question relating to insulation resistance testing of low voltage electrical installation. Likewise, the maximum leakage current values and tripping times for RCDs affording protection against electric shock (as prescribed in regulation 24).

However, where candidates are required to solve questions that involve calculations specifically relating to selection of cables, extracts from the relevant Standard/s will be included in that examination.

5.2 Electrician Regulation Examination

Questions will cover any of the aspects of the electrician regulations prescription. It may also include some aspects of underpinning electrical theory knowledge necessary to understand and apply a Regulation or a Standard.

For example, an understanding of electrical instrument testing procedures is required to carry out insulation resistance testing **or**, in service testing of RCDs on an electrical installation and may be incorporated in questions on testing to comply with the Electricity (Safety) Regulations 2010 and section 8 of AS/NZS 3000 and any additional requirements cited in the relevant Companion Standards.

6. Practical Skills Assessment

To ensure that applicants for registration are competent, a three-stage practical skill assessment incorporates the essential capabilities and practical skills.

Note: The three-stage practical assessment is applicable to electrician, electrical installer and electrical engineer registration class applicants.

7. Safety

Safety must be promoted at all times, whether it be classroom tuition, carrying out practical exercises or practical skill assessments.

Safety applies not only to tutors, assessors and candidates, but also to others who may in future depend on the candidate's standard of workmanship and competency.

8. Definitions

Unless the context otherwise requires, within these guidelines:

Term	Definition
Act	means the Electricity Act 1992
Code or ECP	means New Zealand Electrical Code of Practice issued under Part IV of the Act
Regulation	means the Electricity (Safety) Regulations 2010
Standard	means as the case may be: • AS/NZS3000 and companion Standards as cited in Schedule 2 of the Electricity (Safety) Regulations 2010, being o A New Zealand Standard (NZS) o An Australian Standard (AS) • A Joint Australian / New Zealand Standard (AS/NZS) • A British Standard (BS) • An International Electro-Technical Commission Standard (IEC) • An International Standards Organisation (ISO)

Interpretations and terms are also defined in the Electricity Act 1992, Electricity (Safety) Regulations 2010 and AS/NZS 3000 incorporating any applicable amendments.

9. Reference texts

(a) The Electricity Act 1992

(b) The Electricity (Safety) Regulations 2010

(c) EWRB Supervision Companion Guide

(d) AS / NZS 3000 electrical installations (known as the Australian/New Zealand Wiring Rules) including Amendments.

9.1 Legislation

(a) The Electricity Act 1992 and the Electricity (Safety) Regulations 2010.

(b) Standards cited in Schedule 2 of the Electricity (Safety) Regulations 2010

10. Theory

Subject matter for Electrician training is based on essential capabilities incorporating critical items. Critical items are allocated A and B knowledge designations.

Letters “A”, “B”, “C” and “D” appearing in the right-hand margin represent levels of knowledge candidates are expected to attain by completing Board approved courses of study – designations are as follows.

Knowledge Level	Description
A	Thorough knowledge
B	Good working knowledge
C	General knowledge
D	Basic understanding

11. Basic Electrical Theory

(a)	Demonstrate how energy is converted through heat, chemical, magnetic and mechanical processes.	**C**
(b)	Demonstrate knowledge of Ohm’s law, material resistivity, resistor parameters, and introduction to measuring methods.	**C**
(c)	Demonstrate knowledge of how electrical energy is produced from various forms of energy.	**C**
(d)	Explain the operation of a simple practical circuit including current path, circuit control, load, EMF source and conductors.	**C**
(e)	Determine the resistance, voltage and power in any part of a d.c. series and/or parallel circuit using practical knowledge and safe use of measuring instruments.	**C**

12. Systems of Supply

12.1 New Zealand Electrical Supply System

(a)	Illustrate with labelled diagrams the New Zealand electrical supply system showing the generation, transmission and distribution systems.	**A**
(b)	State the typical voltages involved in each of the above areas.	**B**
(c)	Draw and label the three phase four wire New Zealand distribution system to show how it can be used to supply: • a three phase consumer • a two phase consumer • a single phase consumer	**A**
(d)	State the relationship between line and phase voltages and line and phase currents for both star and delta connections.	**A**
(e)	State the advantages of balancing the load over the three phases.	**A**
(f)	Calculate the power in a three phase load	**B**
(g)	Determine the neutral current in a three phase star connected load	**B**

12.2 Multiple Earth Neutral System

(a)	Explain how the MEN system of supply in New Zealand is configured.	**A**
(b)	Explain reasons for earthing the neutral at multiple points.	**B**
(c)	List the features of the multiple earth neutral (MEN) system used in New Zealand.	**B**
(d)	Explain the implications of a missing MEN link in an installation during fault conditions in respect to; line voltage to earth, fault current path, earth loop impedance and operation of protective devices.	
(e)	Distribution type system – explain that an alternative system (e.g. distribution system) can be connected downstream of the MEN system.	**A**

13. Electrical Protection

13.1 Protection

(a)	State what is meant by the terms rated current and excess current protection.	**A**
(b)	Describe the danger of excess current to cables and equipment.	**A**
(c)	State forms of excess current protection:	**A**

	• close excess current protection • coarse excess current protection.	
(d)	Explain the following terms applicable to sub-circuit protection: • voltage rating • current rating • utilisation categories – that replace fusing factors • breaking capacity and kVA rating.	**A**
(e)	Describe, with the aid of labelled diagrams the construction, operation principles and applications of the following protective devices: • semi-enclosed rewirable fuses (installed in existing installations) • HRC fuses labelling in accordance with BS88:1998, IEC and AS/NZS 60269 • miniature circuit breakers • cartridge fuses • fusible links • magnetic overload relays • thermal overload relays.	**A**
(f)	Understand and explain the following terms as related to protective devices: • current rating • voltage rating • fusing current • utilisation category • tripping factor • cut-off characteristic • time versus current characteristic • category of duty • discrimination • back-up protection • rupturing capacity • prospective short-circuit current • sensitivity • earth-fault loop impedance.	**A**

13.2 Residual current devices (RCDs)

(a)	Understand that RCDs provide supplementary protection for users of electrical appliances and equipment.	**A**
(b)	Demonstrate knowledge of the maximum tripping current and operating times for RCDs to be deemed electrically unsafe (see regulation 24).	**A**
(c)	Explain the checking and testing requirements to ensure that RCDs installed for protection against shock are type A for New Zealand.	**A**
(d)	Understand the operating principles of an RCD.	**A**

(e)	Be aware of how RCDs are classified including: • method of operation • type of operation • number of poles and current paths • possibility of adjusting the residual operating current • resistance to unwanted tripping due to voltage surges • behaviour of the presence of d.c. components • protection against external influence • method of mounting • method of connection	**A**
(f)	Understand the operational characteristics of RCDs and how different types of the available RCDs operate including: • residual current-operated circuit breakers (RCCB) • residual current-operated circuit breakers with over current protection (RCBO) • socket-residual current protection devices (SRCD) • portable residual current protection devices (PRCD) • RCDs functionally independent of line voltage (used in residential type switchboards and SRCDs) • RCDs functionally dependent on line or auxiliary voltage (used in PRCDs) • typical residual current ratings • classification of RCDs according to the presence of d.c. components • load leakage currents.	**A**
(g)	Methodologies for installing RCDs in residential situations, industrial and commercial situations, single phase and three phase.	**A**
(h)	Understand and apply the principles relating to protection for safety in AS/NZS 3000 and the role RCDs can play in protection for additional safety in damp situations.	**A**
(i)	Understand and apply the requirements of • AS/NZS 3000 regarding the installation of RCDs in domestic and residential premises • regarding the use of RCDs with hand-held electrical appliances..	**A**
(j)	Understand the considerations of installing 10 mA RCD for protecting areas of increased risk and children against electric shock as detailed in AS/NZS3000	**A**
(k)	Testing RCDs to ensure compliance with regulation 24.	**A**

13.3 Isolating Transformers

(a)	Describe the basic operating principle of an isolating transformer.	**B**
(b)	Explain why the isolating transformer provides maximum safety when used with only one electrical appliance connected.	**A**
(c)	Explain why it is necessary, when two or more electrical appliances are connected simultaneously to one isolating transformer, their earth continuity conductors are bonded together at the transformer but must not be earthed.	**B**

(d)	Understand that the isolating transformer may be used in conjunction with other approved safeguards for extra protection where considered desirable.	**C**
(e)	Explain why transformers are rated in kVA and not watts.	**C**

14. Electrical Safety – Personal

14.1 Effects of Current

(a)	Demonstrate knowledge of the physiological effects of electricity on humans.	**A**
(b)	Explain: • Why peak voltages are an important consideration in respect to insulation resistance values providing protection from exposure to electric shock. • The danger of simultaneously contacting active (phase) and neutral or active (phase) and earth conductors. • The effects that varying values of voltages, current, duration of contact and other conditions (wet or punctured skin, etc) have on the severity of electric shock received by the victim.	**A**

14.2 Isolation Procedures

(a)	State the benefits of working equipment that has been isolated.	**A**
(b)	Explain the SAFETY TAG system.	**A**
(c)	State the benefits of using the safety tag system to promote safety in the workplace.	**A**
(d)	Explain methods employed to isolate and “lock off” equipment. The importance of using danger tags when working on equipment which may become live.	**A**
(e)	Explain the importance of the PROVE TEST PROVE safety rule, and the benefits of TESTING before touch to prevent electric shock.	**A**
(f)	Explain the conditions covering the use of SAFETY TAGS, their correct placement and removal procedures.	**A**
(g)	Detail written isolation procedures.	**A**

14.3 Legislative Requirements for Workplace Safety

(a)	Understand that employers are required by legislation to provide and maintain equipment and PPE supplied for employees use in a safe condition.	**B**
(b)	Understand that employees must use the PPE supplied by the employer and comply with all employer established safety procedures.	**B**

14.4 Safe Working Practices

(a)	Explain that it is essential to identify hazards and potential hazards and take appropriate steps to eliminate, isolate or minimise the hazard risk by observing safety measures at all times to ensure the safety of: • Electricians, electrical workers or electrical trainees • other workers in the area • members of the public • equipment and property.	**A**
(b)	Explain that Electricians are required to be conversant with the Electricity Safety Regulations to be competent.	**A**
(c)	Explain the importance of using the correct tools, clothing and equipment that is appropriate for the job and being trained to competently use any specialised equipment required.	**A**
(d)	Explain the importance of preliminary safety checks and observing proven safety rules when working at height and when ladders and scaffolding are involved.	**A**
(e)	Understand that good housekeeping and tidy work habits promote a safety culture in the workplace.	**A**
(f)	Explain that personal protective equipment (PPE) such as covers, mats, gloves, safety harnesses, insulated tools and glasses or goggles are required to be manufactured to an approved safety standard.	**A**
(g)	Explain that regular checks are required to retain the integrity of the safety equipment.	**A**
(h)	Explain why it is necessary to use insulated tools of an approved type when working on electrical fittings.	**A**
(i)	Explain that when working in outdoor or damp situations it is important to supply electrical appliances from either an isolating transformer or from an RCD.	**A**
(j)	Detail the dangers when working with metal ladders, tape, tools and the like on or near electrical supplies or equipment.	**A**
(k)	Explain the dangers of working in explosive atmospheres and stress the importance of ensuring that all electrical equipment is correctly isolated before removing any covers.	**A**
(l)	Explain the procedures when a fire is discovered.	**A**
(m)	Explain the procedures for rescue of a person or persons in contact with live conductors or equipment.	
(n)	Detail the types of fire extinguishers that are suitable for use on electrical fires and explain how each type is used.	**A**
(o)	Detail the dangers and hazards involved when working on high voltage fittings.	**A**
(p)	Explain the precautions necessary when working on circuits which have capacitors connected or other sources of stored energy.	**A**
(q)	Detail the requirements and the need for the presence of a second competent person, in situations where a danger or a potential risk exists.	**A**

(r)	Explain the dangers and hazards associated with short circuits and where potentially high prospective short circuit currents could be present.	**A**
(s)	Understand concepts associated with working in the vicinity of high voltage equipment, distribution systems and exposure to risk from step and touch potentials, induced voltages, creepage and inadequate clearances.	**B**
(t)	Explain that electrical arcing exposes the victims of electric shock to additional hazards: arc eye and serious burns.	**A**
(u)	Explain that electricians are not permitted to work on live high voltage lines or equipment without written approval of the asset owner.	**A**
(v)	Explain that under Schedule 1(2) electricians are however permitted to operate works, electrical installations, switching of works, etc., if they are deemed competent to undertake such work having received training, instruction and approval from the asset owner.	**B**

15 Transformers and their Applications

15.1 General

(a)	Explain the principles of operation for the double wound transformer and the autotransformer.	**B**
(b)	State the formulae and perform transformer calculations involving voltage ratios, current ratios, turns ratios and kVA ratings.	**B**
(c)	Describe the basic construction of a power transformer.	**C**
(d)	Explain why the low voltage windings are generally placed closest to the core and why special additional insulation separates them from the high voltage winding.	**D**
(e)	Explain the terms ‘iron losses’ and ‘copper losses’ and the practical methods of reducing these losses.	**D**
(f)	Explain that the kVA rating of a transformer is limited by the temperature of the core and windings.	**B**
(g)	Describe the methods employed to dissipate the heat energy from the cores and windings of various transformer types	**C**
(h)	Describe the effect of the load current on the secondary terminal voltage of a transformer.	**C**
(i)	Explain the term “regulation” as applied to transformers.	**D**
(j)	Explain that the regulation of a transformer can be maintained by incorporating tap changes.	**D**

(k)	Explain how the primary and secondary windings of a three phase transformer are configured to achieve these four basic combinations: • star – star • star – delta • delta – star • delta – delta	**B**

15.2 Voltage Transformers

(a)	Describe a voltage transformer, its operation and applications.	**C**
(b)	State the common secondary voltages of a voltage transformer when supplied at its full primary voltage.	**C**
(c)	Using typical symbols, show how voltage transformers would be represented on diagrams.	**C**

15.3 Current Transformers

(a)	Describe the current transformer, its operation and applications.	**C**
(b)	Explain the term 'Burden', as it relates to current transformers	**C**
(c)	State the common secondary current ratings of current transformers	**C**
(d)	Using typical symbols, show how CTs would be represented on diagrams.	**C**
(e)	State the precaution that must be taken before disconnecting the load from a current transformer.	**A**

16. Selection of Cables

(a)	Explain that the cable selection process involves factors such as the current and voltage rating, environmental conditions, length of run, earthing requirements, mechanical factors and additional considerations including derating factors and prospective short circuit currents.	**A**
(b)	Provide examples and explain how a cable is chosen for a stated application considering all of the above factors.	**A**
(c)	Determine cable type and size required for a sub-circuit under specified load conditions, using the appropriate parts of AS/NZS 3000 and AS/NZS 3008.1.2 for a stated application.	**A**
(d)	Determine the maximum demand for domestic and non domestic mains and sub-mains in accordance with AS/NZS3000.	**B**
(e)	Determine the cable type and size of mains and sub-mains for given applications, including: **Cable Types**: • flexible (PVC, TPS, rubber-sheathed) • fixed wiring (TPS, conduit wire, neutral screened cable, XLPE, SWA) • underground • aerial	**A**

	In consideration of: • conductor material • maximum conductor temperature • air and soil ambient temperatures (de-rating and re-rating factors) • mechanical protection • installation method • maximum demand • length of run • grouping • current carrying capacity • short circuit capability • voltage drop • earth loop impedance.	
(f)	Demonstrate sound understanding of installation techniques for a wide range of "low voltage" cable types in accordance with AS/NZS3000 and AS/NZS3008.1.2 including: • enclosed in conduit • installed on a cable tray • clipped to the surface • underground wiring • aerial wiring. Considering such factors as: • conductor material • maximum conductor temperature • air and soil ambient temperatures (de-rating and re-rating factors) • mechanical protection • grouping • current carrying capacity • length of run • voltage drop limitations • earth loop impedance.	**B**
(g)	Candidates are expected to demonstrate a good appreciation for selecting the correct and appropriate protective device associated with the cable chosen for the stated application.	**B**

17. Switchboards and Isolation Devices

(a)	Define the terms 'mains switchboard', 'switchboard', and 'switchgear' with reference to the regulations interpretations and AS/NZS 3000.	**B**
(b)	Discuss the special requirements for main switchboards, MEN switchboards and distribution switchboards as per AS/NZS 3000.	**A**
(c)	Explain with reference to AS/NZS 3000 requirements for switchboards considering: • the location • access to the wiring and switchgear • protection against the spread of fire • environment and mechanical conditions • revenue metering (energy distributor) requirements • prospective short circuit current levels	**B**

	Explain the application of AS/NZS 3000 and the earthing requirements for MEN switchboards	**A**
	Describe the different types of fittings and accessories used as isolation devices for electrical circuits, located on switchboards	**C**

18. Basic Electronics and Semi-Conductor Devices

(a)	Explain the function, characteristics and typical applications of the following devices: • Diodes • Diacs • SCRs • Thermistors • Transistors • Zener diodes • Triacs	**C**
(b)	State that semiconductor devices are temperature sensitive and explain the methods of heat dissipation.	**A**
(c)	Explain that there is a possibility of damage occurring to semiconductor devices during insulation resistance testing.	**A**
(d)	Give examples of the causes of transient voltages on power supply circuits and explain how these can be minimised to prevent damage to semi-conductor devices.	**A**
(e)	Explain the term peak inverse voltage with respect to semiconductor devices.	**A**
(f)	Explain the differences between the semiconductor device and circuit conditions with respect to peak inverse voltage.	**A**
(g)	State that the PIV is referred to as V rrm.	**B**
(h)	Explain with the aid of diagrams the operation of a single diode as a half wave rectifier.	**A**
(i)	Explain with the aid of diagrams the operation of a single SCR as a controlled rectifier.	**C**
(j)	Explain with the aid of diagrams full-wave rectification using different transformer and diode arrangements on a single phase supply	**A**
(k)	Explain how a transistor is used as: • a switch • a common emitter amplifier	**C**
(l)	Explain with the aid of a diagram how a triac controls the load current in an a.c. circuit.	**B**
(m)	Explain with the aid of diagrams controlled full wave rectification on a single phase supply.	**C**
(n)	Explain with the aid of diagrams how three phase half and full wave rectification can be achieved using diodes and a suitable transformer.	**A**
(o)	Compare the output waveforms of all the above uncontrolled rectifiers in terms of smoothness of the output.	**C**
(p)	State that capacitors, chokes and resistors are used for filtering the output of rectifier circuits.	**A**

19. Purpose and Use of Test Instruments

(a)	Explain the purpose and give typical applications of the following types of test instruments: • Insulation resistance tester • Phase rotation meter • Voltmeter • Ammeter • Earth loop impedance tester • Ohmmeter • RCD tester	**A**
(b)	Explain how the above types of test instrument should be connected to test a circuit.	**A**
(c)	Detail any specific precautions required when using the above instruments.	**A**
(d)	Explain the importance of ensuring that the correct connections, functions and range are selected on the test instrument before it is used to test a circuit.	**A**

20. Testing of Installations, Appliances and Fittings

(a)	Explain that an Electrician should approach an installation for testing in both an orderly and logical manner.	**A**
(b)	Explain that visual and mechanical checks of the installation are required by AS/NZS 3000 prior to instrument testing. Explain that this is done to ensure that all the specific requirements for issuing compliance certification are satisfied.	**A**
(c)	Explain the specific tests that are required by AS/NZS3000 and state the test instrument type required to perform each of those tests.	**A**
(d)	Describe the methods of carrying out the tests specified in AS/NZS3000 stating the minimum and maximum values (where appropriate) that are acceptable.	**A**
(e)	Explain that specific installations have additional checks and test requirements as prescribed in the companion Standards listed in Schedule 2.	**A**
(f)	State that regulation 70 specifies the installation work requiring inspection by a registered electrical inspector prior to connection to the power supply.	**A**
(g)	State that all the tests of installation wiring work as detailed under regulation 65 and certification for compliance regulation 66 to 68 must be completed before connection to a power supply.	**A**
(h)	Detail and identify those fittings that form part of the installation which may be damaged by test voltages.	**B**
(i)	Explain the methods by which fittings can be either disconnected from the circuit under test or shorted out to prevent damage from the test voltages.	**B**
(j)	State the requirement that approvals are required before equipment can be connected to a power supply.	**B**
(k)	State that following repairs electrical appliances must be tested to ensure they are safe in accordance with the requirements of AS/NZS 5762 (regulation 90(2)).	**A**

21. Testing, Inspection and Certification

(a)	Define the terms: Testing; Certification and Inspection as prescribed in Schedule 1 of the Electricity Safety Regulations 2010.	**A**
(b)	List the types of installation work requiring testing and certification by a registered Electrician before connection to the supply.	**A**
(c)	List the types of installation work which can only be inspected by a registered electrical inspector.	**A**
(d)	List the installations that are subject to periodic inspections by electrical inspectors.	**B**
(e)	Explain who is responsible for performing the prescribed tests associated with the completion of the compliance documentation involving: • self-certification – work which does not require inspection • work requiring inspection – by a registered electrical inspector.	**A**
(f)	Understand that certifying prescribed electrical work means that the work: • is electrically safe and has been tested in accordance with the Standards cited in the Regulations • has been carried out in accordance with the Standards cited by the Regulations.	**A**
(g)	Describe how the tests for compliance are performed and state the values which are acceptable.	**A**
(h)	Understand that the Certificate of Compliance must be: • completed as soon as practicable and in no case later than three days of the work being completed, but no later than end of the day which the contract for the work terminates, and • one copy of the certificate must be given to the person for whom the work was carried out within 20 days of the certificate being completed, and • one copy of the Certificate must be retained for three years by the person certifying the work. A copy must be supplied to the Board within 20 working days of a written request from the Board.	**A**
(i)	State that wiring installation work is subject to audit by the Electrical Workers Registration Board to ensure worker competency.	**B**

22. Three-phase Motors and Starters

22.1 Three-phase motor construction

(a)	Describe the components of a three phase induction motor, i.e: • rotor - include differences between cage and wound types • stator windings • iron circuit.	**B**
(b)	Describe the frame types and ventilation methods available, giving typical applications for each type.	**B**

22.2 Three-phase Induction Motor Principles

(a)	Explain the principles of operation of a three phase induction motor in terms of the stator rotating field, rotor currents and flux, relative motion between the rotating field and rotor and the direction of rotor rotation.	**B**
(b)	Define the terms: • synchronous speed • slip speed (expressed as % of synchronous speed) • full load speed (N rotor).	**B**
(c)	Draw a torque/speed characteristic graph to explain relationship between slip, NS and NR.	**B**
(d)	Explain the effect that a reduction in supply voltage has on the line currents of a loaded induction motor.	**A**
(e)	Explain the effects on a three phase induction motor if one supply line is open circuited on: • star connected motor • delta connected motor.	**A**
(f)	Explain the effects on a three phase induction motor if one of the stator windings is reversed.	**B**
(g)	Explain how the winding reversal problem may be diagnosed and rectified.	**C**
(h)	Explain the effect of load on an induction motor's P.f. and efficiency.	**B**
(i)	Explain how capacitors are connected to three phase induction motors to correct the power factor and to reduce line current.	**A**
(j)	Explain how: • the direction of rotation is changed in a three phase induction motor • the windings of a three phase motor may be connected in either star or delta and the effects on voltage rating and power produced.	**B**
(k)	Explain the difference between starting current and run current for a three phase induction motor and how they may be calculated.	**B**
(l)	Solve problems involving three phase induction motors including: • true power, apparent power, reactive power • synchronous speed, full load speed, frequency and slip • output power, voltage, run currents, start current and P.f. for both star and delta connections. • Input power, output power, torque, efficiency and speed.	**B**

22.3 Three-phase Induction Motor Starters

(a)	Describe the protection a motor starter may provide and explain how this may be achieved.	**A**
(b)	Describe how phase reversal protection can be provided.	**A**

(c)	Describe the operation of a D.O.L. starter. Give advantages, disadvantages and applications for D.O.L. starters.	**B**
(d)	Explain why reduced voltage starting is required in some installations, including advantages and disadvantages.	**A**
(e)	Describe the operation of the following types of reduced voltage starters including advantages, disadvantages for specific applications: • Star – delta • Auto transformer • Primary resistance • Electronic (e.g. soft starting and wave chopping types).	**A**

23. Single Phase Motors

23.1 Single-phase Induction Motor Operation

(a)	Explain how a single-phase supply can be used to provide an alternating magnetic field.	**B**
(b)	Explain how phase splitting can be used to provide starting torque in a single-phase motor.	**B**

23.2 Types of Single-Phase Induction Motors

(a)	Describe the operation and construction of the following types of single phase induction motors. Include advantages, disadvantages, applications and reversal connections for each type: • split phase (resistance start) • capacitor start • permanently split capacitor (capacitor start and capacitor run) • capacitor start capacitor run (dual value capacitor).	**B**
(b)	Explain how external start relays may be used to start single phase induction motors. Include advantages, disadvantages and applications for each type.	**C**

23.3 Additional Single-Phase Motors

(a)	Explain the operation and construction of the following types of single phase motors – include the advantages and disadvantages, application, and reversal procedures for each type – universal, shaded pole, synchronous.	**B**
(b)	Explain methods of speed control for universal motors and state typical applications where universal motor speed control is employed.	**B**

24. Selection and Suitability of Motor Protection

(a)	Explain why electric motors may require protection against: • excess current • mechanical overload • under voltage • phase failure • phase reversal.	**A**
(b)	Describe the construction and operating principle of both thermal and magnetic overload units. • for the protection of three phase motors • for the protection of single phase motors.	**B**
(c)	Explain the use of the following protective systems: • phase failure • phase reversal • thermistor.	**C**
(d)	Explain back up protection and discrimination with respect to protecting motor circuits.	**B**

25. Alternators

(a)	Explain the basic construction of an alternator.	**B**
(b)	Describe and explain the various types of commonly used rotors.	**B**
(c)	Describe the types of prime movers.	**B**
(d)	Explain the basic principles of A.C. generation three-phase.	**B**
(e)	Explain the relationship between and perform calculations involving frequency, number of pairs of poles, and speed.	**B**

26. Prescribed Electrical Work Requiring Inspection

(a)	Explain that certain installation work requires inspection by a registered electrical inspector prior to connection to the power supply.	**A**
(b)	Detail the requirements of regulation 70 and list the installation work that requires inspection.	**A**
(c)	Explain that regulation 72 cites companion Standards that cover the inspection requirements for installation work in addition to AS/NZS3000.	**A**

27. Lighting

(a)	Define the following terms and state the unit: • luminous intensity • luminous flux • illuminance	**C**
(b)	List the essential components required to produce good illumination.	**C**
(c)	Explain that recommended and recognised minimum levels of illuminance are required for various work areas.	**B**
(d)	Explain the basic principles of operation of the following: • sodium vapour low pressure and high pressure • mercury vapour high pressure • metal halide • neon lighting • incandescent • fluorescent lighting low pressure mercury vapour • halogen	**C**
(e)	Compare the output efficacy, colour output, handling requirements, effects of vibration, ventilation of the above lamp types and practical applications, for each type.	**D**
(f)	Explain colour rendering and give practical examples of applications.	**A**
(g)	Explain the stroboscopic effect of discharge lamps and how this effect can be minimised.	**A**
(h)	Describe with the aid of a circuit diagram the operation of a single tube switch start type fluorescent fitting.	**B**
(i)	Describe the common faults that occur with single tube fluorescent fittings and explain how these are overcome.	**B**
(j)	Describe the hazards that are present with gas discharge lamps and their control circuits.	**A**

28. Regulations Examination Prescription

Regulations examinations are open book and cover any aspects of the Regulations Prescription. A prerequisite level of underpinning knowledge of electrical theory is also expected from candidates to demonstrate how regulations or a specific Standard is applied.

As stated earlier in the scope of this document the regulations examination is for capstone purposes and a means to establish competency.

The majority of examination questions will be sourced from primary reference documents designated with A and B knowledge levels and supported by supplementary questions from documents designated with C and D knowledge levels as follows:

(a)	The Electricity (Safety) Regulations 2010.	**A**
(b)	The Electricity Act 1992	**B**
(c)	AS/NZS3000 including Amendments.	**A**
(d)	AS/NZS3008.1.2 (Electrical installations – Selection of cables, typical New Zealand conditions)	**B**
(e)	AS / NZS 3012	**C**
(f)	AS / NZS 3019	**C**
(g)	AS / NZS 3760	**B**
(h)	AS / NZS 5761	**B**
(i)	AS / NZS 5762	**B**
(j)	NZECP 34	**A**
(k)	NZECP54	**B**

Supplementary questions will also be developed from Companion Standards and applicable New Zealand Electrical Codes of Practice (NZECPs) cited in Schedule 2 of the Electricity Regulations 2010.

(a)	Companion Standards	**C**
(b)	Additional NZECPs	**D**

29. Practical Tasks and Skills Assessment

During the course of practical instruction and assessment; stress the importance of understanding how practical skill tasks relate to “on the job” situations.

The candidate shall demonstrate an acceptable level of skill and competency in the practical skill tasks listed for Stages 1, 2, and 3.

29.1 Skill assessment grading

A consistent grading system has been introduced for all registration classes: C = competent

Skill Level	Description
C	Competent
NC	Not Competent

Any skill that has not been assessed is to be awarded a NC result and the reason entered into the comments section on the practical assessment record form.

To pass the practical assessment stage all skills must be successfully completed with "C" entered into corresponding result column and initialled by the assessor.

30. Stage 1 – Practical Assessment Skills

Skill no.	Definition and task requirements	
1	Cardiac pulmonary resuscitation (CPR) training in New Zealand Resuscitation Council approved methods.	
2	Electrical safety and safe working practices by observing candidate's ability to competently use the appropriate tools for the job, apply safety principles whilst carrying out practical skills.	
3	Make up two single-phase cord extension sets using different types of plug-tops and cord connector fittings.	
4	(a) Identify, withdraw and replace rewireable fuse elements at a functional switchboard (selection of correct fuse element size for cable rating). (b) Identify, withdraw and replace HRC fuse links at a functional switchboard – emphasis on replacing fusing factor with correct utilisation category.	
5	Terminate flexible cords, cables and conductors using crimp lugs.	
6	Soldering and de-soldering of components on printed circuit boards, solder tags.	
7	Design, install and terminate single-phase TPS sub-circuits for 10 amp and 15 amp flat pin socket outlets protected by RCDs to comply with AS/NZS3000.	
8	Design, install and terminate TPS sub-circuits incorporating one-way, two-way and intermediate switching of ES and BC lamp holders, ceiling roses and fluorescent lighting protected by RCDs to comply with AS/NZS3000.	
9	Design, install and terminate a three heat switching control circuit to a suitable load.	
10	Design, install and terminate an energy regulator control circuit to a suitable load.	

11	Using appropriate test instruments obtain voltage and current ratings of single-phase appliances.	
12	Test three portable electrical appliances in accordance with AS/NZS3760, AS/NZS5761, AS/NZS5762 affix an appropriate tag and complete a test sheet for each appliance (minimum of two Class I appliances).	
13	Identify at least ten (10) electrical fittings and accessories and state an application for each.	
14	Identify at least ten (10) flexible cords and cable types and specify a typical application for each type.	
15	Install a single-phase induction motor and direct on line motor starter, test for safety, connect to the supply and run. Isolate and change the motor connections to reverse direction of rotation and test run.	
16	Install a three-phase induction motor and direct on line motor starter, test for safety, connect to the supply, test run. Isolate and change the motor connections to change direction of rotation and run.	
17	Make up, test and tag a three-phase cord extension set.	
18	Install Class I and Class II fixed wired appliances connected by flexible cord to permanent connection units.	
19	Disconnection and re-connection of single-phase fixed wired electrical appliances including safety tagging.	
20	Basic first aid training – complete a course with St John or Red Cross.	

31. Stage 2 – Practical Assessment Skills

Skill no.	Definition and task requirements	
1	Electrical safe working practices – observation of candidate's competency to apply safety principles whilst carrying out practical skill tasks.	
2	Visual checks of sub-circuit wiring for compliance with AS/NZS3000.	
3	Testing of an existing installation main earthing conductor and equipotential bonding conductors for compliance with AS/NZS3000.	
4	Testing installation protective earthing conductors for continuity and acceptable resistance values in accordance with AS/NZS3000.	
5	Testing sub-circuit wiring for polarity and correct connections for compliance with AS/NZS3000.	
6	Test switchboard mounted residual current devices (RCDs) affording personal protection for compliance with regulation 24, and AS/NZS3000.	
7	Test portable RCDs for compliance with of AS/NZS3760.	
8	Insulation resistance testing of a Class I portable electrical appliance using the leakage current test method in accordance with AS/NZS3760.	

9	Testing earth fault loop impedance of socket-outlet sub-circuits that **are not** RCD protected for compliance in accordance with AS/NZS3000.	
10	Live test single-phase and three-phase sub-circuits using appropriate test instruments to obtain voltage, current and earth fault loop impedance values.	
11	Design, install and terminate sub-circuit wiring for single-phase lighting and socket-outlets enclosed in PVC conduit to comply with AS/NZS3000.	
12	Design, install and terminate sub-circuit wiring for three-phase socket- outlets enclosed in PVC conduit to comply with AS/NZS3000.	
13	Make up, test and tag single-phase and three-phase cord extension sets suitable for industrial applications.	
14	Construct/assemble and wire a MEN switchboard for a domestic installation that incorporates correct components, fittings, layout, wiring and terminations to comply with Part 2 of AS/NZS3000 (energy revenue meters are not required).	
15	Design, Install and connect electrical appliance control circuits including protective devices for domestic water heating or space heating or similar applications.	
16	Design, install, terminate and protect lighting control circuits suitable for switching lighting banks in commercial and industrial applications. Control circuits are to include light sensing devices, contactors or relays, etc.	

32. Stage 3 – Practical Assessment Skills

Skill no.	Definition and task requirements	
1	A comprehensive installation wiring exercise that incorporates Stage 1 and Stage 2 skills including: • wiring a MEN switchboard • mains cabling • sub-circuits wired in TPS • sub-circuits enclosed in PVC conduit • lighting control sub-circuits protected by switchboard mounted RCDs • single-phase socket-outlets sub-circuits protected by switchboard mounted RCDs • a range socket-outlet • a controlled electric water heater sub-circuit • three-phase switched socket-outlets • equipotential bonding conductors connected to metallic piping • a single-phase induction motor supplied from a DOL starter • testing in accordance with AS/NZS3000 for compliance • completion of compliance certification to satisfy regulatory requirements • livening the supply and testing circuits for correct operation.	
2	Safe working practices – observation of candidate's competency to apply safety principles whilst carrying out practical skill tasks.	

3	Install necessary wiring, carry out winding, component connections and safety tests on following single-phase cage induction motors. Capacitor start, capacitor start/capacitor run and split-phase. Liven, test run, and then reverse direction of rotation.	
4	Install component wiring connections and safety tests on three-phase cage induction motors. Liven, test run and reverse direction of rotation.	
5	Diagnose and locate common single-phase and three-phase cage induction motors electrical faults.	
6	Direct on line starting for three-phase cage induction motors – carry out connections and wiring of various starter components for two wire control and three wire control. Circuits to include overload protection and no volt release, local and remote stop/start stations.	
7	Single-phase universal motor and three-phase slip ring induction motor. Connections, testing, reverse direction of rotation of each motor. Speed control – for either a universal motor or a slip ring motor.	
8	Three-phase reduced voltage motor automatic starters – star/delta, primary resistance, auto transformer. Install control wiring and power circuits, test and liven a suitable three-phase motor (at least two starter types).	
9	Testing – an existing single-phase MEN installation – mains, sub-circuit wiring and fittings *in accordance with AS/NZS3019*. *Ensuring the neutral conductor of mains has been positively identified and confirmed as correct by the candidate*.	
10	Testing – an existing three-phase MEN installation – mains, sub-circuit wiring and fittings *in accordance with AS/NZS3019. Task is to ensure that the candidate positively identifies and confirms that neutral conductor of mains is correctly connected the supply network*.	
11	Testing – electrical appliances and electrical fittings. In service testing of three electrical appliances and completion of an appliance test sheet for each appliance. Include at least one poly-phase appliance.	
12	Using Prove-Test-Prove method – Identification and isolation of single-phase and three-phase sub-circuits.	
13	Disconnection and reconnection of single-phase and three-phase fixed wired electrical appliances using safety tagging system – out of Service tags and danger tags.	
14	Residual current device installed for personal protection. Correct connections and operational testing for compliance with regulation 24 and AS/NZS 3190.	
15	Isolating transformer installed for personal protection. Correct connections, operational testing for verification of compliance with AS/NZS 3760.	
16	Selection and replacement of high rupturing capacity fuse links at a functional switchboard. Tasks to include consideration of cable sizing, connected load and conditions of use. Special emphasis on replacing links labelled fusing factor (class) with correct utilisation category gG (gL) or gM.	

17	Install, wire and terminate necessary components for at least two high intensity discharge light fittings: range – sodium vapour, mercury vapour and metal halide. Test for safety and then live test each fitting with appropriate HID lamp fitted.	
18	Satisfactory completion of a basic St John or Red Cross first aid course or equivalent as approved by the Board.	



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