

## IT 9 - ELECTRICAL INSPECTORS THEORY ANSWER SCHEDULE

- Notes:
- (1 mark) means that the preceding statement/answer earns 1 mark.
  - This schedule sets out the expected answers to the examination questions. The marker can exercise their discretion and decide on the overall accuracy of any answer that is presented in the candidate's own words.
  - Symbols and terms - alternatives  
Power                      W or P  
Voltage                    V or E or U  
Phase                      Active
  - Key to abbreviated terms:  
EA                      Electricity Act 1992  
ER                      Electricity Regulations 1997  
AS/NZS                  Australia and New Zealand Joint Standard  
NZS                      New Zealand Standard  
AS                      Australian Standard  
ECP                      New Zealand Electrical Code of Practice  
GK                      General Knowledge
  - Those parts of an answer that are under-lined indicate the parts required to be covered by a candidate.

### Question 1

Each part is worth 1 mark

- (a) The installation or maintenance of electrical wiring, and connection or disconnection of fittings to or from electrical wiring.  
EA: 2
- (b) Holds a current practising licence  
EA: 95 (1)
- (c) In respect of electricity supply by either a single-phase MEN system or a multiple-phase MEN system, a nominal voltage of 230 volts a.c. between phase and neutral.  
ER 2
- (d) Any ONE of:
- Suitable warning notices affixed at the means of disconnection
  - If locking facilities are available for disconnection, they must be used to lock the disconnection
- ER34

- (e) Any TWO of:
- The repair or replacement of a faulty or damaged conductor:
  - The replacement of a fuse carrier with a circuit breaker appropriate to the rating of the electrical circuit in which the replacement is being made:
  - The replacement of any fitting with a fitting -
    - Of the same size, type, and rating; and
    - Of the same or higher prospective short-circuit current duty, - provided that the fitting that was removed was of an appropriate size, type and rating for the electrical circuit;
  - The installation of revenue meters and associated load control fittings of mains.
- ER 39(2)(a)-(d)
- (f) AS/NZS 3016
- ER: 69C
- (g) • Where the metal is not fully isolated from both live parts and earth.  
 • Where the metal is located within arm's reach.
- ER 84(2)
- (h) Any ONE of:
- (The earthing contact of every socket-outlet that is provided with an earthing contact shall be earthed.) This requirement need not apply to socket-outlets supplied as a separated circuit in accordance with Clause 1.7.4.5.  
 AS/NZS 3000: 5.7.3.2
  - The source supplying a separated circuit shall be an isolating transformer complying with AS/NZS 3108  
 AS/NZS 3000: 1.7.4.5.2(a)
  - The source supplying a separated circuit shall be a source of current, e.g. a motor-generator set or uninterruptible power supply, that is selected and installed so that the output is separated from the input by double insulation or equivalent.  
 AS/NZS 3000: 1.7.4.5.2(b)
  - When socket outlets are supplied by SELV or PELV  
 AS/NZS 3000: 7.7.11(c)
- (i) • No  
 • AS/NZS 3000: 2.9.8.4(e)
- (j) • Orange marker tape  
 AS/NZS 3000: 3.11.3.4  
 • Marker signs where cable enters or leaves a building  
 AS/NZS 3000: 3.11.3.5
- (k) • No  
 • AS/NZS 3000: Tables 3.6 and 3.7

- (l) Must be low enough to permit the passage of current necessary to operate the circuit protective devices.

AS/NZS 3000: 5.4.3

AS/NZS 3000: 6.3.3.2.2

- (m) Any TWO of:

- Earth electrode.
- Main earthing conductor.
- Main earthing terminal/connection or bar.
- MEN link.
- Protective earthing conductors.
- Equipotential bonding.

AS/NZS 3000: 5.6.1

- (n) Any TWO of:

- Electrical equipment complying with AS/NZS 3100 for double insulation.
- Where cables connecting electrical equipment having double insulation enter the electrical equipment in such a manner that they may come into contact with accessible external conductive parts of the electrical equipment, the cables shall be of a type affording double insulation.
- Conductors within electrical equipment having double insulation shall be protected, secured or insulated so that, if any one conductor becomes detached from its termination, neither the conductor nor its functional insulation can come into contact with accessible metal.
- Exposed conductive parts are not earthed for electrical equipment supplied in accordance with Clause 1.7.4.5.
- If electrical equipment is supplied by a SELV or PELV system in accordance with Clause 1.7.2.

AS/NZS 3000: 5.7.2

- (o) Any ONE of:

- In Zone 3 located above 300 mm from the floor.
- Outside any Zone and located above 300 mm from the floor.

AS/NZS 3000: 7.1.4.3

- (p) 15 A

AS/NZS 3000: Table C1

- (q) IP24

AS/NZS 3001: 3.6.3.4

(r) Any TWO of:-

- Insulation resistance
- Earth continuity
- Polarity
- Earthing and equipotential bonding

NZS 3019: 4.1

(s) Any TWO of:

From NZS 3019 (INT):2002: 4.8.2.1

- At rated residual current for an a.c. fault the devices shall operate to disconnect the supply within 300 milliseconds.
- At five times the rated residual current for an a.c. fault the devices shall operate to disconnect the supply within 40 milliseconds.
- At 1.4 times the rated residual current for a pulsating d.c. fault the devices shall operate to disconnect the supply within 300 milliseconds.
- At seven times the rated residual current for a pulsating d.c. fault the devices shall operate to disconnect the supply within 40 milliseconds.
- The integral test device together with confirmation that the RCD is labelled "Type A"

or

From NZS 3019:2002: 4.8.2.1

- At rated residual current for an a.c. fault the devices shall operate to disconnect the supply within 300 milliseconds.
- At five times the rated residual current for an a.c. fault the devices shall operate to disconnect the supply within 40 milliseconds.

(t) To ensure that three-phase motors operated from any outlets will run in the same direction of rotation at the one installation.

GK

## Question 2

(a) Any TWO of:

- Where effective protection for a conductor is afforded by a protective device located on the supply side of its origin or the point of reduction in current-carrying capacity.
- Where short-circuit protection for a conductor is provided in accordance with Clause 2.4.4.
- Where a conductor has no branch circuits or socket-outlets; and
- Where electrical equipment supplied by a conductor is not capable of causing overload currents.
- Installations for telecommunication, control, signalling, and the like.
- A conductor within a switchboard or busway that supplies one or more circuits that are individually protected against overload where —
  - (i) short-circuit protection of the conductor is provided in accordance with Clause 2.4.4; and
  - (ii) overload protection of the conductor is provided when the sum of the current ratings of the circuit protective devices is not more than the current-carrying capacity of the conductor.

AS/NZS 3000: 2.4.3.4  
(2 marks)

(b) Any TWO of:-

- Circuit-breakers incorporating short-circuit and overload releases.
- Circuit-breaker fuse combinations.
- Enclosed fuse links.

AS/NZS 3000: 2.4.2  
(2 marks)

- (c) (i)
  - 0.4 seconds
  - AS/NZS 3000: 1.7.4.3.4.

(2 marks)

- (ii)
  - 16A
  - AS/NZS 3000: Appendix B, Table B4.1

(2 marks)

(d)  $I_{PSSC} = \frac{V}{Z_L}$

(½ mark)

$= \frac{230V}{0.18\Omega}$

(½ mark)

$= 1278A$

(1 mark)

### Question 3

- (a) (i) • Overhead lines and their entry points into buildings show no evidence of insulation deterioration, rusting of anchorages or deterioration of line-connection boxes.
- Safety distance clearances have not been compromised by the introduction of, or modification to, any structures or by increased ground-level build-up
- NZS 3019: 5.1(k) & (l)  
(1 mark)
- (ii) • Switchboard and electrical equipment have no conductor insulation deterioration.
- NZS 3019: 5.1(f)
- MCBs, fuses and switches show no evidence of mechanical damage.
- NZS 3019: 5.1(g)
- Semi-enclosed rewirable fuses have not deteriorated due to arcing and have no exposed live parts when the removable part of the fuse fitting is fitted into the base.
- NZS 3019: 5.1(h)
- Switchboard equipment is correctly labelled.
- NZS 3019: 5.1(i)  
(4 marks)
- (iii) Covers of fixed-wired appliances are not broken or missing, giving access to live parts or basic insulation
- NZS 3019: 5.1(j)  
(1 mark)
- (b) • Ensure that the polarity of the supply is correct
- Ensure that the protection of the supply is correctly rated
- Verify the safety of revenue meters and associated load control fittings of mains
- Verify that there is a main earthing system, if the supply is from a MEN system.
- ER43A(c),(d),(e),(f)  
(4 marks)

#### Question 4

##### Inductive load

##### Load group A

60        250W Metal Halide lamps  
10        75W, fluorescent lights

$$(60 \times 250) + (10 \times 75) \qquad 15.75 \text{ kW} \qquad (1 \text{ mark})$$

##### Load group B

9            10A socket outlets  
1000 + (8 x 750)

$$7 \text{ kW} \qquad (1 \text{ mark})$$

12           15A socket outlets

$$3450 + (11 \times 2588) \qquad 31.92 \text{ kW} \qquad (1 \text{ mark})$$

##### Load group D

1            6 kW Skimming machine  
1            8 kW lathe  
6            0.75 kW drill presses  
3            1 kW grinders

$$8 + 4.5 + 0.5(4.5 + 3) \qquad 16.25 \text{ kW} \qquad (1 \text{ mark})$$

$$\text{Total inductive load} \qquad 70.91 \text{ kW} \qquad (1 \text{ mark})$$

##### Non inductive load

10 kW water heater            10.00 kW/kVA

Total inductive load = 70.91 kW

$$\begin{aligned} \text{pf} &= 0.972 \\ \theta &= \cos^{-1} \times 0.972 \\ &= 13.59^\circ \end{aligned} \qquad (1/2 \text{ mark})$$

$$\begin{aligned} Q &= P \tan \theta \\ &= 70.91 \times \tan 13.59^\circ \end{aligned} \qquad (1/2 \text{ mark})$$

$$= 17.14 \text{ kVAr} \qquad (1 \text{ mark})$$

$$\text{Total kW} = 70.91 + 10 = \mathbf{80.91 \text{ kW}} \quad (\frac{1}{2} \text{ mark})$$

$$\begin{aligned} \text{Total kVA} &= \sqrt{80.91^2 + 17.14^2} \\ &= \sqrt{6546.43 + 293.78} \\ &= \mathbf{82.71 \text{ kVA}} \end{aligned} \quad (\frac{1}{2} \text{ mark})$$

$$\text{Amps per phase} = \frac{\text{VA}}{\sqrt{3} \times 400} \quad (\frac{1}{2} \text{ mark})$$

$$= \frac{82710}{\sqrt{3} \times 400} \quad (\frac{1}{2} \text{ mark})$$

$$= \mathbf{119.38 \text{ amps per phase}} \quad (1 \text{ mark})$$

AS/NZS 3000: Table C2

## Question 5

(a) Any THREE of:

- The current rating, fusing factor (utilization category) and breaking capacity of the protective devices are appropriate for the circuits they protect.
- Switches and protective devices are clearly labeled showing the circuit type they control or protect;
- Live conductors are insulated or provided with a barrier requiring the use of a tool to gain access;
- Neutral bars are supported on insulated fittings;
- Earthing conductors are connected to the earth bar, and neutral conductors are connected to the neutral bar;
- The main earthing conductor from the earth electrode is correctly connected to the main switchboard;
- There is a MEN link between the neutral bar and the earth bar at the main switchboard. The link shall have a secure connection system at each end of the link (i.e. a stud with nut and locknut, or two screws);
- The switchboard is constructed of fire re-resistant materials, and is suitable for the environment for which it is installed
- Residual current devices installed for personal protection shall have a residual operating current of 30 mA or less. They shall also be of the type providing protection against residual alternating current, and residual pulsating direct current.

NZS 3019: 3.3  
(3 marks)

(b) Any FOUR of -

- The mains, main switchboards, or main earthing systems of an electrical installation that is to be connected to a power supply for the first time; or
- The replacement of existing mains with mains comprising larger conductors; or
- The extension, shortening, or replacement of mains due to the relocation of a main switchboard or point of supply; or
- The alteration of mains or a main switchboard for the purpose of relocating metering and associated load control fittings; or
- The alteration of a main switchboard to increase the current rating of that switchboard; or
- The relocation of a main switchboard; or

ER 41(1)(c)(i)-(vii)  
(4 marks)

(c) (i) Install extend and alter subcircuits (including submains).

ER 47(e)  
(1 mark)

(ii) NZS 3019

ER 47 (e)(ii)  
(1 mark)

(iii) Provided they are supplied by tough-plastic sheathed cables.

ER 47(1)(d)  
(1 mark)

### Question 6

- (a) • The high impedance of the fault loop would not permit the fuse to operate.
- All metal work that forms part of the electrical installation would be at a potential of 230V to earth.
  - All electrical equipment would operate normally
  - All switches would now be in the neutral conductor creating a potential hazard.

GK  
(4 marks)

- (b) (i) A polarity test

(1 mark)

- (ii) A voltmeter

(1/2 mark)

- (iii) Independent earths

(1/2 mark)

- (iv) Test 1

Checking between the supply side of the main switch and an independent earth.

Reading should be approx. 220 volts and above.

(2 marks)

- (v) Test 2

Checking between the neutral bar and an independent earth.

Reading should be approx. 0 volts.

(2 marks)

### Question 7

(a)  $I_{(FL)} = \frac{P}{\sqrt{3} \times V}$  (1/2 mark)  
 $= \frac{80,000}{\sqrt{3} \times 400}$  (1/2 mark)  
 $= 115.47 \text{ A}$  (1 mark)  
(Total - 2 marks)

(b) From table 12, the minimum size cable is 25 mm<sup>2</sup>. The cable is rated for 104 amps. (1/2 mark)

Applying the correction factor from table 27(1) of 1.12. The cable rating would rise to 104 x 1.12 = 116.48 A. (1/2 mark)

Therefore from Table 12, the minimum size cable is 25 mm<sup>2</sup>, based on cable rating (1 mark)  
(Total - 2 marks)

(c) From table 42, a 25 mm<sup>2</sup> cable, with an operating temperature of 75 °C, has a 1.11 mV/A.m (1/2 mark)

Voltage drop = mV/A.m x amps x metres (1/2 mark)

= 1.54 x 10<sup>-3</sup> x 115.47 x 78 (1/2 mark)

= 13.87 V (1/2 mark)

(Total - 2 marks)

(d) From regulation 53(3)(b) maximum voltage drop is 5%. (1 mark)

400 x 4.5% = 18 volts – volt drop from (c) within permissible limits (1 mark)

(Total - 2 marks)

(e) 25 mm<sup>2</sup> (2 marks)

### Question 8

- (a) (i) As current through a fuse or circuit breaker increases beyond its current rating, the time taken to operate decreases. (2 marks)
- (ii) 3 seconds (1 mark)
- (iii) 0.05 seconds (1 mark)
- (b) • Neutral current out of balance with the phase current. (1 mark)
- A magnetic field is induced into the iron core. (1 mark)
- The induced magnetic field induces a current in the sensing coil (1 mark)
- The tripping coil is energised, isolating the circuit (1 mark)
- (c)  $Z = \frac{20 \text{ volts}}{1443 \text{ A}}$  (1/2 mark)
- $= 0.01386 \Omega$  (1/2 mark)
- $I_{PSC} = \frac{400}{0.01386}$  (1/2 mark)
- $= 28,860 \text{ A}$  (1/2 mark)

### Question 9

- (a) (i) Must be installed and maintained so that they operate safely if used for their intended purpose.  
ER 98 (1)  
(1 mark)
- (ii) Must have a rating that does not exceed the rating of the socket-outlet.  
ER 98 (4)  
(1 mark)
- (b) • Through a shore-mounted isolating transformers with the hull of metallic-hulled pleasure craft and conductive parts bonded together in accordance with Clause 4.3.1.  
• Through an on-board isolating transformers with the hull of metallic-hulled pleasure craft and conductive parts bonded together in accordance with Clause 4.3.2.  
• Connection without an isolating transformer in accordance with clause 4.3.3.  
AS/NZS 3004: 1.8  
(3 marks)
- (c) • Must comply with IEC 60309-2 (round pin)  
• Rated at not less than 16 A  
• Outlets rated at 32A or more shall be arranged to prevent the removal of the plug when energised.  
AS/NZS 3004: 2.4.2.4.2  
(3 marks)
- (d) Fuses and unenclosed neutral links.  
AS/NZS 3004: 3.4.5  
(2 marks)