Title	**Explain the properties of conductors, insulators, and semiconductors and their effect on electrical circuits**		
Level	**2**	**Credits**	**7**

Purpose	This unit standard covers knowledge of the properties of conductors, insulators, and semiconductors and the concepts of voltage, current, and resistance in electrical circuits, which underpins all technical careers in the electrical and electronic industries. People credited with this unit standard are able to: – demonstrate knowledge of electrical conductors, insulators, and semiconductors; – demonstrate knowledge of resistance, resistivity, and resistors; – demonstrate knowledge of resistor characteristics; – compare calculated with measured values in resistive circuits; – demonstrate knowledge of electrical power and energy; and – analyse resistive circuits.

Classification	Electrical Engineering > Core Electrical

Available grade	Achieved

Explanatory notes

1 This unit standard has been developed for learning and assessment off-job.

2 This unit standard meets the assessment requirements of ERAC EPC 1.
This unit standard and unit standard 29476 together meet the assessment requirements of ERAC EPC 3.
This unit standard and unit standard 5932, 15848, and 15855 together meet the assessment requirements of ERAC CEPC 5.

3 This unit standard is one of three designed to cover knowledge of magnetism and electricity, the others being Unit 25071, *Demonstrate knowledge of electromotive force (e.m.f.) production* and Unit 25072, *Demonstrate knowledge of electromagnetism theory*. It is recommended that this unit standard be achieved before assessment against unit standard 25071 is attempted.

4 Definitions
CEPC – Critical Essential Performance Capability.
e.m.f. – electromotive force.

EPC – Essential Performance Capability.
ERAC – Electrical Regulatory Authorities Council.
Industry practice – those practices that competent practitioners within the industry recognise as current industry best practice.
LDR – light dependent resistor.
NTC – negative temperature co-efficient.
PTC – positive temperature co-efficient.
PVC – polyvinyl chloride.
Safe and sound practice – as it relates to the installation of electrical equipment is defined in AS/NZS 3000:2007, *Electrical Installations (known as the Australian/New Zealand Wiring Rules).*
VDR – voltage dependent resistor.

5 For assessment purposes:
- a Candidates will be supplied with formulae involving more than three quantities.
- b Candidates are supplied with data tables and colour code charts.
- c Use of a calculator during assessment is permitted.
- d Candidates are expected to express calculated values in the relevant Système Internationale (SI) units, including multiples and sub-multiples, for example: pico (p) 10^{-12}; nano (n) 10^{-9}; micro (μ) 10^{-6}; milli (m) 10^{-3}; kilo (k) 10^{3}; mega (M) 10^{6}; Giga (G) 10^{9}; and to be able to convert between them.

6 Range
- a Formulae quoted in this unit standard use internationally recognised symbols and units.
- b Conventional current flow direction (positive to negative) is implied. Trainees should be aware of the opposite direction of electron flow.
- c Candidates may refer to current legislation and Standards during assessment.
- d Demonstration of safe working practices and installation in accordance with *safe and sound practice* are essential components of assessment of this unit standard.
- e All activities and evidence presented for all outcomes and evidence requirements in this unit standard must be in accordance with:
  - i legislation;
  - ii policies and procedures;
  - iii ethical codes;
  - iv Standards – may include but are not limited to those listed in Schedule 2 of the Electricity (Safety) Regulations 2010;
  - v applicable site, enterprise, and industry practice; and,
  - vi where appropriate, manufacturers' instructions, specifications, and data sheets.

Outcomes and evidence requirements

Outcome 1

Demonstrate knowledge of electrical conductors, insulators, and semiconductors.

Evidence requirements

1.1 Describe the nature of conductors, insulators, and semiconductors in terms of their atomic structure.

Range conductors – loosely-bound valence electrons;

insulators – tightly-bound valence electrons;
semiconductors – sharing of valence electrons.

1.2 State typical uses of conductors and insulators.

Range evidence of three uses for conductors and three uses for insulators is required.

1.3 Identify conductor and insulator materials suitable for given environmental conditions, and state reasons for their suitability.

Range conductors – copper, silver, aluminium, tungsten, carbon, nichrome, brass, gold, lead, tin;
insulators – glass, mica, oil, ceramics, rubber, PVC;
environmental conditions – heat, moisture, corrosive materials, dust, tension, compression, vibration;
evidence is required of one electrical conductor and one electrical insulator material for each environmental condition.

Outcome 2

Demonstrate knowledge of resistance, resistivity, and resistors.

Evidence requirements

2.1 Describe resistance in terms of opposition to current flow.

2.2 State the unit for resistance and draw the symbol.

2.3 State the factors affecting resistance and the relationships between them.

Range factors – length, cross-sectional area, resistivity of material, temperature, temperature co-efficient of resistance;
relationship – $R = \frac{\rho l}{A}$.

2.4 Describe briefly linear and non-linear resistors with reference to their construction, operating characteristics, symbols, connections, and applications.

Range linear resistors include – carbon, metal film, wire-wound, slider potentiometer, rotary carbon potentiometer, rheostat;
non-linear resistors include – NTC thermistor, PTC thermistor, VDR, LDR;
evidence of two linear and two non-linear resistors is required.

2.5 Identify materials commonly used for conductors, insulators, and semiconductors and list in order of their resistivity.

Range conductors – copper, brass, silver, gold, aluminium, steel, tungsten, carbon, nichrome, lead, tin;
insulators – rubber, PVC, ceramics, mica, glass;
semiconductors – silicon, germanium.

2.6 Explain the concept of insulation resistance of a cable in terms of typical values and the effect of cable length.

2.7 Calculate insulation resistance for a specified length of cable from the known insulation resistance of a different length of the same cable.

Outcome 3

Demonstrate knowledge of resistor characteristics.

Evidence requirements

3.1 State the meanings of the terms tolerance, preferred values, stability, power rating, power dissipation, voltage rating, and current rating, as used in connection with resistors.

3.2 Interpret resistor markings relating to resistance, rating, and tolerance.

Range evidence of three different linear resistors is required. Use of resistor colour code chart is permitted.

Outcome 4

Compare calculated with measured values in resistive circuits.

Range circuits – series, parallel and series-parallel combinations of up to five resistances, a single source of e.m.f., internal resistance;
values – resistance, applied e.m.f., volt-drop, current, power.

Evidence requirements

4.1 Define Ohm's Law.

4.2 Describe the relationship between resistance, voltage, and current in terms of the effect that a change in any one value has on the other two.

4.3 Calculate values for a given circuit.

4.4 Compare values from measurements on a circuit to calculated values for the same circuit.

4.5 Explain variations between measured and calculated values in terms of component tolerance, supply variations, non-linear components, and instrument and measurement accuracy.

Outcome 5

Demonstrate knowledge of electrical power and energy.

Evidence requirements

5.1 Define electrical power in terms of voltage, current, and resistance, and state its unit and symbol.

5.2 Calculate total power, and power in individual resistors, from given data for series circuits, parallel circuits, and series-parallel circuits.

5.3 Define energy in terms of power and time taken, and state its units and symbols.

5.4 Convert horsepower values to kilowatts.

5.5 Describe efficiency in terms of the relationship between input and output powers of electrical machines.

5.6 Calculate quantity and cost of energy from given data for a simple domestic loading, and express in kilowatt-hours and dollars.

Outcome 6

Analyse resistive circuits.

Range resistive circuits – one source of e.m.f., up to five resistances connected in any combination, one internal resistance.

Evidence requirements

6.1 Define Kirchoff's Laws for voltage and current.

6.2 Calculate the total resistance of a circuit from resistor values.

6.3 Calculate the current flowing in any part of the circuit and verify Kirchoff's Current Law.

6.4 Calculate the voltage across any two points in the circuit and verify Kirchoff's Voltage Law.

Replacement information	This unit standard, unit standard 25071, and unit standard 25072 replaced unit standard 15843.

Planned review date	31 December 2019

Status information and last date for assessment for superseded versions

Process	Version	Date	Last Date for Assessment
Registration	1	22 August 2008	31 December 2021
Rollover and Revision	2	15 March 2012	31 December 2021

Process	Version	Date	Last Date for Assessment
Revision	3	15 January 2014	31 December 2021
Review	4	21 July 2016	N/A

Consent and Moderation Requirements (CMR) reference	0003

This CMR can be accessed at http://www.nzqa.govt.nz/framework/search/index.do.

Please note
Providers must be granted consent to assess against standards (accredited) by NZQA, before they can report credits from assessment against unit standards or deliver courses of study leading to that assessment.

Industry Training Organisations must be granted consent to assess against standards by NZQA before they can register credits from assessment against unit standards.

Providers and Industry Training Organisations, which have been granted consent and which are assessing against unit standards must engage with the moderation system that applies to those standards.

Requirements for consent to assess and an outline of the moderation system that applies to this standard are outlined in the Consent and Moderation Requirements (CMR). The CMR also includes useful information about special requirements for organisations wishing to develop education and training programmes, such as minimum qualifications for tutors and assessors, and special resource requirements.

Comments on this unit standard

Please contact The Skills Organisation at reviewcomments@skills.org.nz if you wish to suggest changes to the content of this unit standard.