| | | | |
|---|---|---|---|
| **Title** | **Demonstrate knowledge of electrical power system engineering** | | |
| **Level** | **6** | **Credits** | **15** |

| | |
|---|---|
| **Purpose** | People credited with this unit standard are able to demonstrate knowledge of:<br>• New Zealand electricity generation, transmission and distribution systems<br>• principles of operation and suitability of the main types of prime movers used in the generation of electricity in New Zealand<br>• principle of operation and characteristics of electricity generators<br>• the operation, construction and performance of three phase power transformers<br>• construction and principle of operation of transmission and distribution circuits<br>and evaluate:<br>• the need for, and methods of, control of the main parameters of a power system<br>• the nature of faults on electrical systems, and<br>• the function of circuit breakers, reclosers, earth switches and disconnectors in the electricity transmission and distribution system.<br><br>This standard provides electricity supply industry power technicians with the fundamental knowledge of power protection and control network theory, and hardware. |

| | |
|---|---|
| **Classification** | Electricity Supply > Electricity Supply - Power System Maintenance |

| | |
|---|---|
| **Available grade** | Achieved |

**Guidance Information**

1 Evidence presented for assessment against this unit standard must be consistent with safe working practices and be in accordance with applicable legislative and industry requirements.

2 Legislation, regulations, and /or industry standards relevant to this unit standard include but are not limited to:
- Electricity Act 1992
- Health and Safety at Work Act 2015
- Electricity supply industry codes of practice and documented enterprise procedures, including *Safety Manual – Electricity Industry* (SM-EI) and relevant EEA guides available at www.eea.co.nz

and any subsequent amendments and replacements.

3 Definitions
*AC* – alternating current.
*HVDC* – high voltage direct current.
*SF6 – sulfur hexafluoride*
*VAR – volt-ampere reactive*

4 It is recommended that Unit 29732, *Demonstrate knowledge of electrical principles in power engineering*, and Unit 29734, *Demonstrate knowledge of power engineering mathematics* be achieved, or equivalent knowledge and skills demonstrated, prior to assessment of this standard.

## Outcomes and performance criteria

### Outcome 1

Demonstrate knowledge of the New Zealand electricity generation, transmission and distribution systems.

Range includes – electricity power stations, main power transmission and distribution lines, major substations and the HVDC inter island power link and cable.

### Performance criteria

1.1 The key system components in the New Zealand electricity supply system are described.

1.2 Voltage levels in electricity generation and transmission are identified and explained.

1.3 Line diagrams of a simplified New Zealand electricity supply system are drawn.

1.4 The need for a HVDC link is explained.

### Outcome 2

Evaluate the need for, and methods of, control of the main parameters of a power system.

Range load control, voltage, frequency, reliability of supply, purity of waveforms.

**Performance criteria**

2.1 The need for stability in a power grid system is explained.

Range voltage, frequency, reliability of supply and purity of the AC waveform.

2.2 Methods used to achieve correct grid system voltage control are explained.

Range may include – reactive power flow, shunt capacitors, synchronous condensers, tap-changing transformers, static VAR compensators, statcoms, cables and voltage regulators; evidence of three methods is required.

2.3 Methods used to achieve stable frequency control are explained.

Range turbine governors, dividing load among generators, master stations, active power scheduling, spinning reserve, load shedding.

**Outcome 3**

Demonstrate knowledge of principles of operation and suitability of the main types of prime movers used in the generation of electricity in New Zealand.

Range hydro, gas engines, wind, solar, thermal and co-generation, geothermal.

**Performance criteria**

3.1 The principles of operation of common generation prime movers are explained.

3.2 The suitability of the various types of prime mover is compared.

Range cost of unit of electricity, reliability of generation, location to grid load, reaction demand time, renewable source.

**Outcome 4**

Demonstrate knowledge of the principle of operation, and characteristics of electricity generators.

**Performance criteria**

4.1 The construction and operation of cylindrical and salient pole generators is explained.

4.2 The effects and methods of paralleling generators are explained.

Range operation of standalone generators and generators on an infinite bus and the effect of saliency on parallel operation.

4.3 Phasor diagrams are used to explain the effect of paralleling generators onto an infinite bus.

Range power factor, power output, performance charts.

4.4 Practical methods of alternators synchronisation and the effects of excitation control are demonstrated.

4.5 The main protection systems used with electricity generators are explained.

4.6 Generator auxiliary systems are described.

Range cooling, lubrication.

**Outcome 5**

Evaluate the nature of faults on electrical systems.

**Performance criteria**

5.1 Causes of faults and their effect on electrical equipment are explained.

Range partial short circuit, short circuit; limiting fault current by generator reactance, reactors, and bus bar sectioning; electromagnetic, heating, arcing effects during fault conditions.

5.2 Fault magnitudes are calculated for symmetrical and asymmetrical faults.

Range the per unit system, faults on high voltage and low voltage systems.

**Outcome 6**

Demonstrate knowledge of the operation, construction and performance of three phase power transformers.

**Performance criteria**

6.1 The constructional components of a power transformer are identified and their functions are explained.

6.2 The equivalent circuit and vector diagram of a power transformer is drawn and described.

Range single phase or per phase units.

6.3 Transformer calculations using the equivalent circuit are performed and explained.

Range impedance, reactance.

6.4 The rating systems used with transformers are explained.

Range single rating and dual rating.

6.5 Percentage impedance for a transformer is defined and a calculation performed.

6.6 The use of tertiary windings to reduce harmonic currents, and inrush currents in transformers are explained.

6.7 Interconnection of transformers and the problems associated with paralleling are explained and calculation performed.

Range winding identification, vector grouping, phasing, code symbols, New Zealand practice for interconnecting and paralleling.

6.8 Efficiency of transformers at various loadings is calculated and the reasons for losses occurring are explained.

Range variable load efficiency, annual efficiency, maximum efficiency.

6.9 Tap changing in power transformers is explained.

Range on and off-load.

6.10 Common test methods used with power transformers are explained.

Range includes but is not limited to – oil, polarity, ratio, resistance, power factor.

6.11 Methods of protection used with power transformers are explained.

Range includes but is not limited to – Buchholz relay, differential, restricted and unrestricted earth fault, pressure release, under impedance and over temperature protection.

6.12 Purpose of special transformers in an electricity system identified and explained.

Range earthing transformers, neutral earthing transformers.

**Outcome 7**

Evaluate the function of circuit breakers, reclosers, earth switches and disconnectors in the electricity transmission and distribution system.

**Performance criteria**

7.1 Commonly used circuit breakers, disconnector circuit breakers and reclosers, earth switches and disconnectors are identified.

Range fault current isolations, auto reclose, isolation function, earth function.

7.2 The method of arc control and extinction is described when disconnection of the circuit current is occurring.

Range bulk oil, air blast, vacuum, SF6 gas.

7.3 Circuit breaker operating mechanisms are described.

Range includes but is not limited to – springs, pneumatic, hydraulic, electric motor.

7.4 Effect of circuit breaker timing on fault clearance time is described.

**Outcome 8**

Demonstrate knowledge of the construction and principle of operation of transmission and distribution circuits.

**Performance criteria**

8.1 The construction of transmission lines and their support structures is explained.

Range poles, towers, insulation, conductors, materials used.

8.2 An impulse graph is drawn and analysed for a specific piece of electrical material.

8.3 The causes, effects and protection from over voltages associated with transmission lines are explained.

Range lightning strikes, switching surges, earth wires, rod gaps, lightning arrestors.

8.4 The construction and electrical characteristics of high voltage power cables are explained.

Range insulation materials, conductor materials, formation of conductors, current capacity, capacitance, inductance, losses, installation.

8.5 The cause of overvoltage surges in transmission and distribution circuits is explained, and methods for their elimination or reduction are described.

8.6 The causes, effects and methods of reducing corona discharge in conductors and power cables is explained.

8.7 The relationship between capacitance and inductance of a three-phase line with respect to conductor radius and spacing is explained.

Range overhead lines, cables.

8.8 The inductance and capacitance of a three-phase distribution line or power cable is calculated from given manufacturers conductor or power cable specifications.

8.9 The Ferranti effect is explained in relationship to transmission lines and calculation performed.

Range sending and receiving end voltage, current and power factor.

8.10 The function of shunt reactors and capacitors in distribution or transmission networks is explained.

| | |
|---|---|
| **Planned review date** | 31 December 2025 |

**Status information and last date for assessment for superseded versions**

| Process | Version | Date | Last Date for Assessment |
|---|---|---|---|
| Registration | 1 | 20 July 2017 | N/A |
| Rollover and Revision | 2 | 2 March 2023 | N/A |

| | |
|---|---|
| **Consent and Moderation Requirements (CMR) reference** | 0120 |

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

**Comments on this unit standard**

Please contact Waihanga Ara Rau Construction and Infrastructure Workforce Development Council at qualifications@WaihangaAraRau.nz if you wish to suggest changes to the content of this unit standard.