



Australian Government

Department of Education, Employment and Workplace Relations

UETTDRDS53A Design power system transmission and sub-transmission substation primary plant

Release: 1

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Modification History

Not applicable.

Unit Descriptor

Unit Descriptor

1) Scope:

1.1) Descriptor

This Competency Standard Unit covers the design of transmission, sub-transmission and zone substation primary plant. This may include busbar upgrades, equipment replacement projects or new installations on green field sites. The design must conform to safety regulations and environmental standards and incorporate the principles of safe design.

Application of the Unit

Application of the Unit 2)

This competency standard Unit is intended to augment formally acquired competencies. It is suitable for employment-based programs under an approved contract of training.

Licensing/Regulatory Information

License to practice 3)

The skills and knowledge described in this unit may require a licence/registration to practice in the work place subject to regulations for undertaking of electrical work. Practice in workplace and during training is also subject to regulations directly related to Occupational Health and Safety, electricity/telecommunications/gas/water industry safety and compliance, industrial relations, environmental protection, anti discrimination and training.

License to practice

3)

Commonwealth, State/Territory or Local Government legislation and regulations may exist that limits the age of operating certain equipment.

Pre-Requisites

Prerequisite Unit(s)

4)

Competencies

4.1)

Granting of competency in this unit shall be made only after competency in the following unit(s) has/have been confirmed.

Where pre-requisite pathways have been identified. All competencies in the Common Unit Group must be have been completed plus all the competencies in one (1) of the identified Pathway Unit Group(s):

Common Unit Group

Unit Code	Unit Title
UEENEEE101A	Apply Occupational Health and Safety regulations, codes and practices in the workplace
UEENEEE104A	Solve problems in d.c. Circuits
UEENEEE107A	Use drawings, diagrams, schedules, standards, codes and specifications
UEENEEG101A	Solve problems in electromagnetic devices and related circuits
UEENEEG102A	Solve problems in electromagnetic devices and related circuits
UETTD RDS39A	Prepare and manage detailed construction plans for electrical power system infrastructure
UETTD RDS44A	Design power system substations modifications
UETTDREL11A	Apply sustainable energy and environmental procedures

Prerequisite Unit(s) 4)

UETTDREL16A	Working safely near live electrical apparatus
UETTDNIS62A	Implement and monitor the power system organisational OHS policies, procedures and programs
UETTDNIS63A	Implement and monitor the power system environmental and sustainable energy management policies and procedures

Literacy and numeracy skills 4.2)

Participants are best equipped to achieve this unit if they have reading, writing and numeracy skills indicated by the following scales. Description of each scale is given in Volume 2, Part 3 “Literacy and Numeracy”

Reading 5 Writing 5 Numeracy 5

Employability Skills Information

Employability Skills 5)

The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit of competency is packaged will assist in identifying Employability Skill requirements.

Elements and Performance Criteria Pre-Content

6) Elements describe the essential outcomes of a competency standard unit	Performance Criteria describe the required performance needed to demonstrate achievement of the element. Assessment of performance is to be consistent with the Evidence Guide.
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Elements and Performance Criteria

ELEMENT	PERFORMANCE CRITERIA
1 Plan for and coordinate the design of transmission, sub-transmission and zone substation primary plant	1.1 OHS practices/procedures and environmental and sustainable energy procedures, which may influence the design of primary plant component of substations, are reviewed and determined.
	1.2 Purpose of the design is established and expected outcomes of the work are confirmed with the appropriate personnel.
	1.3 Established policies, procedures and specifications for the design are obtained or established with the appropriate personnel.
	1.4 Equipment/tools and personal protective equipment are selected and coordinated based on specified requirements and established procedures
	1.5 Work is prioritised and sequenced for the most efficient and effective outcome following consultation with others for completion within acceptable timeframes, to a quality standard and in accordance with established procedures
	1.6 Risk control measures are identified, prioritised and evaluated against the work schedule
	1.7 Relevant work permits are secured to coordinate the performance of work according to requirements and/or established procedures
	1.8 Resources including personnel, equipment, tools and personal protective equipment required for the job are identified, scheduled and coordinated and confirmed in a safe and technical working order
	1.9 Liaison and communication issues with other/authorised personnel, authorities, clients and land-owners are resolved and activities coordinated to carry out work
	1.10 Site is prepared according to the work schedule

ELEMENT

PERFORMANCE CRITERIA

		and to minimise risk and damage to property, commerce, and individuals in accordance with established procedures
	1.11	Personnel participating in the work, including plant operators and contractors, are fully briefed and respective responsibilities coordinated and authorised where applicable in accordance with established procedures
2	Carry out and coordinate the design of transmission, sub-transmission and zone substation primary plant	
	2.1	Circuit/systems modelling is used to evaluate alternative proposals as per established procedures.
	2.2	OHS and sustainable energy principles, functionality and practices to avoid incidence and accidents and minimise waste are incorporated into the project in accordance with requirements and/or established procedures
	2.3	System design decisions are made on the basis of safety and effective outcomes according to requirements and/or established procedures
	2.4	Mathematical models of the design are used to analyse the effectiveness of the finished project as per requirements and established procedures
	2.5	Technical advice is given regarding potential hazards, safety risks and control measures so that monitoring and preventative action can be undertaken and/or appropriate authorities consulted, where necessary, in accordance with requirements and established procedures
	2.6	Essential knowledge and associated skills are applied to analyse specific data and compare it with compliance specifications to ensure completion of the project within an agreed timeframe according to requirements.
	2.7	Solutions to non-routine problems are identified and actioned using acquired essential knowledge and associated skills according to requirements
	2.8	Quality of work is monitored against personal performance agreement and/or established

ELEMENT

PERFORMANCE CRITERIA

- organisational and professional standards.
- 3 Complete and coordinate the design of transmission, sub-transmission and zone substation primary plant
- 3.1 Final checks of the design are undertaken to ensure they comply with all requirements and include all specifications and documentations needed to complete the design brief.
- 3.2 Appropriate personnel are notified of completion and reports and/or completion documents are finalised.
- 3.3 Reports and/or completion documents are submitted to relevant personnel/organisations for approval and, where applicable, statutory or regulatory approval
- 3.4 Approved copies of design documents are issued and records are updated in accordance with established procedures.

Required Skills and Knowledge

REQUIRED SKILLS AND KNOWLEDGE

8) Essential Knowledge and Associated Skills (EKAS): This describes the essential skills and knowledge and their level, required for this unit.

Evidence shall show that knowledge has been acquired of designing transmission, sub-transmission and zone substation primary plant.

All knowledge and skills detailed in this unit should be contextualised to current industry practices and technologies.

KS01-TDS53A Power system transmission and sub-transmission substation primary plant

Evidence shall show an understanding of designing power system transmission and sub-transmission substation primary plant to an extent indicated by the following aspects:

T1 Materials properties encompassing:

- Identification and classification of engineering materials material properties
- Types and applications - properties of tensile strength, effects of temperature on the expansion of metals, ductility, malleability, work hardening and annealing and the conditions that lead to corrosion and the properties of timbers.

T2 Principles of power transformer construction and operations encompassing:

- Transformer types; note examples include shell, core, auto, double wound, three phase, single phase and combinations of these types, step up and step down transformers, transmission and generation types
- Reactor types - shunt and series, applications and design considerations
- Iron circuit characteristics - steel types, losses and techniques used to eliminate excess eddy currents and other circulating currents
- Winding configurations and construction techniques - helical, spiral, disc, interleaved disc types
- Insulation methods and techniques - fully insulated windings and graded insulation techniques, oil filled and gas filled power transformers
- Transformer and reactor ratings, losses and efficiency - equivalent circuits and vector relationships, impedance percent
- Nameplate details - BIL, tapping winding detail, physical layout, cooling ratings, physical details
- Transformer and reactor cooling types and their effects on design and rating
- Transformer and reactor auxiliaries - temperature indicators, over pressure devices and control systems
- Winding configurations - star-star, star-delta, star-zigzag, nomenclature and common methods of diagrammatic representation of winding configuration
- Operating constraints as single units and in parallel
- Tapping windings encompassing: placement issues, tapping range and OLTC versus off load TC techniques - high speed resistor, reactor and vacuum types, Jansen mechanisms, dead tank and live tank types
- Control system characteristics

REQUIRED SKILLS AND KNOWLEDGE

- High voltage bushing selection - insulation system used, rating, BIL, selection criteria and testing considerations

T3 Principles of power transformer construction and operations encompassing:

- Applications of static reactive plant in high voltage networks, including voltage control, VAR control, transient response capacity
- Types of static reactive plant including high voltage capacitors, high voltage reactors, static VAR compensators and combinations of these
- Operating characteristics and operational constraints including point on wave switching issues
- Ratings, cooling systems and control systems and ancillary equipment used
- Configurations and system layout including single star, double star, bridge type
- Typical protection systems used including neutral unbalance current, neutral unbalance voltage
- Techniques used when balancing elements within static reactive plant
- Safety precautions when testing and maintaining high voltage static reactive plant - safe working practices and procedures, identification of hazards, assessment and control of OHS risks and types, selection, maintenance and use of personal protective equipment

T4 Principles of power transformer high speed on load tap changers encompassing:

- Selector types and applications for high voltage power transformers
- Diverter switch types and applications for high voltage power transformers including live tank, dead tank, resistor type, reactor type, vacuum type, pennant flag, pennant cycle
- Ratings and construction principles
- Operating mechanism types, stored energy systems and associated control systems
- Operating principles and operating sequences of selectors and diverters
- Measurement requirements including contacts, differential wear, transition resistors and transient protection devices, rotation lag, out of sequence controls and end-of-life unit and component assessment
- Online diagnostic tools and devices
- Ancillary equipment including online filters, over pressure relays and devices
- Testing requirements including cycle timing, differential delay, energy accumulator mechanical and operational tests and control system functional tests
- Safety precautions when testing and maintaining high voltage power transformer on load tap changers - safe working practices and procedures, identification of hazards and assessment, control of OHS risks and types, selection, maintenance and use of personal protective equipment

T5 Substation switching practices encompassing:

- Standards, codes, legislation, supply authority regulations and or enterprise requirements applicable to substation switching

REQUIRED SKILLS AND KNOWLEDGE

- Requirements for the use of manuals, substation diagrams/plans and drawings
- Types, characteristics and capabilities of HV substation equipment to be switched
- Procedures for obtaining correct HV switching authorisation - identification of hazards and controlling risks, safety procedures and precautions, responsibilities and protocols and identifying switching resources
- Techniques in HV substation switching - isolation procedures and proving dead, earthing procedures, pre-switching checks, switching operational procedures, emergency fault procedures and commissioning procedures
- Use, care and operation of equipment associated with HV substation equipment - test instruments and sticks
- HV switchgear encompassing: types, categories, application and operating capabilities
- Basic Operation of protection systems
- Restrictions pertaining to HV substation switching equipment
- Restrictions pertaining to Enterprise Specific procedures

T6 Circuit breaker construction principles encompassing:

- Standards, codes, legislation, supply authority regulations and or enterprise requirements applicable to circuit breakers
- Requirements for the use of manuals, circuit breaker diagrams/plans and drawings
- Types, characteristics and capabilities of HV substation circuit breakers installed
- Use, characteristics and capabilities of specialised tools and equipment
- Identification of components within the circuit breaker and associated control housings
- Identification of energy sources within the circuit breaker and associated control housings
- Identification of insulation paths within the circuit breaker
- Types and characteristics of operating mechanisms
- Types and characteristics of interrupter chambers
- Safety precautions when Constructing circuit breakers - safe working practices and procedures, identification of hazards, assessment and control of OHS risks and types, selection, maintenance and use of personal protective equipment

T7 Synchronous Condenser Principles encompassing:

- Standards, codes, legislation, supply authority regulations and or enterprise requirements applicable to Synchronous Condensers
- Requirements for the use of manuals, substation diagrams/plans and drawings
- Types, characteristics and capabilities of Synchronous Condensers installed
- Identification of components within the Synchronous Condensers and associated control housings
- Use, characteristics and capabilities of specialised tools and equipment
- Enterprise Specific Policies and Procedures for Synchronous Condensers
- Techniques in evaluating serviceability of Synchronous Condensers operation

REQUIRED SKILLS AND KNOWLEDGE

- Safety precautions when testing and measuring Synchronous Condensers - safe working practices and procedures, Identification of hazards and assessment and control of OHS risks, types, selection, maintenance and use of personal protective equipment, responsibilities and protocols and safe working clearances
- Communicating worksite procedures

T8 Commissioning procedures associated with relevant equipment encompassing:

- Standards, codes, Commonwealth/State/Territory legislation, supply authority regulations and or enterprise requirements associated with the commissioning procedures
- Requirements for the use of commissioning manuals, system diagrams/plans and drawings
- Techniques in commissioning procedures - planning, policy, testing techniques and close out requirements

T9 Detailed operation of instrument transformers encompassing:

- Voltage and current transformer principles and terminology
- Types and classes of current transformers
- Constructions of current transformers
- Characteristics of current transformers
- Testing of current transformers
- Types and categories of voltage transformers
- Constructions of voltage transformers
- Characteristics of voltage transformers
- Testing of voltage transformers

T10 Detailed operation of metering devices and principles encompassing:

- Common circuit configurations
- Meters and measurement principles
- Instrument transformer application
- Testing of metering systems and devices
- Implications of market operation

T11 Detailed operation of communication devices and principles encompassing:

- Types of communication systems
- Interface to power system equipment
- Hardware configurations
- Testing of communication links

T12 Primary Plant testing encompassing:

- Transformers - DC high voltage tests, AC high voltage tests, induced high voltage tests, ratio tests, polarity tests, winding resistance tests, impedance tests, insulation resistance tests, transformer vector group test, winding temperature indicator test, alarm tests, neutral ct tests

REQUIRED SKILLS AND KNOWLEDGE

- Circuit breakers - DC high voltage tests, AC high voltage tests, induced high voltage tests, function tests, operation timing, minimum voltage operation test, insulation resistance test, contact resistance test, auxiliary contact test, alarm tests
- Capacitor banks - DC high voltage tests, AC high voltage tests, induced high voltage tests, neutral ct tests, balance tests, insulation resistance

T13 Effects of harmonics encompassing:

- Characteristics and effects of harmonics on protection device functions/malfunction
- Effects of harmonics on the following: transformers, generators motors and quality of supply

T14 Basic design features and characteristics of underground cables, lines, poles/structures and associated equipment and or components encompassing:

- Standards, codes, legislation, supply authority regulations and or enterprise requirements applicable to installing conductors and associated equipment
- Overhead lines characteristics - type of components, characteristics of conductor material, mechanical limitations and physical dimensions of lines, current rating factors (heating, voltage drops, power losses) of conductors, aerial bundled cables (HV and LV), covered conductors.
- Characteristics and constructional features of poles and structures - types of poles and structures, characteristics of poles/structure materials, mechanical limitations of poles/structures, footings and additional support techniques.
- Characteristics and constructional features of underground cables - underground cables constructional features, insulation materials and abbreviations, cable dielectrics, electric stress, cable voltage drop.
- Calculation of cable volt drop in relation to length of cable run
- Techniques in reducing electrical stress on cables
- Cable rating factors
- Methods of joining and terminating cables
- Techniques in the installation of cables above and below ground
- Techniques in cable testing and the location of cable faults
- Techniques in cable drawing.

T15 Power test equipment testing encompassing:

- Safety precautions specific to the use and connection of power test equipment
- Meter operational principles; note examples include moving coil, moving iron, transducer, digital and analogue
- Types, operation and use of meters - phase sequence meters, phase angle meters, instrument transformers, wattmeters, energy meters, phase system analysers, power oscilloscopes and frequency meters

T16 Principles of transmission, sub-transmission and zone substation primary plant designs encompassing:

- Commonwealth, State/Territory and local government legislation, Standards,

REQUIRED SKILLS AND KNOWLEDGE

- codes, supply authority regulations and or enterprise requirements applicable to the substation design management principles
- Requirements for the use of the substation system construction manuals, system diagrams/plans and drawings and for plans such as work method statements for the control of OHS risks
 - Types of primary plant designs parameters: note examples include electrical equipment in accordance with the Single Line Diagram, bay spacing, busbar heights, statutory and maintenance clearances in accordance with AS2067 and organisational requirements, switchyard equipment layout, lightning protection, control and power cables routes within and outside switchyard

Evidence Guide

EVIDENCE GUIDE

9) This provides essential advice for assessment of the unit of competency and must be read in conjunction with the Performance Criteria and the range statement of the unit of competency and the Training Package Assessment Guidelines.

The Evidence Guide forms an integral part of this Competency Standard Unit and shall be used in conjunction with all component parts of this unit and, performed in accordance with the Assessment Guidelines of this Training Package.

Overview of Assessment 9.1)

Longitudinal competency development approaches to assessment, such as Profiling, require data to be reliably gathered in a form that can be consistently interpreted over time. This approach is best utilised in Apprenticeship programs and reduces assessment intervention. It is the Industry's preferred model for apprenticeships. However, where summative (or final) assessment is used it is to include the application of the competency in the normal work environment or, at a minimum, the application of the competency in a realistically simulated work environment. It is recognised that, in some circumstances, assessment in part or full can occur outside the workplace. However, it must be in accord with Industry and, Regulatory policy in this regard.

Methods chosen for a particular assessment will be influenced by various factors. These include the extent of the assessment, the most effective locations for the assessment activities to take place, access to physical resources, additional safety measures that may be required and the critical nature of the competencies being assessed.

The critical safety nature of working with electricity, electrical equipment, gas or any other hazardous substance/material carries risk in deeming a person competent. Hence, sources of evidence need to be 'rich' in nature so as to minimise error in judgment. Activities associated with normal every day work have a bearing on the decision as to how much and how detailed the data gathered will contribute to its 'richness'. Some skills are more critical to safety and operational requirements while the same skills may be more or less frequently practiced. These points are raised for the assessors to consider when choosing an assessment method and developing assessment instruments. Sample assessment instruments are included for Assessors in the Assessment Guidelines of this Training Package.

Critical aspects of evidence required to demonstrate competency in this unit 9.2)

Before the critical aspects of evidence are considered all prerequisites shall be met.

Evidence for competence in this unit is based, shall be considered holistically. Each element and associated Performance Criteria shall be demonstrated on at least two occasions in accordance with the "Assessment Guidelines – UET12UET12". Evidence shall also comprise:

- A representative body of Performance Criteria demonstrated within the timeframes typically expected of the discipline, work function and industrial environment. In particular this shall incorporate evidence that shows a candidate is able to:
 - Implement Occupational Health and Safety workplace procedures and practices including the use of risk control measures as specified in the Performance Criteria and range; and
 - Apply sustainable energy principles and practices as specified in the Performance Criteria and range; and
 - Demonstrate an understanding of the essential knowledge and associated skills as described in this unit to such an extent that the learner's performance outcome is reported in accordance with the preferred approach; namely a percentile graded result, where required by the regulated environment; and
 - Demonstrate an appropriate level of employability skills;

and

- Conduct work observing the relevant Anti Discrimination legislation, regulations, policies and workplace procedures; and
- Demonstrated performance across a representative range of contexts from the prescribed items below:

Range of tools/equipment/materials/procedures/workplaces/other variables		
Group No	The minimum number of items on which skill is to be demonstrated	Item List
A	Completion of two (2) compliant technical designs including each of the following:	Electrical equipment in accordance with the Single Line Diagram. Bay spacing, busbar heights, statutory and maintenance clearances in accordance with AS2067 and organisational requirements. Switchyard equipment layout. Lightning protection.

		Control and power cables routes within and outside switchyard.
B	Designs should also include all the following:	Activities that address the correction of errors in the process. Application of a design control checklist, which lists all of the required design activities to be carried out in this process.
C	At least one occasion	Dealing with an unplanned event by drawing on essential knowledge and associated skills to provide appropriate solutions incorporated in the holistic assessment with the above listed items.

Context of and specific resources for assessment 9.3)

This unit should be assessed as it relates to normal work practice using procedures, information and resources typical of a workplace. This should include:

- OHS policy and work procedures and instructions.
- Suitable work environment, facilities, equipment and materials to undertake actual design of transmission, sub-transmission and zone substation primary plant.

In addition to the resources listed above, in Context of and specific resources for assessment, evidence should show demonstrated competency working realistic environment and a variety of conditions.

Method of assessment

9.4)

This Competency Standard Unit shall be assessed by methods given in Volume 1, Part 3 “Assessment Guidelines”.

Note:

Competent performance with inherent safe working practices is expected in the Industry to which this Competency Standard Unit applies. This requires that the specified essential knowledge and associated skills are assessed in a structured environment which is primarily intended for learning/assessment and incorporates all necessary equipment and facilities for learners to develop and demonstrate the essential knowledge and associated skills described in this unit.

Concurrent assessment and relationship with other units

9.5)

There are no recommended concurrent assessments with this unit, however in some cases efficiencies may be gained in terms of learning and assessment effort being concurrently managed.

Range Statement

RANGE STATEMENT

10) This relates to the unit of competency as a whole providing the range of contexts and conditions to which the Performance Criteria apply. It allows for different work environments and situations that will affect performance.

This Competency Standard Unit shall be demonstrated in relation to the design of transmission, sub-transmission and zone substation primary plant and may include the following:

Primary components of a substation which may include: Electrical equipment in accordance with SLD, bays spaced in accordance with standard requirements, switchyard design in accordance with AS2067, equipment spaced so that space is available for maintenance facilities, maintenance space to fence in accordance with AS2067, switchyard equipment device codes correct, busbar earthing facilities available in appropriate positions, earth switches fitted to high busbar, portable earth attachment points in correct position, connections, busbar and flexibles, earthing points, switchgear operating handle positions, disconnecter operator earth mats, anti-vibration Pads and Transformer location, auxiliary transformer location, earth stick storage, control building equipment layout, H.V. cable layout, wiring/connection diagrams, cable schedule, pilot terminations, streamline filter supply, frame leakage CT's, VT 's and CT's, photo electric cells, earthing of plumbing, distribution feeder cable CB connection and route drawing produced by regional designer and checked. Manufacturer's data sheets, documents, drawings

Manufacturers' recommendations; Reliability performance profiles; Knowledge of local history and experience; Consultation with other Authorities; Environmental influences; Present practices.

Equipment includes; Sectionalisers, air break switches, capacitor banks, transformer taps, metering and protection equipment, data communication systems

Primary and secondary voltage and current injection equipment; time delay measuring equipment; Current transformers; Voltage transformers; Power transformers;

Tapchangers; Circuit breakers; Capacitor banks; Ring main units; Audio frequency load control; Circuit breaker auxiliary systems; Substation and metal structure

earthing systems; SCADA interfaces and transducer inputs; local opto-isolated alarms: PLC programs; Auto Reclosers (ACRs); protection relays; metering; control circuits;

Statistical metering systems; Frame leakage relays; Distance relays; Pilot wire relays; Transformer differential relays; Busbar differential relays; Impedance bus zone relays;

Overcurrent and earth fault relays; Transformer neutral check relays; Circuit breaker fail relays; Multi-trip relays; Auto recloser relays; Voltage transformer failure relays;

Surge protection relays; Buchholz relays; Winding temperature relays; Sensitive earth fault relays; Phase failure relays; Frequency relays; Load shedding relays; General

protection LV devices; Oil temperature protection devices; Oil surge protection devices; Power supplies. differential relays; power systems; multi-faceted schemes;

interactive overload schemes, distance protection (incorporating relay selection, switched/non-switched schemes; mutual coupling and teed feeder systems); protection

signalling (incorporating series, direct, permissive, distance acceleration, block interruption); telecommunication circuits and equipment.

The following constants and variables included in the element/Performance Criteria in

RANGE STATEMENT

this unit are fully described in the Definitions Section 1 of this volume and form an integral part of the Range Statement of this unit:

- Appropriate and relevant persons (see Personnel)
- Appropriate authorities
- Appropriate work platform.
- Assessing risk
- Assessment
- Authorisation
- Confined space
- Diagnostic, testing and restoration.
- Documenting detail work events, record keeping and or storage of information.
- Drawings and specifications
- Emergency
- Environmental and sustainable energy procedures
- Environmental legislation.
- Environmental management documentation.
- Established procedures.
- Fall prevention
- Hazards
- Identifying hazards
- Inspect
- Legislation
- MSDS
- Notification.
- OHS practices
- OHS issues
- Permits and / or permits to work
- Personnel.
- Quality assurance systems.
- Requirements.
- Safe design principles
- Testing procedures
- Work clearance systems

Unit Sector(s)

Not applicable.

Competency Field

Competency Field **11)**
Design