



Australian Government

**UETTDRDS53 Design power system
transmission and sub-transmission
substation primary plant**

Release: 1

UETTDRDS53 Design power system transmission and sub-transmission substation primary plant

Modification History

Release 1. This is the first release of this unit of competency in the UET Transmission, Distribution and Rail Sector Training Package.

Application

This unit covers the design of transmission, sub-transmission and zone substation primary plant. It includes 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.

The application of the skills and knowledge described in this unit may require a licence/registration to practice in the workplace subject to regulations for undertaking of electrical work.

Other conditions may apply under state and territory legislative and regulatory licencing requirements which must be confirmed prior to commencing this unit.

Pre-requisite Unit

Common Unit Group

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 low voltage a.c. circuits

UETTDRDS39 Prepare and manage detailed construction plans for electrical power system infrastructure

UETTDRDS44 Design power system substations modifications

UETTDRREL11 Apply sustainable energy and environmental procedures

UETTDRREL16 Working safely near live electrical apparatus

UETTDRIS62 Implement and monitor the power system organisational WHS/OHS policies, procedures and programs

UETTDRIS63 Implement & monitor power system environmental & sustainable energy management policies & procedures

Competency Field

Design

Unit Sector

Not applicable.

Elements and Performance Criteria

ELEMENTS

Elements describe the essential outcomes.

1 Plan for and coordinate the design of transmission, sub-transmission and zone substation primary plant

PERFORMANCE CRITERIA

Performance criteria describe the performance needed to demonstrate achievement of the element.

- 1.1** Work health and safety (WHS)/occupational health and safety (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 appropriate personnel
- 1.3** Established policies, procedures and specifications for the design are obtained or established with appropriate personnel
- 1.4** Equipment/tools and personal protective equipment (PPE) 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 PPE, required for the job are identified, scheduled and

- coordinated and confirmed safe and in 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 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 in accordance with established procedures
 - 2.2** WHS/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 in accordance with 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 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 it complies with all requirements and includes 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

Foundation Skills

Foundation skills essential to performance are explicit in the performance criteria of this unit of competency.

Range of Conditions

Range is restricted to essential operating conditions and any other variables essential to the work environment.

Non-essential conditions may be found in the Companion Volume Implementation Guide.

Unit Mapping Information

This unit replaces and is equivalent to UETTD RDS53A Design power system transmission and sub-transmission substation primary plant.

Links

UET Training Package Companion Volume Implementation Guide is found in VETNet - <https://vetnet.gov.au/Pages/TrainingDocs.aspx?q=229bace1-b7bc-4653-9300-dffb13ecfad7>

Assessment Requirements for UETTDRDS53 Design power system transmission and sub-transmission substation primary plant

Modification History

Release 1. This is the first release of this unit of competency in the UET Transmission, Distribution and Rail Sector Training Package.

Performance Evidence

Evidence required to demonstrate competence in this unit must be relevant to and satisfy all of the requirements of the elements and performance criteria on at least two separate occasions and include:

- applying relevant work health and safety (WHS)/occupational health and safety (OHS) requirements, including the use of risk control measures
- applying sustainable energy principles and practices
- completing 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 AS 2067:2016 Substations and high voltage installations exceeding kV a.c. and organisational requirements
 - switchyard equipment layout
 - lightning protection
 - control and power cables routes within and outside switchyard
- completing designs, including 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
- dealing with unplanned events on at least one (1) occasion.

Knowledge Evidence

Evidence required to demonstrate competence in this unit must be relevant to and satisfy all of the requirements of the elements and performance criteria and include knowledge of:

- 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
- principles of power transformer construction and operations encompassing:

- transformer types - 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 and 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, and impedance percent
- nameplate details - basic impulse insulation (BIL), tapping winding detail, physical layout, cooling ratings and 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 - placement issues, tapping range and on-load tap changer (OLTC) versus off load tap changer (TC) techniques - high speed resistor, reactor and vacuum types, Jansen mechanisms, dead tank and live tank types
- control system characteristics
- high voltage (HV) bushing selection - insulation system used, rating, BIL, selection criteria and testing considerations
- principles of power transformer construction and operations encompassing:
 - applications of static reactive plant in HV networks, including voltage control, VAR control, and transient response capacity
 - types of static reactive plant, including HV capacitors, HV 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 and bridge type
 - typical protection systems used, including neutral unbalance current and neutral unbalance voltage
 - techniques used when balancing elements within static reactive plant
 - safety precautions when testing and maintaining HV static reactive plant - safe working practices and procedures; identification of hazards; assessment and control of WHS/OHS risks and types; selection, maintenance and use of personal protective equipment (PPE)
- principles of power transformer high speed OLTC encompassing:
 - selector types and applications for HV power transformers

- diverter switch types and applications for HV power transformers, including live tank, dead tank, resistor type, reactor type, vacuum type, pennant flag and 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 HV power transformer OLTC - safe working practices and procedures; identification of hazards and assessment; control of WHS/OHS risks and types; selection, maintenance and use of PPE
- substation switching practices encompassing:
 - standards, codes, legislation, supply authority regulations and/or enterprise requirements applicable to substation switching
 - 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 - types, categories, application and operating capabilities
 - basic operation of protection systems
 - restrictions pertaining to HV substation switching equipment
 - restrictions pertaining to enterprise-specific procedures
- 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 WHS/OHS risks and types; selection, maintenance and use of PPE
- 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
 - safety precautions when testing and measuring synchronous condensers - safe working practices and procedures; identification of hazards and assessment and control of WHS/OHS risks; types, selection, maintenance and use of PPE; responsibilities and protocols; and safe working clearances
 - communicating worksite procedures
- 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
- 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
- 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

- detailed operation of communication devices and principles encompassing:
 - types of communication systems
 - interface to power system equipment
 - hardware configurations
 - testing of communication links
- primary plant testing encompassing:
 - transformers - direct current (d.c.) HV tests, alternating current (a.c.) HV tests, induced HV tests, ratio tests, polarity tests, winding resistance tests, impedance tests, insulation resistance tests, transformer vector group tests, winding temperature indicator tests, alarm tests and neutral ct tests
 - circuit breakers - d.c. HV tests, a.c. HV tests, induced HV tests, function tests, operation timing, minimum voltage operation tests, insulation resistance tests, contact resistance test, auxiliary contact test and alarm tests
 - capacitor banks - d.c. HV tests, a.c. HV tests, induced HV tests, neutral ct tests, balance tests and insulation resistance
- effects of harmonics encompassing:
 - characteristics and effects of harmonics on protection device functions/malfunction
 - effects of harmonics on transformers, generators motors and quality of supply
- 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 and power losses) of conductors, aerial bundled cables (HV and low voltage (LV)) and 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 and cable voltage drop
 - calculation of cable voltage 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
- power test equipment testing encompassing:
 - safety precautions specific to the use and connection of power test equipment
 - meter operational principles, such as:

- 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
- principles of transmission, sub-transmission and zone substation primary plant designs encompassing:
 - Commonwealth/state/territory and local government legislation, standards, 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 WHS/OHS risks
 - types of primary plant designs parameters, such as:
 - electrical equipment in accordance with the single line diagram, bay spacing, busbar heights, statutory and maintenance clearances in accordance with AS 2067:2016 Substations and high voltage installations exceeding kV a.c, and organisational requirements, switchyard equipment layout, lightning protection, and control and power cable routes within and outside switchyard.

Assessment Conditions

Assessors must hold credentials specified within the Standards for Registered Training Organisations current at the time of assessment.

Assessment must satisfy the Principles of Assessment and Rules of Evidence and all regulatory requirements included within the Standards for Registered Training Organisations current at the time of assessment.

Assessment must occur in workplace operational situations where it is appropriate to do so; where this is not appropriate, assessment must occur in simulated conditions involving realistic and authentic activities that replicate operational workplace conditions.

Assessment processes and techniques must be appropriate to the language, literacy and numeracy requirements of the work being performed and the needs of the candidate.

Resources for assessment must include access to:

- a range of relevant exercises, case studies and/or other simulations
- relevant and appropriate materials, tools, facilities, equipment and PPE currently used in industry to undertake actual design of transmission, sub-transmission and zone substation primary plant
- applicable documentation, including workplace procedures, relevant industry standards, equipment specifications, regulations, codes of practice and operation manuals.

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