



Australian Government

**Assessment Requirements for
UETDRTS018 Maintain, test and
commission power systems voltage
regulating equipment**

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Modification History

Release 1. This is the first release of this unit of competency in the UET Transmission, Distribution and Rail Sector Training Package Release 2.0.

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
- testing, on two (2) occasions, at least two (2) of the following:
 - automatic circuit recloser (ACR) control box and recloser functions
 - line capacitor controller
 - voltage regulating relay and voltage regulator
- commissioning, on two (2) occasions, at least two (2) of the following:
 - ACR control box and recloser
 - line capacitors
 - voltage regulating relay and voltage regulator
- 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:

- WHS/OHS enterprise responsibilities encompassing:
 - provisions of relevant WHS/OHS legislation
 - principles and practice of effective WHS/OHS management
 - management arrangements relating to regulatory compliance
 - enterprise hazards and risks, control measures and relevant expertise required
 - characteristics and composition of workforce and their impact on WHS/OHS management
 - relevance of enterprise management systems to WHS/OHS management
 - analysis of working environment and design of appropriate WHS/OHS management systems

- analysis of relevant data and evaluation of WHS/OHS system effectiveness
- assess resources to establish and maintain WHS/OHS management systems
- generation systems encompassing:
 - methods of generating electricity - types of power stations and reasons for their location, and layout of thermal and hydroelectric power stations
 - relationship between power control and load requirements - operating speeds for thermal and hydroelectric generating sets, typical generator voltage levels and output ratings
 - the purpose and features of typical types of co-generation systems
- transmission, distribution and rail systems encompassing:
 - relationship between the transmission, distribution and rail/tram system within an overall power system - different organisations responsible for generation, transmission, distribution and rail/tram; how they correlate and their functions
 - characteristics of a transmission, distribution and rail system - principal components, typical voltage levels and methods of transmission and distribution, including grid type transmission systems, radial, parallel and ring main feeders
 - relationship between an overhead and underground supply systems within an overall power system - advantages/disadvantages, applications and the basic steps for planning and installing an overhead and underground distribution system
 - single line drawings and layouts - drawings and layouts of transmission and distribution systems, including radial, parallel and ring main feeders and the high voltage (HV) equipment associated with substations
- substations, power transformers and reactors encompassing:
 - relationship between the substations within an overall power system - purpose, location in relation to load centres, layout of HV equipment within the substation and auxiliary equipment
 - characteristics of a power transformer - basic construction of distribution transformers, operation under load/no-load conditions, types and basic operation of tap changing switches, including solid state types, efficiency and cooling
 - auxiliary equipment used on transformers - function and basic operation of equipment
 - maintenance of a power transformer - basic connections, restrictions to parallel operation, problems and remedies associated with harmonics, and testing and fault-finding procedures
 - description, purpose and characteristics of a reactors
- coordinating access authority procedures encompassing:
 - specific enterprise processes, policies and procedures to be followed
 - processes of consultation, negotiation and coordination - clear and concise instructions and information, methods for the encouragement of feedback and contributions of information and ideas, and responsibilities of members of the team
 - techniques in analysing, planning, coordinating and organising work for a safe outcome and according to statutory requirements and regulations
 - techniques in the effective utilisation of available resources
 - techniques in the development of an access authority/permit and/or access authority/permit issuing procedures

- techniques in facilitating and coordinating the delivery and issuing of access authorities
- techniques in gathering, collating and confirming data on different worksites - electrical network diagrams for the specific worksite, earth access authorities, safe working area, work to be carried out in confined space or in hazardous environment, specific outsourcing procedures, specific hazard identification, risk classification and management procedures, and regulatory requirements, such as WHS/OHS and electrical safety
- techniques in the receiving and coordinating the cancellation of access authorities in readiness for restoration
- methods of conducting audits on correct access authority procedures
- process of issuing of other access authorities for work permits - working in confined space, if required, coordination of access authorities, and engaging and briefing contractors on electrical and other work
- issue and receipt of operating agreements
- principles of statutory and safety considerations encompassing:
 - Commonwealth/state/territory legislation, standards, codes, supply authority regulations and/or enterprise requirements associated with working on HV
 - particular reference to state and territory regulations - working near energised conductors, electrical access, heights, confined space, testing procedures and licensing rules
- HV system switching principles including switching authorisation procedures to an extent indicated by the following aspects:
 - legislation, standards, codes, supply authority regulations and/or enterprise requirements applicable to system switching
 - requirements for the use of manuals, system diagrams/plans and drawings
 - types and characteristics of HV systems and equipment to be switched
 - procedures for obtaining correct HV switching authorisation - identification of WHS/OHS hazards, assessing and controlling risks, safety procedures and precautions, and safe approach distances
 - responsibilities and protocols, identifying switching resources, procedures for obtaining electrical access permit authorities, requirements for team switching and procedures for coordination of operations
 - techniques in HV system switching - pre-switching checks, switching operational procedures, isolation procedures and proving dead de-energised, earthing procedures, switching operational procedures, emergency fault procedures and energisation procedures
- low voltage (LV) system switching principles, including switching authorisation procedures, encompassing:
 - legislation, standards, codes, supply authority regulations and/or enterprise requirements applicable to system switching
 - requirements for the use of manuals, system diagrams/plans and drawings
 - types and characteristics of LV systems and equipment to be switched
 - procedures for obtaining correct LV switching authorisation - identification of WHS/OHS hazards, assessing and controlling risks, safety procedures and precautions, safe approach distances, responsibilities and protocols, identifying switching resources, procedures for obtaining electrical access permits authorities, requirements for team switching and

- procedures for coordination of operations
- techniques in LV system switching - isolation procedures and proving dead, earthing procedures, pre-switching checks, switching operational procedures, emergency fault procedures and energisation procedures
- enterprise-specific equipment installation procedures encompassing:
 - standards, codes, legislation, supply authority regulations and/or enterprise requirements applicable to equipment installation
 - requirements for the use of manuals, substation diagrams/plans and drawings
 - types, characteristics and capabilities of HV substation equipment to be installed
 - identification of components within the equipment to be installed and associated control housings
 - use, characteristics and capabilities of specialised tools and equipment
 - enterprise-specific policies and procedures for equipment to be installed
 - control equipment and auxiliary relays, flags and alarms
 - techniques in evaluating serviceability of equipment to be installed
 - safety precautions when testing and measuring equipment to be installed - safe working practices and procedures; identification of hazards; assessment and control of WHS/OHS risks; types, selection, maintenance and use of personal protective equipment (PPE), responsibilities and protocols and safe working clearances
 - remote and local operating principles and conventions
- 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, and 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 level (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, on-load tap changer (OLTC) versus off load tap changer techniques, types in use (high speed resistor, reactor and vacuum

- types, Jansen mechanisms, dead tank and live tank types), and control system characteristics
- HV bushing selection – type, 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, volt-ampere reactive (VAR) control and transient response capacity
 - types of static reactive plant, including HV capacitors, HV reactors, static VAR compensators (SVC) 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; types, selection, maintenance and use of 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; assessment and control of WHS/OHS risks; types, selection, maintenance and use of PPE
- 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; 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, assessment and control of WHS/OHS risks; types, selection, maintenance and use of PPE; responsibilities and protocols; safe working clearances and communicating worksite procedures
- operation and maintenance procedures associated with voltage regulation schemes encompassing:
 - standards, codes, Commonwealth/state/territory legislation, supply authority regulations and/or enterprise requirements associated with the operating procedures
 - requirements for the use of operating manuals, system diagrams/plans and drawings
 - principles of operation and operating sequences - voltage control, VAR control, live bus/dead bus synchronising checks, tap changer principles, requirements for parallel operations, settings and grading
 - techniques associated isolation requirements, enterprise maintenance requirements, setting checks, LV injections and electrical measurements
 - ancillary equipment - transducers, buswire schemes, tap position indicators, local/remote control systems and alarm systems
 - voltage regulation scheme types - electromechanical, micro-processor or combinations of both
- electrical equipment associated with distribution field device protection and control schemes encompassing:
 - types and applications of electrical equipment – characteristics, capabilities (schemes: ACR, gas switches, secondary injection tests, primary injection tests, trunked mobile radio (TMR), supervisory control and data acquisition (SCADA), remote control, overcurrent, earth fault, sensitive earth fault, inverse time curves, definite time curves, tripping, reclose, direct current (d.c.) supplies, alternating current (a.c.) supplies and

alarms)

- voltage control techniques encompassing:
 - conditions leading to voltage collapse
 - effects on system of HV and LV
 - voltage control devices - voltage regulators applied to generators and synchronous phase modifiers; electromagnetic voltage regulators; series and parallel capacitors; OLTC transformers; and SVC, such as saturated reactor compensators, thyristor-controlled reactor compensators and combined systems
 - production of harmonics and methods of harmonic control
 - location of voltage control devices within the system
- voltage control devices encompassing:
 - typical devices applications and capacities
 - estimation of rating of VAR regulating devices using graphical techniques
- transient over voltages encompassing:
 - causes and effects of transient over voltages - switching transients and lightning transients, and effects on plant items
 - control techniques and systems - surge diverters, shield wires and circuit breaker arc control
 - insulation systems - insulation systems, insulation coordination and insulation grading
- 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, close out requirements
- procedures for the location and rectification of faults in electrical equipment up to 1000 volts a.c. and/or 1500 volts d.c. encompassing:
 - relationship of WHS/OHS to the location and rectification of faults in electrical equipment - acts and regulations, identification of personal safety, workplace hazards, working with electrically operated tools and equipment, emergency first aid/resuscitation, rescue from a live electrical situation, and enterprise policies and procedures
 - types of drawings - differentiation between symptoms, faults and causes in malfunctioning equipment, fault-finding techniques and procedures
 - fundamental electrical concepts - effects of current; practical resistors; sources of electromagnetic field; series, parallel and series-parallel circuits; electrical measurement; capacitors; inductors and magnetism
 - fundamentals of general appliances - basic principles of appliances (non-mathematical), appliance identification, appliance ratings, basic principles of operation of control equipment and protection devices, fault conditions and symptoms, safe isolation procedures, test equipment, safe testing procedures, including continuity, fault types in appliances and fault-finding procedures (prescriptive)
 - fundamentals of single phase induction motors - basic principles of operation (non-mathematical), motor identification, motor ratings, basic principles of operation of

- control equipment and protection devices, fault conditions and symptoms, safe isolation procedures, test equipment, safe testing procedures, including continuity, fault types in phase splitting and universal type motors, and fault-finding procedures (prescriptive)
- fundamentals of three phase induction motors - basic principles of operation (non-mathematical), motor identification, motor ratings, motor starter principles, basic principles of operation of control equipment and protection devices, fault conditions and symptoms, safe isolation procedures, safe testing procedures and fault-finding procedures (prescriptive)
 - fundamentals of single and three phase electrical heaters - basic principles of operation, types of electrical heaters, electrical heater identification, electrical heater ratings, basic principles of operation of control and protection devices, fault conditions and symptoms, safe testing procedures and fault-finding procedures (prescriptive)
 - disconnection and reconnection procedures for fixed wiring electrical equipment up to 1000 volts a.c. and/or 1500 volts d.c. encompassing:
 - safe electrical work practices and procedures according to standards such as AS/NZ 4836:2001 Safe working on low-voltage electrical installations and equipment, or equivalent
 - safe use of tools and plant
 - safe use of ladders and elevated work platforms (EWP)
 - safe use of PPE
 - hazards in the (electrical) work environment - shock hazards, fire hazards, chemical hazards and other hazardous areas
 - special situations
 - procedures for dealing with fires associated with electrical equipment
 - procedures for dealing with PCBs
 - electric shock victim rescue methods and procedures - basic first aid treatment for shock, burns and bleeding
 - purpose of each procedure and application - expired air resuscitation (EAR), external cardiac-compression (ECC), cardiopulmonary resuscitation (CPR), combined application of EAR and ECC
 - components of a basic electrical circuit(s) – source, control and protection, load
 - types of circuit diagrams – symbols, conventions, interpretations and free sketches
 - types of circuit connections and functions - open circuit, closed circuit and short circuit
 - techniques in basic electrical measurement - use of multimeters; use of ammeter; use of voltage measuring and indicating devices; testing of measuring instruments; care of measuring instruments; voltage, current and resistance measurement; estimating values of voltage, current and resistance and using Ohms law
 - fundamental principles of electrical concepts - effects of current; practical resistors; sources of electromagnetic field; simple practical circuit; series, parallel and series-parallel circuits; electrical measurement; capacitors; inductors and magnetism
 - techniques in insulation resistance measurement and requirements
 - earthing principles and systems
 - disconnection and reconnection procedures for fixed wiring electrical equipment up to 1000

volts a.c. and/or 1500 volts d.c. encompassing:

- methods for testing insulation resistance - continuity of prospective earthing conductor, continuity between exposed conductive parts and the earthing system
- methods of recognising acceptable test results for compliance with safety requirements
- methods of recognising unacceptable test results requiring an appropriate qualified person to further investigate
- cable types and conductor termination methods and techniques - conductors solid, stranded and flexible, and colour codes
- single and three phase systems and loads - number of active and live conductors required, line and phase voltage, and typical loads
- identification and rating of general appliances
- single phase induction motors - motor identification, motor ratings and direction of rotation
- three phase induction motors - motor identification, motor ratings and direction of rotation
- single and three phase heaters - types of heaters, heater identification and heater ratings
- electrical distribution arrangement - power systems within premises and purpose of switchboards/distribution boards (residual current devices and earth-leakage circuit breakers)
- circuit isolation and protection devices
- isolation procedures - work clearance, testing for voltage, lock-off and tagging, techniques in isolation and tagging, regulation, codes of practice and procedures
- disconnection procedures, practices and requirements
- types of replacement equipment
- methods of ensuring equipment is safe to connect to supply
- methods of reconnection procedures, practices and requirements
- methods of return equipment to service
- 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
- procedures for the systematic fault isolation through the application of diagnostic techniques encompassing:
 - principles of analytical questioning
 - techniques in drawing valid conclusions from first observations
 - concepts of broad first-line testing
 - consideration of/responsibility for avoidance of further damage
 - interpretation of specific test results -cause/effect
 - techniques for isolation to appropriate level - half-split, module/function isolation (kernel technique), substitution, diagnostic software, requirements for the use of manuals, system diagrams/plans, drawings, handbooks, specifications and fault pathways
 - software/firmware functions awareness
 - factors affecting field versus workshop repair costs

- scheduling minor/major repair activities and downtime
- implications of temporary repairs
- use of system knowledge and history
- data interpretation - expected versus actual
- feedback to design/production/installation processes
- subsystems and system structures
- system signals/status indicators
- known failure modes and trends
- action threshold warnings versus catastrophic failure
- component ratings/upgrades
- disassembly/reassembly techniques and care
- relative costs of repair and replacement - remaining life, ongoing maintenance, additional benefits of replacement equipment, e.g., improved productivity and quality
- protection schemes encompassing:
 - standards, codes, legislation, supply authority regulations and/or enterprise requirements applicable to protection schemes
 - types of protection schemes - reasons for use, application of protection zones around system elements and degree of protection
 - types of feeder protection equipment - overcurrent protection inverse time-current operating characteristics
 - operation of overcurrent protection equipment used on distribution systems
 - operation of ACR and their time-current characteristics
 - types and characteristics of overcurrent relays
 - coordination methods of a distribution feeder protection scheme
 - earth fault protection used on a distribution feeder
 - operation of a single wire earth return (SWER) system
- extra-high voltage (EHV) generator control systems encompassing:
 - legislation, standards, codes, supply authority regulations and/or enterprise requirements pertaining to the operation of a portable generator
 - safety precautions specific to the synchronisation of generator sets - safe working policies, practices and procedures, and synchronising procedures
 - techniques in the installation of generator sets control systems - the synchronising of generator control systems onto and off the network without interruption to supply, estimation of EHV load and assessing the appropriateness of the generator
 - operating a generator in parallel to a single EHV job - overhead systems, indoor systems, customer installations and kiosk substations
 - EHV generator set and control system to EHV distribution assets.

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
- applicable documentation, including workplace procedures, relevant industry standards, equipment specifications, regulations, codes of practice and operation manuals.

Links

Companion Volume Implementation Guides are found in VETNet -

<https://vetnet.gov.au/Pages/TrainingDocs.aspx?q=229bace1-b7bc-4653-9300-dffb13ecfad7>