



Australian Government

UETDRTS009 Design testing and commissioning procedures for field devices and substations

Release: 1

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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.

Application

This unit covers the testing and commissioning procedures for new substation and field devices in accordance with design. This will involve analysis of settings, and a thorough understanding of the circuit design, which will involve covering areas such as metering, communication circuits and supervisory control and data acquisition (SCADA).

It also includes the procedures needed to enable proof of correct operation of all circuits to design specifications. It also encompasses the need for supplying accurate communication in the format that is acceptable to the operating or testing authority.

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 licensing requirements which must be confirmed prior to commencing this unit.

Pre-requisite Unit

All competencies in the Common Unit Group must have been completed, plus all competencies in one (1) of the identified Pathway Unit Group(s).

Common Unit Group

UEENED104A Use engineering applications software on personal computers

UEENEEE101A Apply Occupational Health and Safety regulations, codes and practices in the workplace

UEENEEE102A Fabricate, assemble and dismantle utilities industry components

UEENEEE104A Solve problems in d.c. circuits

UEENEEE107A Use drawings, diagrams, schedules, standards, codes and specifications

UEENEEE124A Compile and produce an energy sector detailed report

UEENEEE125A Provide engineering solutions for problems in complex multiple path circuits

UEENEEE126A Provide solutions to basic engineering computational problems

UEENEEG101A Solve problems in electromagnetic devices and related circuits

UEENEEG102A Solve problems in low voltage a.c. circuits

UEENEEG149A Provide engineering solutions to problems in complex polyphase power circuits

UETDREL001 Apply environmental requirements

UETDREL005 Work safely in the vicinity of live electrical apparatus

UETDRIS005 Implement & monitor power system environmental & sustainable energy management policies & procedures

UETDRIS006 Implement and monitor the power system organisational WHS/OHS policies, procedures and programs

Protection Relays and Meters Pathway Unit Group

UETDRTS023 Repair, test and calibrate protection relays and meters

Metering Pathway Unit Group

UETDRTS005 Commission power systems metering schemes

UETDRTS010 Develop power systems secondary isolation instructional documents

UETDRTS014 Maintain and test and metering schemes

Primary Plant Pathway Unit Group

UETDRTS007 Conduct evaluation of power systems primary plant

UETDRTS010 Develop power systems secondary isolation instructional documents

Protection Systems Pathway Unit Group

UETDRTS010 Develop power systems secondary isolation instructional documents

UETDRTS015 Maintain complex network protection and control systems

UETDRTS017 Maintain interdependent network protection and control systems

Competency Field

Testing

Unit Sector

Not applicable.

Elements and Performance Criteria

ELEMENTS

Elements describe the essential outcomes.

PERFORMANCE CRITERIA

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

1 Plan for the design of testing and commissioning procedures for substation and field devices

- 1.1** Work health and safety (WHS)/occupational health and safety (OHS) practices/procedures and environmental and sustainable energy procedures, which may influence the undertaking of design of testing and commissioning procedures for substation and field devices, are reviewed and determined
- 1.2** Purpose for designing of testing and commissioning procedures for substation and field devices is established after data is analysed and expected outcomes of the work are confirmed with appropriate personnel
- 1.3** Organisational established procedures on policies and specifications for the design of testing and commissioning procedures for substation and field devices are obtained or established with appropriate personnel
- 1.4** Testing procedures are discussed with appropriate personnel in order to ascertain the project brief
- 1.5** Testing parameters are established from organisational established procedures on policies and specifications
- 1.6** Equipment/tools and personal protective equipment (PPE) are selected based on specified performance criteria and established procedures
- 1.7** Work roles and tasks are allocated according to requirements and individual competencies
- 1.8** Work is prioritised and sequenced for the most efficient/effective outcome, completed within an acceptable timeframe, to a quality standard and in accordance with established procedures
- 1.9** Liaison and communication issues with others/authorised personnel, authorities, clients and landowners are resolved and activities coordinated to carry out work
- 1.10** Risk control measures are identified, prioritised and evaluated against the work schedule
- 1.11** Relevant work permits are secured to coordinate the performance of work according to requirements and/or established procedures

2 Carry out the design of

- 2.1** Circuit/systems modelling is used to evaluate alternative

**testing and commissioning
procedures for substation
and field devices**

proposals in accordance with established procedures

- 2.2 WHS/OHS and sustainable energy principles, functionality and practices to reduce the incidents of accidents and minimise waste are incorporated into the project in accordance with requirements and/or established procedures
- 2.3 Design of testing and commissioning procedures for substation and field devices decisions are made on the basis of safety and effective outcomes according to requirements and/or established procedures
- 2.4 Mathematical and/or engineering models of design testing and commissioning procedures for substation and field devices 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 Testing and commissioning procedures for substation and field devices are developed according to requirements and established procedures
- 2.8 Work teams/groups are arranged/coordinated/evaluated to ensure planned goals are met according to established procedures
- 2.9 Solutions to non-routine problems are identified and actioned, using acquired essential knowledge and associated skills, according to requirements
- 2.10 Quality of work is monitored against personal performance agreement and/or established organisational and professional standards
- 2.11 Strategic plans are developed incorporating organisation

initiatives in accordance with established procedures

3 Complete the design of testing and commissioning procedures for substation and field devices

- 3.1** Final review of testing and commissioning procedures for substation and field devices is undertaken to ensure they comply with all requirements and include all specifications and documentations needed to complete the project
- 3.2** Appropriate personnel are notified of completion and reports and/or completion documents are finalised/commissioned
- 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 testing and commissioning procedures for substation and field devices 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 UET Transmission, Distribution and Rail Sector Training Package Companion Volume Implementation Guide.

Unit Mapping Information

This unit replaces and is equivalent to UETTDRTS24 Design testing and commissioning procedures for field devices and substations.

Links

Companion Volume Implementation Guides are found in VETNet -

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

Assessment Requirements for UETDRTS009 Design testing and commissioning procedures for field devices and substations

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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
- developing testing and commission procedures for at least three (3) of the following substation equipment:
 - bus protection
 - feeder/line protection
 - transformer protection
 - earth fault protection
 - backup protection
 - metering schemes
 - communication and supervisory control and data acquisition (SCADA) schemes
- developing testing and commissioning procedures for at least two (2) of the following field devices:
 - regulators
 - automatic circuit reclosers (ACR)/gas switch
 - line capacitors
- 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:

- powerline safety practices encompassing:
 - protective apparatus and apparel for linework - responsibilities for the selection, use, maintenance and storage of protective apparatus and apparel and the types of protective apparatus and apparel used for the line worker
 - requirements for the use of ladders - carrying, erecting, collapsing and lowering different

types of extension ladder against a standing pole; maintenance checks on different types of ladders; renewal of extension ropes and the safety issues relating to clearances from overhead conductors

- requirements for climbing and working aloft - methods used to identify a pole is safe to climb; methods used to inspect a line worker's body belt; application of knots and hitches appropriate to the requirements of a line worker; height safety principles, including personal fall protection, prevention and related requirements; and the practical procedures of climbing an overhead structure and fitting a pole chair
- traffic management - purpose of traffic management and a line worker's responsibilities in accordance with relevant statutory requirements and electricity supply industry (ESI) requirements, procedures used to provide an effective traffic management scheme and the use of a two-way radio
- control of small fires - identification, selection and operation of the appropriate extinguishing mediums for various types of fires; general fire prevention methods and the precautions for personal protection when fighting small fires
- rescue victims from heights and confined spaces - planning and identifying procedures; establishing responses; developing techniques; involvement of external emergency services; and practical demonstration/rehearsals of rescuing a person from heights and from confined spaces and emergency procedures for the rescue of an electric shock victim, including cardiopulmonary resuscitation (CPR)
- requirements for aerial linework - planning, establishing and implementing relevant aviation authority clearances, determining system requirements, aircrew familiarisation with network operations and equipment, and requirements for effective communications operations for aerial work
- principles of statutory and safety considerations encompassing:
 - Commonwealth/state/territory legislation, standards, codes, supply authority regulations and/or enterprise requirements associated with working on high voltage (HV)
 - particular reference to state and territory regulations - working near energised conductors, electrical access, heights, confined space, testing procedures and licensing rules
- electrical equipment associated with protection and control schemes encompassing:
 - types and applications of electrical equipment – characteristics, capabilities (schemes: overcurrent, frame leakage, cooling, buchholz, direct current (d.c.) supplies, restricted earth, sensitive earth fault, circuit breaker fail, reclose, d.c. frame leakage, CEL fail, under frequency load shed and earth fault)
- principles of isolation and tagging procedures associated with protection testing encompassing:
 - standards, codes, Commonwealth/state/territory legislation, supply authority regulations and/or enterprise requirements associated with the installation, maintenance, isolation and tagging procedures
 - requirements for the use of isolation and tagging, manuals, system diagrams/plans and drawings
 - techniques in documenting isolations
 - techniques in appropriate isolation and tagging procedures in accordance with Commonwealth/state/territory legislation, supply authority regulations and enterprise standards

- techniques in the installation and maintenance procedures for protection devices in accordance with Commonwealth/state/territory legislation, supply authority regulations and enterprise standards
- maintenance and commissioning procedures associated with discrete protection schemes encompassing:
 - standards, codes, Commonwealth/state/territory legislation, supply authority regulations and/or enterprise requirements associated with maintenance and commissioning procedures
 - requirements for the use of maintenance and commissioning manuals, system diagrams/plans and drawings
 - techniques in maintenance and commissioning procedures – planning, policy and testing techniques
 - close out requirements
- relay manufacturer specifications encompassing:
 - standards, codes, Commonwealth/state/territory and local government legislation, supply authority regulations and/or enterprise requirements applicable to the use and application of relay manufacturer specifications
 - requirements for the use of relay manufacturer manuals, system diagrams/plans and drawings
 - types, function and characteristics of specific relays - differences between specific relays used for the same functionality
- procedure to undertake a visual inspection of a scheme encompassing:
 - standards, codes, Commonwealth/state/territory legislation, supply authority regulations and/or enterprise requirements associated with visual inspection procedures of a scheme
 - requirements for the use of manuals, system diagrams/plans and drawings
 - identifying obvious deficiencies in operating to the standard functionality
 - techniques in determining relay malfunction - targeting
 - techniques in determining wiring defects
- operation and maintenance procedures associated with discrete protection and control systems encompassing:
 - standards, codes, Commonwealth/state/territory legislation, supply authority regulations and/or enterprise requirements associated with operating procedures
 - requirements for the use of operating manuals, system diagrams/plans and drawings
 - techniques - gas collection and analysis, bleeding and resetting, calibration, operational and sensitivity checks, and trip and alarm checks
 - surge relay types and uses, including transformer main tanks and diverter switch chambers
- measurements and the interpretation and analysis of those measurements related to the plant and/or equipment type encompassing:
 - type of measurements - timing, current, voltage, capacitance, inductance, impedance, phase angle, phase shift, resistance, dielectric dissipation factor, frequency, polarisation index, ratio, vector group and temperature
 - interpretation and analysis the use of techniques - digital comparison of data,

- extrapolation, use of graphs and charts, statistics and tables, mathematical calculation of expected values and comparison with manufacturer data and measurements
- techniques in the processes involved in follow-up actions and recommendations resulting from analysis and interpretation of results and measurements
- substation safety practices encompassing:
 - standards, codes, Commonwealth/state/territory/local government legislation, supply authority regulations and/or enterprise requirements pertaining to substation safety practices
 - techniques in the use of protective apparatus and apparel for substations work, including responsibilities with regard to the use and maintenance of protective apparatus and apparel and the types of protective apparatus and apparel used for work in substations
 - requirements for the use of ladders and appropriate ladder types for work in substations - safe work methods when carrying, erecting, collapsing and lowering different types of extension ladder against substation structures; plant and equipment; maintenance checks on different types of ladders; renewal of extension ropes and the safety issues relating to clearances from energised conductors
 - requirements for climbing and working at heights in substations - attached climbing principles; selection, use and operation of elevated work platforms (EWP) and any WHS/OHS requirements associated with the use of EWP
 - control of small fires - identification, selection and operation of the appropriate extinguishing mediums for various types of fires and the precautions for personal protection when fighting small fires
 - control of oil spills - identification, use and maintenance of spill oil control equipment and materials; and oil containment facilities and systems
 - rescue and release procedures - the rescue personnel from energised conductors, emergency descent from an EWP and/or rescue from confined spaces
 - enterprise requirements - safe access and authorisation to work procedures, use of mobile extendable equipment on or near energised HV conductors and emergency response procedures
 - hazards associated with work in substations, including earthing systems, transfer potentials, step and touch effects, electrostatic and electromagnetic induction, and dangers of near approach to energised conductors
- design principles of HV insulation systems encompassing:
 - insulation design principles - common materials used, electrical characteristics, thermal characteristics, uses and applications to substation HV plant and equipment, grading, construction and cooling
 - common contaminants and their effects - internal contaminants and external contaminants
 - testing and measurement of insulation quality - test types and common measuring instruments and techniques, resistance and resistivity, losses, measurement errors, temperature corrections and safe work practices related to testing and measurement
 - safety precautions when testing and measuring HV insulation systems - 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)
- 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 - 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
- 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 with - isolation requirements, enterprise maintenance requirements, setting checks, low voltage (LV) injections and electrical measurements
 - ancillary equipment, including transducers, buswire schemes, tap position indicators, local/remote control systems and alarm systems
 - voltage regulation scheme types, including electromechanical, micro-processor or combinations of both
- types and applications of test equipment encompassing:
 - standards, codes, Commonwealth/state/territory and local government legislation, supply authority regulations and/or enterprise requirements applicable to the use and application of electrical and/or electronic test equipment
 - types and applications of test equipment used on discrete protection scheme
 - techniques in the use of test equipment - electronic test equipment (Doble and Ohmmicrome), gas injection equipment, manufacturer test equipment, multimeters, phase angle meters and meggers
- 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
- 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
- procedure to undertake a visual inspection of a scheme encompassing:
 - standards, codes, Commonwealth/state/territory legislation, supply authority regulations and/or enterprise requirements associated with visual inspection procedures of a scheme
 - requirements for the use of manuals, system diagrams/plans and drawings
 - identifying obvious deficiencies in operating to the standard functionality
 - techniques in determining device malfunction
 - techniques in determining wiring defects
- 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 and setting of discrete protection systems encompassing:
 - earth fault protection - master earth leakage schemes, sensitive earth fault relays and schemes, residual earth fault scheme, core balance earth fault scheme, frame/structure earth leakage scheme, time graded discrimination and backup protection
 - overcurrent protection - feeder overcurrent protection, instantaneous overcurrent schemes, inverse timed overcurrent schemes, types and location of components of an overcurrent scheme, current transformer summation, time graded discrimination and backup protection
 - alarms and controls - auxiliary relays, voltage regulating relays, line drop compensation, gas relay types, gas relay scheme operation and setting, and over temperature schemes
- detailed operation of interdependent protection systems encompassing:
 - overcurrent and earth leakage schemes, including inter-tripping, interlocking and blocking - logic mapping, master control, electromechanical, electronic and shading coils
 - pilot wire, phase comparison - opposed voltage schemes, circulating current schemes, location of components of a scheme and pilot supervisory techniques
 - load shedding, voltage control, parallel operation and load rejection
 - busbar protection and circuit breaker failure protection
 - reclose systems - applications, single shot, multi-shot, blocking schemes and synchronisation checking
- 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 fundamental test equipment encompassing:
 - care and safe use
 - operating principles
 - comparison of different operating principle meters used for the same purpose
 - accuracy and loading effects of meters - measurement of voltage, current, power, resistance, insulation resistance, impedance and phase sequence and the use of oscilloscopes
- detailed operation of protection test equipment encompassing:
 - care and safe use
 - operating principles
 - comparison of different operating principle meters used for the same purpose
 - accuracy and loading effects of meters - measurement of timing, voltage, current, resistance, inductance, capacitance, impedance, frequency, phase angle, phase difference and the use of primary, secondary and gas injection equipment
- detailed operation of metering test equipment encompassing:
 - care and safe use
 - operating principles
 - comparison of different operating principle meters used for the same purpose
 - accuracy and loading effects of meters - measurements of, voltage, current, power, reactive power, phase angle, resistance, inductance, capacitance, impedance, frequency, harmonics and the use of transient and data logging devices
- detailed operation of field device test equipment encompassing:
 - care and safe use
 - operating principles
 - comparison of different operating principle meters used for the same purpose
 - accuracy and loading effects of meters - measurements of voltage, current, power, reactive power, phase angle, resistance, inductance, capacitance, impedance, frequency, harmonics and the use of transient and data logging devices
- procedure 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.

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, equipment and PPE currently used in industry
- applicable documentation, including workplace procedures, equipment specifications, regulations, codes of practice and operation manuals.

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