TRAINING STANDARDS

National Electrotechnology Training Package

Volume 8

Co-ordination Units

UTE99 Electrotechnology Training Package

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Changes in units of competency and packaging of qualifications are reflected on the **National Training Information Service** which displays only current information: **http://www.ntis.gov.au**

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Glossary

Italic typeface is used in this National Training Package and the associated competency standards indicates terms and variables that require further explanation. Explanation of terms and variables that have meaning in a particular unit are given in the range statements and should be referenced accordingly at all times. Those that have a common meaning throughout this standard are explained below.

In many instances, the explanations of relevant terms are direct extracts from or are derived from technical standards published by Standards Australia or jointly by Standards Australia and Standards New Zealand.

It should be noted that some Units of competency have unique features. Consequently, these units have additional glossary terms included within.

Common terms and variables

Accessories -

Any device associated with, and forming an integral part of, the wiring systems such as switch, fuse, plug, socket outlet, lampholder, fitting, adaptor, ceiling rose; connectors, clamps, splitters, termination posts, lugs, strips and blocks; clips, ties and bindings.

Apparatus -

Any equipment forming a component part of an installation used for a particular purpose. *Apparatus* includes, but is not limited to, that contained in the following divisions. It will necessarily include new and emerging technologies:

- **Audio/visual equipment** including televisions, radios, monitors, cameras, closed circuit television, mono and stereo sound systems, gaming machines, electronic display panels, cassette recorders, video cassette recorders, CDROM players, tape recorders, sound and video duplication equipment, digital versatile discs, digital audio tapes, professional and domestic speaker systems, mixer desks.
- **Air conditioning equipment** including room air conditioners, split systems, package units, ducted units, evaporative coolers, ventilation systems.
- **Appliances** including portable electric tools, motor driven pumps, vacuum cleaners, food preparation equipment, hair dryers, refrigerators, washing machines, dish washers, paper shredders, water coolers, clothes dryers, pest exterminators, electric motor driven industrial tools and equipment, sanitary disposal units, radial and tangential fans and blowers.
- **Business equipment** including facsimile machines, photocopiers, printers, scanners, modems, computers and peripherals, financial transaction devices and systems.
- **Communications equipment** including radio transmitters, television transmitters, microwave transmitters and receivers, repeaters, two way radios, antennae, satellite linkage equipment.

- **Computer systems** including personal computers, computer networks, peripherals, supervisory control and data acquisition systems, modems, bridges, servers, routers, automatic data capture equipment.
- **Electrical and electronic controllers and control systems** including switchboards and control centres, alternating and direct current regulated and unregulated power supplies, rectifiers and filters, electromechanical and solid state relays and contactors, programmable controllers, uninterruptable power supplies, oscillators, motor speed controllers, electromechanical and dynamic brakes, battery charging and electroplating equipment, lamp dimmers and flashers, transducers, frequency injection systems.
- **Electrical machines and associated drives** including single phase and polyphase alternating current cage and wound rotor induction motors and synchronous motors and generators, direct current motors and generators, amplidynes, dynamometers, stepper motors, servo motors and synchros, double wound and auto transformers, induction regulators, electronic variable speed and eddy current drives.
- **Energy management and sustainable energy equipment** including solar cells, stand-by batteries, inverters, wind generators, hybrid systems, stand-by alternators, power factor correction controllers.
- **Heating equipment** including single and polyphase instantaneous and quick recovery water heaters, space heaters, induction heaters, electric furnaces, commercial food warmers, microwave and dielectric heaters, electric ranges, stoves and oven tops.
- **Instrumentation/process control devices and equipment** including controllers, transmitters, final control elements, detectors, process loop auxiliary equipment, indicators and recorders, monitors and computer interface equipment.
- **Lighting** including incandescent, quartz halogen and vapour lamps, applications in domestic, commercial, industrial and sporting settings, advertising signs, security lighting, road and highway lighting.
- **Measuring instruments** including digital and analogue ammeters, voltmeters, watt and var meters, frequency meters, phase rotation devices, oscilloscopes, power factor indicators, energy meters, insulation resistance devices, continuity testers, chart recorders, voltage detectors, Wheatstone and double bridges, instruments to measure signal strength, harmonic distortion, electro-magnetic and electro-static fields.
- **Medical electronics and equipment** including x-ray machines, cardiographic monitoring equipment, electrophoresis equipment, electron microscopes, infra-red (deep heat) equipment, physical therapy equipment, CAT scan equipment, ultrasound equipment, defibrillators, infusion pumps, incubators, ventilators, foetal monitors, thermometric devices, anaesthetic units, gas monitors, dialysis equipment, pacemakers, lasers, endoscopes, blood warmers, physiological monitors.

- **Power distribution/transmission systems** including wood, concrete, steel and composite poles and structures, transmission towers, overhead and underground conductors and cables, electrical metering and recording devices.
- **Refrigeration systems** including refrigerators, freezers, icemakers, cool rooms, freeze rooms, beverage coolers, merchandising and display cabinets, blast freezers.
- **Scanning and detection systems** including: radar systems, sonar systems.
- **Security and fire detection systems** including sensors, controllers, alarm devices, telecommunications interfaces, closed circuit television cameras and monitoring systems.
- **Telecommunication equipment** including switching equipment, PABX, microwave transmitters and receivers, customer premises equipment, customer access networks, transmission equipment.

See also *wiring systems.*

Apparatus, fixed wired -

Apparatus (electrical/electronic) connected to a system of wiring in which cables protected or unprotected are fixed or supported in position.

Appliances -

A fixed (for support only), hand-held (held in hand during normal use), portable (moved whilst in operation or easily moved from one place to another while connected to the supply) or stationary (can be moved, but not easily) consuming device, other than a lamp.

Individuals with responsibilities for co-ordination, design installation, maintenance, production, or servicing activities. This can include:

- site managers
- project managers
- engineers and technicians
- technical experts
- line managers/supervisors
- regulatory personnel
- team leaders
- other personnel designated by an organisation or enterprise

Approval of equipment -

Acceptance by the relevant authority for an item of equipment to be used in a particular situation.

AQF -

Australian Qualifications Framework, which describes qualifications in terms of levels, characterised by the outcomes of vocational education and training.

Capacity, load and duty -

Flow rates of air, fluids and gases; current-carrying capacity; air, fluids and gas pressures; mechanical loading on piping, tubing or cables and supports; maximum demand and current ratings; duty cycles; frequency; environmental conditions.

Categories – general -

Competency can be achieved for any number of the following categories for which **formal endorsement** is to be provided, as prescribed in the evidence guide and critical aspects for each unit. These are:

a. Computer systems: The adaptation of Electrotechnology to the processing and control, communication and storage of information.

b. Electrical: Encompasses the systems associated with wiring reticulation, distribution centres, utilising devices and electrical machines for the conversion of electrical energy into other forms and conversely for the conversion of other forms of energy into electromotive force.

c. Electronics: The use of discrete solid state components and integrated circuits and devices and their associated circuits for application within process control systems, communication systems, computers, measurement, entertainment equipment, electro-medical equipment and the like.

d. Instrumentation: The measurement and control of process system data and parameters for industrial and commercial use. It includes the calibration and maintenance of instrument and processes in the chemical, energy, biotechnology, environmental, food processing and manufacturing industries.

e. Refrigeration and air conditioning: Air conditioning is the provision of clean air to an area at proper temperature and humidity. Refrigeration is the cooling of a space or its contents to a lower temperature than that of the surrounding space or of the ambient atmosphere.

f. Data communications: Encompassing the systems associated with communication distribution equipment, components, and the related devices for the distribution of audiovisual and data between points of transmission and reception.

Categories - relating to wiring systems -

g. Cabling/wiring support and protection: Including cable enclosure, ducts, trunking, roughing and cable trays and conduits, cable supports, aerial systems, catenary systems, underground systems, cable harnesses and looms.

h. Network communications: Including wiring systems and cables for the purpose of transmitting audio, visual or data information and may be associated with such things as twisted pair cables, telephone cables, screened and shielded cables, coaxial cables and optical fibre cables.

i. Power and control – extra low voltage: Including wiring systems and cables for the purposes of providing power and/or analogue or digital control and may be associated with such things as figure eight cables, unshielded twisted pair cables, ribbon cables, coaxial cables, and may include the production of printed circuit boards

j. Power and control – low voltage: Including wiring systems and cables for the purpose of providing power and/or analogue or digital control and may be associated with such things as thermoplastic/elastomer insulated/sheathed cable, multicore, armoured cable, mineral insulated metal sheathed (MIMS) cables, fire retardant cables, flexible cables, trailing cables and busways and includes those cables related to the category power and control extra low voltage.

Categories - relating to powerline switching -

k. Low voltage switching: The isolation and energising of low voltage powerlines for power distribution through approved switching and isolation procedures.

l. High voltage switching: The isolation and energising of high voltage powerlines for power transmission and distribution through approved switching and isolation procedures.

m. System switching: The isolation and energising of feeders in switchgear substations on low voltage and/or high voltage systems including load transfer and may include systems control room operations.

Categories - relating to business support -

n. Administration: Functions of record maintenance, quotation preparation, promotion of work and products, attending to customer and employees enquiries and complaints, preparation of invoices, business plans, service reports, maintenance reports and stock control.

p. Technical: Functions of estimating preparation of quotations, tenders related to installation, maintenance, repair and servicing of electrical/electronic apparatus and systems. Managing contracting projects and contracting business operation.

q. Wholesaling: Sales and supply of apparatus/equipment and electrical accessories to contractors and industrial end-users covering wholesaling-general or wholesaling-warehouse or wholesaling-point of sale.

Circuits -

Covers electrical, hydraulic, pneumatic, optical, magnetic, air flow, hydropic and refrigerant circuits.

Competency can be demonstrated in:

- basic circuits and associated apparatus
- complex circuits and associated apparatus
- systems' circuits and associated apparatus
- advanced circuits/systems and associated apparatus

A hierarchy of circuit complexity has been established within this document (independent of supply circuits) and are defined as follows:

Basic circuits: A basic circuit is defined as a single circuit with a single output.

A single circuit may be controlled by one or more devices and the output may control one or more devices.

Complex circuits: A complex circuit is defined as one made up of more than one interdependent circuit.

A complex circuit is made up of more than one circuit, controlling and processing inputs or outputs.

Systems' circuits: A systems' circuit is defined as one that interconnects between a number of interdependent apparatus.

A systems' circuit is made up of more than one interconnecting circuit controlling and processing apparatus inputs and outputs.

Advanced circuits/systems: Advanced circuits/systems may be complex circuits or systems circuits which contain complicated networks, hybrid circuits and which rely on digital or analogue closed loop feedback for the control of outputs.

Component -

That portion of a unit of *equipment*, which has been designed as a discrete unit and that can be identified as such.

Conditions and ratings -

Relates to flexible cables and plugs that are selected in accordance with Australian and New Zealand Standards and technical data including factors such as:

- Voltage rating
- Current rating

- Sheathing requirement
- Length of cable
- Pin configuration
- Control circuits
- Environmental conditions
- Weather proofing
- Fitting types – shielding, anchorage, earthing and polarity

Consistent performance -

Relates to sufficient evidence being present. This requires evidence that competence has been demonstrated for each element of each unit having been achieved at least three times autonomously and to *requirements.*

Design brief/proposal -

Instructions/specifications/outcomes defining the performance of circuits and associated apparatus, usually for the purpose of ensuring the optimum efficiency, environmental performance, economical effectiveness and operation of the system.

Endorsement: to be reported -

Refers to the endorsement on which an item of *apparatus, appliances, components, equipment, plant and machinery,* enclosures and the like that work can be performed on, (including any inspections, reports and risk assessment), as prescribed in regulations and/or by regulatory authorities, to which the unit applies.

Engineering data -

Refers to documents and other sources from which technical data and product specifications/characteristic are obtained, includes recognised standards publications, manufacturers product data publications and design features.

Environment -

The area surrounding the work site which can be directly or indirectly affected by occurrences at the work site. It includes the atmosphere, soils, drains, underground water tables, and the ecosystem. Protection of the environment would require the proper disposal of waste materials, restriction of burning off, the correct handling of toxic substances, the containment of CFCs and the like.

The protection of the environment would also include the minimisation of those factors that contribute, directly or indirectly, to the production of *greenhouse gases*.

These contributing factors might include the minimisation of waste materials, the correct use of enterprise vehicles and machinery, the re-use or recycling of trade

materials where possible and the overall reduction of energy usage through general awareness and the use of appropriate technologies.

Equipment (which is not apparatus) -

Any contributing part of an *installation* which may or may not be composed of *components.*

Established procedures -

Formal arrangements of an organisation, enterprise or statutory authority of how work is to be done. These may include, for example:

- quality assurance systems incorporating, for example:
  - specifications, requirements and procedures
  - work orders / instructions
  - reporting procedures
  - improvement mechanisms
  - compliance requirements
  - safety management
- work clearance systems incorporating, for example:
  - work permits
  - monitoring and clearance procedures
  - isolation procedures
- OH&S practices
- procedures for operating safety systems, operating plant and equipment and reporting work activities
- maintenance, modification or supply of relevant schematic drawings and technical data
- arrangements for dealing with emergency situations.

Greenhouse gases -

Gaseous components of the atmosphere contributing to the greenhouse effect. These gases are produced, for example, when fossil fuels are burned to produce electricity and in other industrial processes.

The greenhouse effect leads to global warming with its ecological and environmental problems.

The minimisation of the use of energy in the workplace, derived from burning fossil fuels, reduces the production of greenhouse gases.

See also *environment*

Initial audit -

An audit that is carried out initially to ascertain whether: a) appropriate procedures have been followed to ensure the safety of the area; b) equipment, systems and installation conform with the design specification and are free from damage; c) any modification have been properly documented and appropriately approved.

Installation -

Wiring systems, *apparatus* and other required items as they are fixed in place and connected as necessary to operate as intended.

Modifications -

To make changes to the physical parameters or operational function of a device, component or piece of equipment or apparatus.

Notification (notified) -

Can include verbal, written, electronic or recorded information at completion of work which may be required to be completed in accordance with established procedures.

OH&S policies and procedures -

Arrangements of an organisation or enterprise to meet their legal and ethical obligations of ensuring the workplace is safe and without risk to health. This may include:

- hazardous and risk assessment mechanisms
- implementation of safety regulations
- safety training
- safety systems incorporating,
  - work clearance procedures
  - isolation procedures
  - gas and vapour
  - monitoring/testing procedures
  - use of protective equipment and clothing
- use of codes of practice

Periodic audit -

An audit that is carried out periodically to ascertain whether: a) appropriate procedures have been followed to ensure the safety of the area; b) equipment, systems and installation conform with the design specification and are free from damage; c) any modification have been properly documented and appropriately approved.

Plant and machinery -

Devices or machines (not considered to be hand tools or hand held power tools) used to facilitate construction, installation or maintenance and are removed after the completion of the work. Examples include chain blocks, winches, compressors, ladders, elevated work platforms, explosive power tools, hand operated battery mobile lift and transfer equipment, accessories and attachments and the like.

Requirements -

That to which equipment and procedures and their outcomes must conform and includes statutory obligations and regulations and *standards* called-up by legislation or regulations. Requirements may also include:

- statutory regulations
- codes of practice
- job specifications
- transport documentation
- *standards* called-up in specifications be they Australian/New Zealand or International
- procedures and work instructions
- quality assurance systems
- manufacturers' specifications
- maintenance manuals, schedules and specifications/standards
- circuit/cable schedules
- design specifications
- customer/client requirements and specifications
- specified underpinning knowledge (specified in units' Evidence Guides)
- National and State guidelines , policies and imperatives relating to the *environment*

Representative range -

That which requires a sufficient body of evidence undertaken across a range of activities and work functions to be present in order that a valid, reliable, fair and timely judgement about an individual's performance for attributing competence can be made.

Sample audits -

A sample audit that is carried out to ascertain whether: a) appropriate procedures have been followed to ensure the safety of the area; b) equipment, systems and installation conform with the design specification and are free from damage; c) any modification have been properly documented and appropriately approved.

Servicing -

Undertaking routine inspection, repair and maintenance of circuits, systems or *apparatus*.

Specialisation -

Describes the work environment in which the core technical requirements of learning are to apply.

Standards -

Technical documents, which set out specifications and other criteria for equipment, materials, and methods to ensure they consistently, perform as intended. The s*tandards* referred to in this competency standard are those published by Standards Australia or in joint venture with Standards New Zealand. Competency in the use of other technical standards may be required in industries not restricted to Australian *requirements*. For example, shipping and off-shore petroleum industries are subject to standards agreed to by underwriters and enterprises or some other international convention.

Statutory Authority -

The person or body responsible for the implementation of legislation.

Sustainable Energy Principles and Practice -

Sustainable Energy Practice refers to workplace actions that contribute to the reduction of greenhouse gases. These are caused by the combustion of fossil fuels such as coal and gas. As most electricity is generated using fossil fuels, a reduction in the unnecessary use of electricity reduces the production of greenhouse gases. Also, most materials used in the workplace are manufactured using electricity or gas, so recycling and reducing the wastage of these materials also helps. There is a worldwide commitment to reducing greenhouse gases, which are considered to contribute to global warming. This User Guide promotes workplace strategies to assist in achieving the same goals.

Sustainable Energy Practice is closely related to the 'environment'. Sustainable energy practice aims to reduce the amount of wastage in electricity and other forms of energy that lead to the production of greenhouse gases. Many of the principles and practices that apply in the workplace also apply in the home and the general environment. These include:

- examining work practices that may use excessive electrical energy
- reducing energy by using energy efficient machines and appliances (eg. star ratings)
- switching off devices such as lights, machines and computers when not in use
- using power-save devices, such as those incorporated in photocopiers, business machines and the like

- replacing incandescent lamps with compact fluorescent lamps
- using natural light to replace artificial light
- regularly cleaning air conditioner filters
- closing windows and doors when climate control units are used
- insulating dwellings, offices and workplaces and preventing draughts
- using reflective curtains to control heat
- using natural or artificial shade to control sunlight
- using solar water heating
- using automatic processes to manage energy usage
- reusing materials used in construction, engineering and manufacturing
- recycling waste materials
- driving motor vehicles and other machines with care
- using natural gas for heating rather than oil or coal based fuels
- using devices to reduce water usage
- checking for leakage in hot water system pressure relief valves and elsewhere in plumbing systems
- sharing information about energy conservation with other workers

System -

A group or combination of inter-related, inter-dependent or interlocking elements forming a collective entity. Includes *circuits, apparatus, equipment* and the like.

Termination -

The act by means of which an electrical connection to an apparatus is established; specifically a prepared joint or connection between a cable, cord or conductor and a point in an electrical circuit such as a terminal or connection point. Such terminations include soldering, crimping, clamping, wire wrapping, insulation piercing/compression.

Testing devices -

Devices and instruments used to ensure safety requirements and operational functions are met, and to diagnose faults in apparatus, circuits or systems.

Utility -

The provision of energy services such as power, water, gas and telecommunications. In the case of UTE NES013 A it applies specifically to remote area essential services operations.

Wiring systems -

Permitted cables, enclosures, supports and *accessories* for power, measurement, control or communications purposes. (See also *Category*)

Work clearances -

Includes any system of permissions and notifications for safely working on or removing equipment/apparatus for service.

Additional glossary terms related to electrical equipment in hazardous area units of competency

Actions -

To limit risk of an explosion can include organisational arrangements for reporting and rectifying non-conformances; shutting down plant or machinery under emergency conditions; evacuating a hazardous area; reporting non-conformances and conditions of plant and machinery; monitoring the hazards area for presence of an explosive atmosphere; meeting OH&S obligations.

Authority -

Refers to documents from which explosive characteristics of products are obtained and include:

- recognised standards publications
- manufacturers product data publications

Certification documentation -

A formal certificate issued by a certifying body stating that an item of equipment/apparatus conforms to particular requirements of a standard. Documentation may include details of limitations of use and manufacturer's specifications and drawings.

Certification of equipment -

A means of verifying that equipment intended for use in a hazardous area complies with the accepted standards.

Classification of hazardous areas -

A concept, which is accepted internationally, of dealing with the risk of fire and explosion by area classification.

Competent person -

A person who has the relevant competencies described in this competency standard.

Electrical equipment -

Equipment used for power, measurement, control or communication purposes.

N. **Pre-assembled** Type 1 and Type 2 cold cathode Neon signs only.

P. A **single enclosed control device** contained in an enclosure which is not part of a Control Panel or Distribution/Switch Board.

Q. **Control devices,** e.g. solenoids, limit switches, pressure switches, thermostats.

R. Electrical heaters, such as water heaters, duct heaters, heaters incorporated as part of a machine or appliance. e.g. moulding machines, cooking appliances and the like.

S. Motors – refers to a single or three phase motor incorporated as part of plant or machinery. For example, a chiller unit, automated production and assembly unit, NC Machine; or independent motors driving such things as pumps, conveyors and other similar parts of plant and machinery.

Engineering assessments -

Using measurements, calculations and test results to determine whether an item of equipment complies with the relevant standard.

Equipment marking -

Information with regards to certification that is required to be marked on each item of equipment incorporating an explosion-protection technique.

Explosion properties of hazardous materials -

- for gases, vapours and mists; vapour pressure; boiling point; flash point; ignition energy; explosive limits relative to vapour density; minimum ignition energy
- for dusts; layer ignition temperature; cloud ignition temperature; minimum ignition temperature

Explosion-protection -

Technique of protection which is applied to equipment or parts of equipment to prevent the ignition of flammable vapours and gases or combustible dusts in hazardous areas. See *Explosion-protected equipment*.

Explosion-protected equipment -

Equipment using the technique which is applied to equipment or parts of equipment to prevent the ignition of flammable vapours and gases or combustible dusts in hazardous areas. Such equipment employs one or more of the following techniques:

T. Mixed explosion-protection techniques - Ex mixed: e.g. the use of one or more explosion-protection techniques for the following sub-endorsements. See *explosion-protection*.

- T1 – Ex "pD" – Pressurisation, dust
- T2 – Ex "mD" – Encapsulation, dust
- T3 – Ex "iD" – Intrinsic safety, dust

U. Pressurised enclosure - Ex p: e.g. rotating machines; specific products

V. Dust-exclusion ignition-proof - DIP: e.g. rotating machines; equipment within (DIP) enclosures

W. Non-sparking - Ex n: e.g. rotating machines; equipment within Ex n enclosures

X. Intrinsic safety - Ex i: e.g. specific products

Y. Increased safety equipment - Ex e: e.g. rotating machines; enclosures, equipment within Ex e enclosures

Z. Flameproof enclosure - Ex d: e.g. rotating machines; enclosures (eg. junction boxes; light fitting; stop-start statics); equipment within enclosures

Encapsulation - Ex m

Oil immersion - Ex o

Purging - Ex pl

Sand-filled - Ex q

Special protection - Ex s

Ventilation - Ex v

Hermetic sealing - Ex h

Functions and process equipment -

Activities that produce a potentially hazardous area and the equipment used in such activities.

Gas groups -

Classification of electrical equipment for use in gas or vapour atmosphere according to groups and sub-groups of gases and vapours.

Hazardous area documentation -

Auditable documentation that shows that a hazardous area has been appropriately classified and the electrical equipment complies with the appropriate certification and other explosion-protection requirements specific to the site.

Under Australian/New Zealand Standards or Codes these records are referred to as a 'Verification Dossier' and include:

- Hazardous area classification drawings and justifications
- The explosion-protection systems design drawings/specifications
- Certification documents for each item type of explosion-protected equipment
- Inspection, testing and maintenance schedules and reports
- Re-classification and authorised modifications documentation, where applicable
- Competent persons

Hazard and risk assessment -

Any recognised methodology of identifying hazards and assessing risks such as 'hazard and operability study' (Hazop) and 'fault tree analysis' (HAZAN).

Hazardous materials -

Flammable gases and vapours and combustible dusts.

Inspection, close -

An inspection which encompasses those aspects covered by a visual inspection and, in addition, identifies those non-conformances, (eg loose fasteners), which will become apparent when access equipment, (eg steps), and tools are used. Close inspections do not normally require an enclosure to be opened or equipment de-energised.

Inspection, detailed -

An inspection which encompasses those aspects covered by a close inspection and, in addition, identifies those non-conformances which only become apparent when an enclosure is opened up, or by use of tools and test equipment.

Inspection, maintenance schedules -

A program of periodic inspections and maintenance that follow set procedures and check lists for the purpose of ensuring the integrity of the explosion-protection and to comply with *requirements.* Details of a schedule will vary depending on the nature of the explosion-protection techniques used and environmental conditions.

Inspection, periodic -

Inspections of all equipment carried out on a routine basis, usually as part of scheduled maintenance.

Inspection, sample -

Inspection of a portion of installed equipment for the purposes of monitoring the effects of environmental conditions, vibration, inherent design weakness and the like.

Inspection, schedule -

A formal arrangement for conducting inspections which details the extent, grade and frequency of the inspections and the explosion-protected characteristics and compliances to be checked.

Inspection, visual -

An inspection which identifies, without the use of access equipment or tools, those non-conformances which are apparent to the eye.

Installation -

Explosion-protected equipment, wiring and other required items as they are fixed in place and connected as necessary to operate as intended.

Integrity of explosion-protected equipment -

Aspects of the equipment design and use that afford explosion-protection.

Load and duty requirements -

Wiring systems include: sufficient current-carrying capacity; maximum permitted voltage drop is not exceeded; temperature limits are not exceeded under normal or fault conditions.

Non-conformances -

Visual damage or corrosion of equipment and wiring and loose or missing fasteners.

Non-conformances and faults -

Equipment or wiring that does not conform to the design specification or other requirements.

Other items -

Those items that are not in themselves explosion-protected but have an influence on the integrity of the explosion-protection technique used. For example, an overload device for a motor or associated equipment in the case of intrinsic safety technique.

Pre-commission testing -

- tests specified by *requirement,* such as, performance and setting of protection devices and systems, earth loop impedance, insulation resistance, and earth continuity
- equipment connection and operation tests

Process specialist personnel -

To responsible persons with expertise in the technical aspects of the activities that produce the explosive hazard and include chemical engineers, process engineers, mining engineers, safety managers and the like.

Re-certification -

The submission of previously certified equipment to an approved testing body or authority to determine whether the equipment complies with the accepted standards after modification or where original certification is not fully known.

Recommended actions -

- non-connection of supply until a non-conformance or fault is rectified
- notice of period in which a non-conformance or fault is to rectified
- other actions within the scope of statutory regulations

Regulatory or statutory authority -

The person or body responsible for the implementation of legislation relating to the handling, processing or storage of materials constituting a hazard.

Servicing -

Maintaining, fault finding and repair of equipment, plant and machinery.

Special tools, equipment and testing devices -

Tools for the removal of enclosure covers and connecting conductors; measuring devices such as feeler gauges and micrometer; gas and vapour sensors; electrical testing devices approved for use in a particular hazardous area.

Specifications -

Can include: documentation of hazardous material; documentation of process pressures and temperatures; process flow diagrams.

Standards -

Technical documents which set out specifications and other criteria for equipment, materials and methods to ensure they consistently perform as intended. The *Standards* referred to in this competency standard are those published by Standards Australia or in joint venture with Standards New Zealand. Competency in the use of other technical standards may be required in industries not restricted to Australian/New Zealand *requirements*. For example, shipping and off-shore petroleum industries are subject to standards agreed to by underwriters and enterprises or some other international convention.

Temperature class -

Classification of electrical equipment according to its maximum surface temperature.

Verification dossier -

See *hazardous area records.*

Zones –

The zones into which hazardous areas are classified based upon the frequency of the appearance and the duration of an explosive gas atmosphere.

UTE NES601 A
Co-ordinate the work of others

Descriptor: Co-ordinate, lead and participate in and facilitate the work of others appropriate to the level of autonomy in the workplace.

Elements		Performance criteria	
601.1	Plan and prepare to co-ordinate the work of others	601.1.1	Communicate *OH&S policies and procedures* planned and prepared to ensure these are followed
		601.1.2	Communicate appropriate work sequence in accordance with *requirements*
		601.1.3	*Appropriate personnel* are consulted to ensure the work is co-ordinated effectively with others involved on the work site
		601.1.4	Work of others is checked against *requirements*
		601.1.5	*Tools, equipment* and *testing devices* needed by others to carry out the work are in accordance with *established procedures* and checked for correct operation and safety
		601.1.6	Materials necessary for others to complete the work are co-ordinated in accordance with *established procedures* and checked against *requirements*
601.2	Co-ordinate the work of others	601.2.1	Co-ordinate *OH&S policies and procedures* for the work of others
		601.2.2	Co-ordinate the work of others in accordance with *established procedures* and *requirements*
		601.2.3	Co-ordinate on-going checks of the quality of work of others in accordance with *established procedures*
601.3	Inspect and notify completion of work	601.3.1	Final inspections are co-ordinated to ensure the work of others conforms to *requirements*
		601.3.2	Completion of the work of others is *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of activities and where required support the outcomes of other units within a qualification structure.

Interdependent assessment of units

Assessment in this unit is related to the knowledge associated with other units within a qualification structure, where appropriate.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to undertake activities that directly support the operational and business activities of an enterprise. This could include the following:

Enterprise documentation and record systems including the use of computers, information systems and business equipment technologies, as appropriate

Enterprise occupational health and safety instructions

Responsibilities and rights of others involved including clients, property owners, other workers and the public

Time management and co-ordination processes

Organisational arrangements for communicating plans, information, intentions and safety criteria to others by appropriate means

Operation of plant and equipment associated with a given workplace

Leadership rights and responsibilities

Leadership policies and practices

Principles of co-ordinating teams

Principles and practices in workplace relations

UTE NES602 (A to Z qualifier) A
Develop commissioning programs for apparatus & circuits

Descriptor: Develop programs for the commissioning/decommissioning of apparatus and associated *circuits*, including sequencing, test parameters and schedules.

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS613 - Develop commissioning programs for apparatus and associated circuits.

Specific unit outcomes

This is presented as a composite unit that has four specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES602A A	Develop commissioning programs for apparatus & circuits *(Computer systems)*
UTE NES602B A	Develop commissioning programs for apparatus & circuits *(Electrical)*
UTE NES602C A	Develop commissioning programs for apparatus & circuits *(Electronics)*
UTE NES602D A	Develop commissioning programs for apparatus & circuits *(Instrumentation)*

Elements		Performance criteria	
602.1	Plan and prepare to develop programs for commissioning	602.1.1	Identified *OH&S policies and procedures* to be followed are planned and prepared, and the work sequence in accordance with *requirements*
		602.1.2	*Appropriate personnel* are consulted to ensure programs for commissioning is co-ordinated effectively with others involved on the work site
		602.1.3	Programs for commissioning are checked against *requirements*

Elements		Performance criteria	
		602.1.4	Materials necessary to complete the work are identified and detailed in accordance with *established procedures* and checked against *requirements*
		602.1.5	*Tools, equipment* and *testing devices* needed to carry out the work are identified and detailed in accordance with *established procedures*
		602.1.6	Preparatory work is identified to ensure no unnecessary damage has occurred and complies with *requirements*
602.2	Develop commissioning programs	602.2.1	*OH&S policies and procedures* to be followed are detailed
		602.2.2	*Circuits* isolation and specified testing procedures are detailed where necessary
		602.2.3	Commissioning procedures are detailed in accordance with *requirements*
		602.2.4	Response to unplanned events or conditions are detailed in accordance with *established procedures*
		602.2.5	Approval to implement contingencies in accordance with *established procedures* from *appropriate personnel* are detailed
		602.2.6	On-going checks of the quality of work in accordance with *established procedures* are detailed
		602.2.7	Final maintenance inspections of *apparatus* conforming to *requirements* are detailed
		602.2.8	*Notification* of work completion in accordance with *established procedures* is detailed
602.3	Inspect and notify completion of work	602.3.1	Final inspections of developed commissioning programs are undertaken in accordance with *established procedures*
		602.3.2	Commissioning programs completion is *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment,* tools, *accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

There is no interdependency associated with this unit. However, this unit has been designed as a natural progression from unit UTE NES604 A. Therefore, it is expected that to achieve this unit, without having gained competence in unit UTE NES604 A, will require that the relevant aspects of knowledge and skills related to unit UTE NES604 A be developed and form part of the requirements for achieving competence in this unit.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled ‘Interdependent assessment of units’.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Calculus.

Differential calculus: the limit concept – definition of the derivative of a function as the slope of a tangent line (the gradient of a curve), easy examples from 1st principles; the rules – derivative of sum (difference), product, quotient, chain (function of a function), use of at most 2 rules for any given functions; the 2nd derivative – implicit differentiation – applications – equations of tangents and normals, stationary points and curve, sketching, rate of change, rectilinear motion, Newton's method; verbally formulated problems involving related rates and maxima/minima

integral calculus: integration as the inverse operation to differentiation: the results – integral of k f(ax + b) where $f(x) = x^n$, six x, cos x, $\sec^2 x$, e^x the method of substitution; the definite integral; applications – areas between curves, rectilinear motion including displacement from acceleration and distance travelled

Data communications systems operations.

Data communications systems fundamentals; principles of operation of a modem; digital data transmission over voice grade lines; digital data transmission and packet switched data; network protocols such as - token ring, token bus, CSMA/CD (ethernet)

Point to point direct connection using serial and parallel protocols; LAN topologies related to – token ring, token bus, CSMA/CD (ethernet) techniques; typical LAN s/w packages (NOS') such as LANtastic and Novell Internet; network interface cards and/or other hardware for typical LAN s/w packages (NOS'); LAN s/w packages (NOS') for a particular situation based upon a finalised system definition

Typical modem operating parameters; physical links – twisted pairs, coaxial cable, infra red (IR), spread spectrum radio, microwave etc; principle features of voice link – DDS, AUSTRPAC and ISDN carrier services; principle features of "PC Anywhere" and "Carbon Copy" packages; functions of routers, bridges etc in order to connect between various types of remote LANs and PCs (ie token ring to ethernet, IBM to MacIntosh); hardware and software required in order to connect remote LANs above

Typical interfacing software such as kermit; physical links

LAN software packages (NOS') such as "LANtastic", "LANmanager"; hardware required for interfacing; select suitable physical lines

Specialised hardware for a LAN printer; serial and parallel printer links – serial, parallel, etc; printer buffer size selection; NOS printer queue management – considering buffer size, spooling and job priority

User priority levels; allocated buffer sizes

Use of a DC ohm-meter to check for short/open circuits in network cabling, network terminators, etc; use of time domain reflectometry (TDR) to locate the position(s) of short/open circuits and other faults in network cabling; use of manufacture supplied diagnostics to test suspected network interface cards; conflicts with I/O addresses, shared memory, DMA or interrupts at any station; typical NOS diagnostics, extended NOS diagnostics

Typical network dial in/out facilities – network cache buffering, network E-mail facilities, network chat facilities; network data security aspects – requirements and typical ways in which these may be implemented; different PC types – ie IBM and MacIntosh in a typical network; typical network remote users and to connect to other LANs'/WANs'

Typical network software backup and recovery files; consequences if typical network software backup and recovery files are absent or corrupted; configuring the way typical network software backup and recovery files are generated; use of typical network software backup and recovery files to recover from a system failure/crash

Analysis and design project.

Systems concepts: software and hardware systems; systems development life cycle; roles of the analyst and user

Feasibility analysis: problem definition – scope and objectives, schedules, preliminary report; fact finding interviews – surveys and questionnaires, observations, researching (new technology, similar systems etc); systems design options and alternatives – hardware technologies, batch or online processing, centralised or remote, user inputs and outputs, hardware inputs and outputs, interconnections, existing packages, off-the-shelf components and subsystems, prototyping, application generators, language selection; evaluation of hardware and software – sizing, performance, reliability, ergonomics, support, cost/benefit analysis, feasibility report

Systems analysis: software design tools and methodologies – system flowcharts, data flow diagrams, HIPO charts, data dictionary, ER diagrams, decision tables and decision trees, pseudocode or structured English, structured walkthroughs, application generators, CAS tools, hardware system design tools - manufacturers' data books, application notes, functional block diagrams, flowcharts, test specifications, standards

Internetworking operations.

Bridges: selection of bridges based on given data link types – ethernet to ethernet, token ring to token ring, ethernet to token ring, token ring to fibre distributed data interface (FDDI); bridge installation – network address tables, priority for forwarding of packets, filters to restrict broadcast packets

Routers: selection based on given backbone network layer protocols – ISO, internet; selection based on LAN protocol or multiprotocols to be routed; installation – network address tables, filters to restrict broadcast packets, priority and class of service for forwarding of packets; topology of internetworks using local and remote routers

Formats: IBM systems network architecture (SNA) protocol; DEC DECnet protocol

Topology of internetworks: using gateways with local and remote connection to hosts

Gateway installation: table linking end users to host recognised resources such as SNA controls points (CPs) and logical units (LUs)

Protocol formats: ISO – end system (ES)-to-intermediate system (IS) and IS-to-IS protocols; internet – control message protocol (ICMP), open shortest path first (OSPF) protocol, exterior gateway protocol (EGP); spanning tree bridge protocol data units (BPDUs); (Source) routing information field; route broadcast frame

Relationships: between ISO global network service access points (NSAPs) and local subnet points of attachment (SNPAs); between internet global internet protocol (IP) address and local network point of attachment (NPA)

Protocol formats: for hello – poll and redirect messages, holding time

Format error messages: recognition of – destination unreachable, time (to live) exceeded

Database and 4GL.

DBMS approach: non-database vs database approach; data models – advantages, limitations; user requirements; role of the DBMS administrator

Data analysis: entity – relationship and occurrence; E.R model; representing entities and relationships

Normalisation: tuple; first normal form; other normal forms; conversion to optimal forms

Design and/or specifications: design approaches; development of a corporate data model including long range information system plans; information requirements analysis; logical and physical database design; data dictionary; standards – documentation and security; distributed databases

Relational algebra: relational operators – union, intersection, cartesian product, selection, projection, join, division

Queries: producing enquiry reports; producing formatted output

Programming in 4GL: creation of databases; maintenance of databases; producing reports; formatting outputs

Network layer operations.

Use of CCITT X.25 packet level protocol (PLP) and packet assembler /disassembler (PAD) hardware and software

Awareness of occupational health and safety: for mains operated electronic equipment when installing hardware

Recognition of format for CCITT X.25 PLP: "Q" bit PAD control; internet protocol

Recognition of format for network service access point (NSAP), CCITT X.21:

Recognition of format for IP addresses including: address resolution protocol (ARP)

Recognition of format for CCITT X.25 PLP including: quality of service; fast select; user facilities; PAD parameters; clear; reset; restart

Recognition of format for IP: type of service; time-to-live; options

Correlation of end user error messages with abnormal traffic

Network administration.

Network installation: review LAN server installation; system configuration; conflict avoidance; disk mirroring; file server preparation; fault tolerant systems; cable preparation; establishing workstations; boot disks; remote boot proms; documenting the network

Establishing network users: establishing accounts; establishing directories; access right and security; login scripts

Establishing printer servers: print spooling

Loading applications software: considerations for selecting and loading applications software

Network maintenance and troubleshooting: monitoring network usage; cable faults; workstation faults; server faults; system backup/restore; diagnostics

Data link planning.

Determination of data link cost/performance criteria

Error control techniques: idle repeat request, selective repeat request, go-back-N retransmission strategy ; calculations for data link utilisation

Data compression techniques: CCITT V.42

Data encryption techniques: data encryption standard (DES)

Data link user configuration factors: line speed – octets per frame, window size

Data link simulation

Analysis of non-OSI data link protocols: asynchronous byte-orientated – KERMIT, synchronous byte-orientated – IBM binary synchronous control (BSC), synchronous bit-orientated – IBM synchronous data link control (SDLC), ANSI advanced data communications control procedure – (ADCCP)

Data link technology trend analysis

System acquisition and evaluation.

Evaluation: typical electronics applications; establishing the need – objectives and requirements; performance specifications; evaluation criteria – performance effectiveness, performance efficiency, ease of use, flexibility, quality of documentation, manufacturer/supplier/support, cost/benefit analysis; techniques – performance evaluation, benchmarks, acceptance testing

Procurement: tenders, contracts; request for proposal; identifying and assessing suppliers; duties and taxes; importing regulations and procedures; purchasing options; maintenance contracts

Implementation: planning installation; training requirements; consumables; changeover

Data communications systems planning.

Network system performance: protocol parameters including – overhead, windowing; node parameters including – congestion, queue length, service time; load traffic estimation based on – number of users, types of application, bandwidth costs

Network system reliability: protocol parameters including – error recovery, link redundancy; node parameters including – component mean time between failure (MTBF); system MTBF with and without single point failure

Network system management: OSI defined functions including – fault configuration, change, performance management, financial services, inventory control, security; concepts – hierarchical vs distributed, architecture, objects, agents, collection point, console, system manager, management information base (MIB); user interface – display of network topology, statistics and error conditions, commands to control remote nodes; system automation – programming language interfaces, alert filtering, software distribution of files and jobs

Help desks: procedures – adequate incident description, incident tracking, problem escalation; tools – view remote screen, file transfer, remote keyboard control

Network personnel: network manager; network administrator; network system engineer; field service technician; service centre technician; technical salesperson

Bandwidth management planning.

Illustrate a system of host to remote terminals via multiplexers showing the relative number of async host ports required; illustrate a system which utilises x.25 and provide for x.25 switches and PADs at the remote end; illustrate bandwith requirements for the two systems; illustrate the host end configuration for both systems; illustrate a resilient configuration; perform a cost/benefit analysis – describe the management benefits of the X.25 system; block schematic diagram for the mux/demux system; provide a block schematic of the X.25 system

Provide the standards and analyse

Provide a brief of the pricing structure of the services offered for DDS and ISDN; develop a simple cost/bandwidth matrix for the ISDN; provide brochures of various manufacturers' terminal adaptors and multiplexers for ISDN connection; develop a cost comparison; illustrate requirements for resilience and define the configuration and costs associated – show how disaster recovery may be planned into the WAN connections

Illustrate a typical LAN and WAN connection with and without resilience using DDS; illustrate a typical LAN and WAN connection with and without resilience using ISDN; show typical costing of hardware for both systems

Electrical engineering mathematics.

Basic determinants and solution of 2/3 simultaneous linear equation by determinants exponents and logs

Time dependent trig functions - $\sin(\omega t+\theta)$

Trig of oblique triangles

Introduction to vectors

Complex numbers

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

Problem solving and decision making: the difference between symptoms and causes of problems – defining problems, specifying problems in terms such as cost, quality and quantity; the contingency approach which differentiates between programmed and non-programmed decisions, as well as rational and bounded rationality problem solving decision making; the steps in the decision making process – brainstorming, group-think, how and when to involve groups such as nominal groups, the Delphi techniques; practical problem solving and decision making integration in the engineering workplace environment involving decision alternative of certainty risk and uncertainty

Introduction to human behaviour: understanding factors of human behaviour – definition of terms, physical and psychological factors, why people work in engineering industries; concepts and theories of motivation; content and process approaches – critical analysis of applicability of significant theories of motivation and human behaviour to the engineering workplace; people in organisations; individual and group behaviour; formal and informal groups, interpersonal relations and behaviours in organisations; managing/supervising people (as distinct from tasks or projects); the role of the manager/supervisor, applying the theory; situational and contingency approaches, including managing conflict; functional and dysfunctional aspects of conflict; resolving conflict using problem solving techniques

Leadership and discipline: theories – types and styles of leadership; appropriateness of styles, advantages and disadvantages; effective leadership in the engineering workplace – application and evaluation of leadership styles; managing and leading – differences; authority, responsibility, power, delegation; use of decision making processes – Meetings., advisory groups, consultative groups, executive groups; discipline and interpersonal, relations; manager/staff relations, disciplinary processes and purposes, self discipline in organisations

Staff selection and personnel procedures: engineering job analysis, design and description – duties, responsibilities, authority; job requirements – qualifications, specific aptitudes and experience, achievements; effect on award restructuring on engineering job descriptions; engineering staff selection processes; establishing appropriate process, panel, selection criteria; advertising vacancy, matching applicants to criteria; interviewing – preparation, the setting, questions, making the selection, modifying successful and unsuccessful applicants; appointment of engineering staff and conditions of employment; staff placement and induction; role and responsibility of engineering managers/supervisors in the application of relevant industrial awards

Category: Electrical (B)

Common

Advanced DC machines.

Basic DC machine construction and operation: application of DC machines; construction of DC machines; DC machine connections; insulation; ratings; cooling paths; bearings; general maintenance of DC machines

Construction and use of lap and wave windings: coils and elements; generated voltage equation for generator; generated voltage equation for motors; application of lap and wave windings

Process of communication: the use of interpoles; loading of machines; brush shifting

Armature reaction in DC machines: effect of armature reaction on DC machine characteristics; use of compensating winding

External characteristics of a DC generator: performance of generators supplying various loads; voltage regulation as a percentage or per unit value; operation in parallel

Torque equation for a DC motor: shape of motor speed/torque curves; reversal of machines

Starting of DC motors: types of DC motor starters in use; DC motor protection

Speed regulation and speed control of DC motors: methods in use; effect on motor design and operation caused by the use of SCR speed control equipment

Braking of DC motors: plugging; dynamic; regenerative; mechanical

Losses and efficiency

Acceleration of DC motors and loads: characteristics of typical loads; matching loads to a suitable motor; heating of windings; de-rating of motors

Permanent magnet materials and circuits: types of materials and characteristics; BH loop and demagnetisation; temperature effects; reversible losses; irreversible losses; high temperature effects; mechanical properties – handling and magnetisation; application; power density; temperature range; duty cycle

Special DC motors – construction, operation and applications: permanent magnet motors; brushless motors; coreless and moving coil motors; linear motors; printed circuit motor; stepping motors; voice-coil motors

Safety: safety aspects in relation to motors; safety aspects in relation to associated control circuits including the use of PLCs

Operating characteristics: obtaining nameplate details; measuring DC machine parameters; obtaining the magnetising characteristic of a DC generator; determining the external characteristic of DC generators; load characteristics of DC motors; determining the efficiency of a DC machine; speed control of DC motors; braking of DC motors; troubleshooting and repair techniques

Building management systems.

Functions of a BMS: autonomous functions; input; output; general I/O; installation management items; energy management; risk management; information processing; objective; building running costs

BMS hardware: system architecture; communication devices; substations; PCs

Input and output functions: digital – input, outputs; digital output with status feedback; analogue input, output; sensors; alarms

Energy management: night cycle; optimum stop, start; time and event programs; night purge; outside air percentage control; enthalpy control; power demand control; duty cycle; presence detection; lighting control

Information processing functions: computer systems; central system management; programs; system configuration and security; operator – machine interface; data points

Risk and maintenance management: system files; fire – intruder control; access control

Circuit analysis.

Phasors: time domain; frequency domain; frequency, angular frequency and units of measurement

Complex impedance: impedance diagram; resistance; reactance; admittance; conductance; susceptance; equivalent series circuit; equivalent parallel circuit

AC series/parallel circuits: Kirchhoff's laws; series equivalent impedance; parallel equivalent impedance; voltage divider rule; current divider rule; phasor diagrams

Complex power: true power; reactive power and apparent power; units of measurement – watt, volt-amp; reactive, volt amp; power triangle; power factor

Superposition theorem: power considerations

Thevenin and Norton theorems: voltage source models; current source models; practical sources; open circuit voltage; equivalent impedance; short circuit current; source conversion

Star/delta conversions: equivalent circuits; star/delta transformation formulae; selection of appropriate conversion

Fault calculations.

Norton's and Thevenin's theorems and their application to AC circuits: "J" notation and conversion between rectangular and polar – conjugate complex form for maximum power transfer; current and voltage divider rules and their application in AC circuits; theory and application of the "per unit" system; currents and voltages in 3 phase (balanced and unbalanced) circuits; representation of unbalanced currents and voltages using the method of symmetrical components; phasor diagrams for 3 phase circuits; power (P) –

vars (Q), apparent power (s) and power factor and their measurement; factors influencing the impedance of system components – cables, lines, buses and transformers

Calculation of fault currents: calculation/determination of positive, negative and zero sequence impedances; determination of fault current breaking and let-through energy capacities of circuit breakers and fuses; the importance of fault/arc impedances; the impedances operative for phase-to-phase and phase-to-earth faults; calculation of fault currents for phase-to-phase and phase-to-earth faults; "quick" (approximate) calculations by selecting the components with the major impedance

Advanced AC machines.

Three phase induction motor operating principles (wound and cage rotors): basic construction, windings; rotating magnetic field from stationary coils; EMF equation produced by a 3 phase stator winding and its significance; rotor impedance at a given value of slip given standstill values; rotor frequency; relationship between torque and speed for both small and large values of slip; slip for maximum torque; losses; relationship between air-gap power, gross torque, and net torque; definition of torque – starting, pull-up, pull-in, breakdown, maximum, full-load, no load

Analysis of a three phase induction motor using equivalent circuit: extract and approximate equivalent circuits and assumptions used; no-load test, locked rotor test and resistance tests; equivalent circuit component values from the no-load and locked rotor tests; motor performance parameters from the approximate equivalent circuit; slip for maximum torque; slip for maximum power output; motor performance from separation of losses test and load test

Three phase induction motor starting and braking techniques: supply authorities rules regarding direct on line starting; performance of the reduced voltage motor starting techniques; comparison of star/delta, primary resistance, auto-transformers, electronic "soft-start", secondary resistance starters, schematic diagrams; braking functions and methods, schematic diagrams

Three phase synchronous motors: construction and operating principles; cylindrical and salient pole rotors; excitation schemes; equivalent circuit ; measurement of synchronous impedance; causes of hunting and stability limits; power factor correction applications; paralleling and synchronisation techniques

Thee phase synchronous motors starting and braking requirements: power, control circuitry and applications for starting; power, control circuitry and applications for braking circuits

Single phase induction motors: theory of operation and construction; counter rotating field theory and cross field theory; optimum impedance of start winding or capacitor; no-load and locked rotor test; equivalent circuit component values from the no-load and locked rotor test; motor parameters from the equivalent circuit values

Single phase shaded pole, reluctance, hysteresis and universal motors: construction, operation and applications of the various types of fractional kilowatt motors

Acceleration and deceleration time: moment of inertia; reflected inertia and torque through a gearbox; time estimations given motor and load speed/torque characteristics

Cyclic loading – RMS method: motor winding temperature; forward and braking power; peak torque capability; estimation of motor rating when subjected to a cyclic varying load which could be subjected to – discrete power steps, linear power ramps, periods when the rotor is stationary

Co-generation.

Heat and power production

Fuel types: advantages and disadvantages; topping, bottoming and combined co-generation cycles

Prime movers: applicability and relevant efficiencies; commercial viability, competition barriers and site environmental factors

Regulatory and contract issues

Safety requirements

Power system protection.

Identify the types of likely faults for overhead lines, strung buses, insulated buses, transformers and voltage control equipment considering various plant configurations

The principles of operation of over-current, earth fault, differential and impedance/admittance measuring protection

Define selectivity, discrimination (time and current), stability, sensitivity, reliability, security, primary protection, duplicate protection, back-up protection and protection zones

Components used including current/voltage transformers, summation and multi-tapped CTs and interposing transformer

Relays including all or nothing relays, induction disc relays “balanced beam” (and derivative) relays, induction cup/directional relays, biased relays and solid state/micro-processor based relays

Communication systems including hardwired (dedicated and telephone), power line carriers (PLCs), micro-wave and fibre optics

Protection schemes applied to lines, buses, transformers and other major plant items

Power transformers.

The principles of operation and construction of 3 phase transformers including shell or core type iron circuits, disc coils, sandwich or helix windings, transposition of windings; transportation of large transformers

Tests applied to transformers including tests to establish losses (open and short circuit tests) and the per unit or percentage impedance (voltage); use the results to develop the approximate equivalent circuit of a transformer; calculate referred values, efficiency, regulation and load sharing

Methods of connecting the windings including star, delta, zigzag and open delta; the grouping (on the basis of phase shift) and precautions to be taken for parallel operation; forward and backward roll; calculations involving parallel operating and load sharing

The use of off-load and on-load tap changing to compensate for voltage variation; comparison of fault current levels and voltage regulation requirements

Transformer temperature limitation: the equipment required and the means of cooling transformers; cooling nomenclature; changes of rating based on cooling and multi-rating transformers; oil testing and maintenance; conservator, desiccation, Buchholz relay operation

The choice and use of multi-winding, auto transformers and neutral earthing compensators; types of harmonics produced and methods of attenuation; the use of tertiary windings to suppress harmonics

Qualitative treatment of the effect of connecting single phase loads to three phase transformers

Power system operation.

Control of voltage: conditions leading to voltage collapse and system disintegration; effects on the system of high/low volts; voltage control devices including - voltage regulators applied to generators and synchronous phase modifiers, electromagnetic voltage regulators, series and parallel capacitors, OLTC transformers and static var compensations (SVCs)

The range of devices covered by SVCs including: saturated reactor compensations (SRs), thyristor controlled reactor compensators (TCRs), combined TCR/TSCs and the production of wave-form distorting harmonics and control devices

The importance of the location in the system of voltage control devices

The use of graphical methods to calculate the size of Var regulating plant

Control of power including base load, spinning reserve, regulating machines, rapid start plant, phase shifting transformers and various forms of load shedding; principles and practices of automated control of individual machines, stations and transmission/tieline elements; synchronising power

The relationship between power and frequency: limiting values; machine stabilising including steam by-pass, rapid valving, slip stabilisers and overspeed limiting; use of single pole generator CBs; use of machine AVRs as angular stabilisers; damped and un-damped system oscillations; relationship between fault clearance times and system stability; the calculation of critical clearance angles based on equal area criteria

Types of communication systems including telephone, power line carrier, dedicated cable, micro-wave links and fibre optics; quantities and signals to be communicated; advantages and disadvantages of the various systems; equipment requirements

Transient over-voltages in power systems; switching and lighting over-voltages and their effect on different plant items; transient over-voltage control and reduction using surge diverters, shield wires and CB are control; insulation systems, insulation co-ordination, insulation grading in plant items, bushings and capacitor bushings

Factors leading to the generation of corona; consequences of corona; reduction of corona including conductor bundling, grading rings and conductor surface treatment

Fault calculations and "power system protection"; location of CTs in major plant items; earthing principles and devices; fault current control/limitation using neutral earthing compensators (NECs), neutral point earth impedances, high conductivity shield wires and parallel feed interlocking; application of different types of protection

PLC systems applications.

Introduction to alternative/enhancing programming methods: structured programming techniques (ie flow charts); limitations with ladder/statement list programming; introduction to other programming methods (ie step sequence special functions, and other high level languages); apply system diagnostic techniques

Regulated and PID loop control: regulated control; proportional + integral + derivative (PID) control; applications of PID control; advantages and disadvantages/limitations of PID control using a programmable controller; read, change and monitor data to achieve PID control using a PLC

Specialist instructions: interrupt driven applications; high speed counters; positional encoders; other specialist features

Communications: common protocols and interface standards; requirements when networking/interfacing PLCs; communication mediums; network types and topologies (LAN, WAN, ring, bus); hierarchal networks; peer to peer networks; handshaking; open architecture communications; remote I/O

Control electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

Problem solving and decision making: the difference between symptoms and causes of problems – defining problems, specifying problems in terms such as cost, quality and quantity; the contingency approach which differentiates between programmed and non-programmed decisions, as well as rational and bounded rationality problem solving decision making; the steps in the decision making process – brainstorming, group-think, how and when to involve groups such as nominal groups, the Delphi techniques; practical problem solving and decision making integration in the engineering workplace environment involving decision alternative of certainty risk and uncertainty

Introduction to human behaviour: understanding factors of human behaviour – definition of terms, physical and psychological factors, why people work in engineering industries; concepts and theories of motivation; content and process approaches – critical analysis of applicability of significant theories of motivation and human behaviour to the engineering workplace; people in organisations; individual and group behaviour; formal and informal groups, interpersonal relations and behaviours in organisations; managing/supervising people (as distinct from tasks or projects); the role of the manager/supervisor, applying the theory; situational and contingency approaches, including managing conflict; functional and disfunctional aspects of conflict; resolving conflict using problem solving techniques

Leadership and discipline: theories – types and styles of leadership; appropriateness of styles, advantages and disadvantages; effective leadership in the engineering workplace – application and evaluation of leadership styles; managing and leading – differences; authority, responsibility, power, delegation; use of decision making processes – Meetings., advisory groups, consultative groups, executive groups; discipline and interpersonal, relations; manager/staff relations, disciplinary processes and purposes, self discipline in organisations

Staff selection and personnel procedures: engineering job analysis, design and description – duties, responsibilities, authority; job requirements – qualifications, specific aptitudes and experience, achievements; effect on award restructuring on engineering job descriptions; engineering staff selection processes; establishing appropriate process, panel, selection criteria; advertising vacancy, matching applicants to criteria; interviewing – preparation, the setting, questions, making the selection, modifying successful and unsuccessful applicants; appointment of engineering staff and conditions of employment; staff placement and induction; role and responsibility of engineering managers/supervisors in the application of relevant industrial awards

Engineering project.

Tender documents and contracting; engineering project specifications; client interaction (interpersonal skills); assessment of client need; report writing; preliminary design sketches; preliminary design calculations; general arrangement drawing

Component design: sizing, material selection and brought outside selection of standard components; detailed drawings of parts and assemblies showing linear and geometric tolerancing (where necessary); final report – to contain client brief of requirements and specifications (as tender documents), all drawings, design calculations and any special/novel design problems and/or solutions, a written report; oral presentation

Category: Electronics (C)

Common

Calculus.

Differential calculus: the limit concept – definition of the derivative of a function as the slope of a tangent line (the gradient of a curve), easy examples from 1st principles; the rules – derivative of sum (difference), product, quotient, chain (function of a function), use of at most 2 rules for any given functions; the 2nd derivative – implicit differentiation – applications – equations of tangents and normals, stationary points and curve, sketching, rate of change, rectilinear motion, Newton's method; verbally formulated problems involving related rates and maxima/minima

integral calculus: integration as the inverse operation to differentiation: the results – integral of k f(ax + b) where $f(x) = x^n$, six x, cos x, $\sec^2 x$, e^x the method of substitution; the definite integral; applications – areas between curves, rectilinear motion including displacement from acceleration and distance travelled

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

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Specialisation: Analogue and digital

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Analysis and design project.

Systems concepts: software and hardware systems; systems development life cycle; roles of the analyst and user

Feasibility analysis: problem definition – scope and objectives, schedules, preliminary report; fact finding interviews – surveys and questionnaires, observations, researching (new technology, similar systems etc); systems design options and alternatives – hardware technologies, batch or online processing, centralised or remote, user inputs and outputs, hardware inputs and outputs, interconnections, existing packages, off-the-shelf components and subsystems, prototyping, application generators, language selection; evaluation of hardware and software – sizing, performance, reliability, ergonomics, support, cost/benefit analysis, feasibility report

Systems analysis: software design tools and methodologies – system flowcharts, data flow diagrams, HIPO charts, data dictionary, ER diagrams, decision tables and decision trees, pseudocode or structured English, structured walkthroughs, application generators, CAS tools, hardware system design tools - manufacturers' data books, application notes, functional block diagrams, flowcharts, test specifications, standards

Advanced analogue electronics.

Differential and instrumentation amplifiers

Integrators

Single supply operation – using blocking capacitors and norton amplifiers

Comparators with and without hysteresis; non-saturating comparators

Piece wise approximations to non-linear transfer curves – increasing and decreasing slopes and bipolar curves

Function generators

Precision rectifiers – half-wave and full-wave

Active filters – low-pass, high-pass and band-pass

Applications of power; amplifiers and definitions

Additional considerations related to large signal operations

Class A, B, AB, C and D power amplifiers

Distortion/feedback

Heat transfer and sinking

Data sheet usage related to typical characteristics of fully integrated power amplifiers

Specification and testing of power amplifiers

Advanced circuit analysis.

H-parameters: hybrid parameters; hybrid parameters for the bipolar junction transistor; voltage gain; current gain; dependent sources; input and output impedance

Complex waveforms: fourier series; odd and even functions; half wave symmetry; harmonic components; root mean square value of a complex wave; effect of frequency on inductive and capacitive reactance; effect of reactive components on harmonic component

Digital design.

Types of programmable logic devices; features of programmable array logic (PAL) devices; reprogrammable PALs (GALs); PAL combinatorial design; logic family characteristics; interfacing between logic families; interfacing to external devices; schmitt trigger devices

Project management; advanced state machines; system design considerations; timing analysis and hazards; testing and debugging; engineering standards; documentation

Digital signal processing.

DSP applications; signal sampling; impulse response of linear phase filter; FIR filters; adaptive filters; DSP chip architecture; DSP programming; integer arithmetic; analogue filtering

Simple IIR filter; high-order IIR filter; discrete fourier transform; complex signals; fast fourier transform; FIR filtering using the FFT; data-rate conversion; modulation and demodulation; applications; support chips

Electronic software tools.

Circuit analysis software: general description; documentation (written and on-line); common features – circuit entry, input data format, output data format; hardcopy of circuit and results; evaluation of package

Computer aided drafting (CAD) software: general description; documentation (written and on-line); common circuit schematic features – component selection, text and line selection, placement, movement, erasure, numbering; common printed circuit board design features – component selection, text and circuit trace selection, placement, movement, erasure, manual and auto-routing; hardcopy of results; evaluation of package

Microprocessor applications.

User interface devices (LEDs, 7 segment displays, LCDs, keypads

Serial I/O

Interrupts

Software development techniques (program structure and design, use of assembler features)

Project – operational minimum system

Digital to analogue converters

Analogue to digital converters

Interfacing actuators (relays, solenoids)

Controlling ac power

Linking assembly language modules with high level language modules (using C)

Project work

Specialisation: Communications

Electronic software tools.

Circuit analysis software: general description; documentation (written and on-line); common features – circuit entry, input data format, output data format; hardcopy of circuit and results; evaluation of package

Computer aided drafting (CAD) software: general description; documentation (written and on-line); common circuit schematic features – component selection, text and line selection, placement, movement, erasure, numbering; common printed circuit board design features – component selection, text and circuit trace selection, placement, movement, erasure, manual and auto-routing; hardcopy of results; evaluation of package

Communications engineering project.

Researching and analysing information related to a communications system

Generation and selection of solutions to a communications system problem

Comparison and evaluation of possible technical solutions

Organisation and management of research processes

Antenna systems.

Half wave dipole radiation, radiation resistance, input impedance, gain, beam width, effective radiated power, front to back ratio, TEM wave polarisation, VSWR, specifications

Surface wave propagation, loss factors, sky wave propagation, terrestrial space wave propagation

Radiation pattern diagrams for half wave, folded dipole quarter wave and longer ground plane, yagi antenna types, dimensions, input impedance, applications for these types of antennae

Characteristic impedance, load impedance, attenuation of transmission lines; Smith Charts, parallel wire, coaxial cable, stripline, waveguide mediums; load impedance mismatch, SWR at transmitter and load; impedance matching

Multi element Yagis (3-24): stacked and bayed Yagis; slot panel and bayed dipoles, corner reflector; log periodic; co-linear, end fed dipole; cardioid dipole; circular polarisation; paging antennae; mobile and portable radio antennae; vehicle antennae

Signal coverage, new sites, interference, environmental effects, sharing an existing system wind loading, weight; antennae on structures, mounting materials, coaxial cable connectors, isolation, physical separation, waterproofing, documentation inspections; corrosion, weather effects (wind, snow, rain); pollution; lighting protection, radiation hazard

Antenna separation, duplexers; different radiation patterns resulting from insufficient antenna spacing duplexers enable one antenna and one feeder to be utilised preserving the correct radiation pattern; bandpass, bandstop duplexers; method of connection to transmitters and receivers, waveguide cavity, ceramic types; insertion loss, rejection in transmit and receive legs, power handling, separation temperature range

Construction of a ferrite circulator DC field effects and their alteration of resonant frequencies; direction of signal flow; circularity for each port; permanent or electro-magnets for bias use as a circulator or isolator with a port matched load

Transmission lines.

Types of lines and their applications: microstrip, waveguides; line parameters using primary constants; standing wave patterns for any termination; line parameters, given terminations; DC transients on a transmission line; time-space diagrams and oscillograms; smith charts; single and double stub matching; waveguide propagation and field patterns therein; cavities and field patterns therein; launch/pickup of waves in waveguides and cavities; stripline structures

Optical fibre transmission; components of an optical fibre system; characteristics of optical fibre; safety and handling; attenuation measurements; optical cable installation; optical fibre joining; optical fibre connectors; optical sources and detectors

RF amplifiers.

Classes of amplifiers: class A; class B; class C; efficiency of amplifier classes

RF amplifier terminations: termination of ideal voltage current and RF amplifiers; resonant circuit principles

RF amplifier operation, alignment and neutralisation

RF amplifier coupling methods: impedance transformation/coupling; L and pi coupling circuits; double tuned transformer coupling

Decoupling of RF circuits: radio frequency coils (RFC); capacitor decoupling; ferrite beads

Microstrip amplifiers: stripline geometrics and impedances; application of stripline techniques; basic stripline design

Masthead amplifiers: noise considerations; characteristics

Transmitters and receivers.

Transmitters: block diagram of both high level and low level AM transmitters; class A, class B and class C amplifiers in AM transmitters; applications using AM transmitters; block diagram of the filter method SSB transmitter; block diagram of the phase method SSB transmitter; SSB transmitter stage frequencies; two tone testing of SSB transmitter; block diagram of the direct method FM transmitter; frequency multipliers and converters in FM transmitters; block diagram of the indirect method FM transmitter; classes of stage amplifiers in an FM transmitter; pre-emphasis and de-emphasis in FM systems; stereo FM principles; transmitter frequency stability requirements; transmitter spurious signal suppression; transmitter power level requirements; transmission modes; radiation exposure levels; measure output power of a transmitter; measure output carrier frequency; measure spurious output levels

Receivers: block diagram of a single conversion superheterodyne receiver; RF amplifier – filtering, gain, low noise, antenna match, AGC, stability, typical circuit; local oscillator – frequency stability, signal purity, synthesiser local oscillator, typical circuit; mixers – function, problems, typical circuits; IF strip – function, choice of frequency, IF selectivity, AGC, typical circuits; demodulation – AM, FM, SSB, BFO, DC for AGC, S Meters; image frequency; dual conversion superheterodyne; AM, SSB AND FM receivers; applications of AM, SSB and FM receivers

Microwave systems.

General microwave systems: radar; terrestrial microwave links; satellite microwave links; global positioning system (GPS); fleet management systems

Antenna systems: yagi and dipole arrays (including electronically steerable); slots and slotted arrays; microstrip arrays; horns; axial and offset reflector systems; metallic and dielectric lenses

Terrestrial link planning: K-factor; earth's bulge; refraction; knife-edge diffraction; fresnel zones; absorption; carrier frequency; distance; Tx EIRP; Rx antenna gain

Satellite link planning: tracking requirements and beamwidth; figure of merit; absorption distribution; outage causes; EIRP; C/N; process gain

Microstrip structures: matching circuits; filters; couplers; splitters; circulators

Matching techniques: single stub matching using smith chart; physical length of matching network

Microwave devices.

Waveguide propagation

Cavity devices: couplers; T; hybrid T; directional; diplexers; phase shifters; power splitters; circulators; horns

Stripline structures

Ferrite and dielectric devices

Therminoic microwave devices: klystrons; magnetrons; cross field amplifiers (CFA); travelling wave tubes (TWT)

Solid state microwave devices: diodes – tunnel, PIN, Gunn, TRAPPATT, BARRATT; stimulated emission devices – MASER; parametric amplifiers – Josephson devices (explain need for circulators with the above)

Matching systems: single stub match using a smith chart; determine physical length of matching network

Satellite communications.

Typical satellite communications systems, major sub-systems and critical components; antenna pointing parameters; up/down link considerations; figure of merit; EIRP; common types of baseband signal processing; process gain; types of system access – TDMA, FDMA, CDMA, DAMA, PAM; types of RF modulation – n-FSK, n-PSK, n-QAM

Digital radio.

Digital modulation concepts; baseband signal processing; effect of noise on digital systems; signalling methods; optimising multipath radio reception; digital radio systems

RF principles.

Oscillators and tuned circuits: barkhausen criteria; LC oscillators; crystal oscillators; phase locked loops (PLL)

Filters: butterworth, chebyshev and bessel filter networks; crystal filters; ceramic filters; mechanical filters; surface acoustic wave (SAW) filters

Modulation techniques: amplitude modulation (AM); phase modulation (PM); frequency modulation (FM); single sideband (SSB); double sideband (DSB); high and low level modulation methods; modulator alignment procedures

Demodulation techniques

Frequency multiplier techniques

Mixer circuit techniques 1

Characteristics of components at RF

Communication measurements and techniques.

Operation of digital storage oscilloscope (DSO): analogue – variable persistence mode; single shot storage; digital – saving and recalling set-ups and displays; hardcopy storage; signal processing function

TDR and OTDR operation: transmission line characteristics

Q-meter measurements: Q-meter operation – block diagram; measurement using following connection modes – direct, series, parallel; distributed capacitance

Spectrum analyser: frequency-domain identification of baseband and modulated signals; frequency-domain measurement of signals

Network analyser: component measurement; impedance measurement; insertion loss; load impedance variation with frequency

GPIB bus: GPIB operation; test procedure; equipment connection

Category: Instrumentation (D)

Common

Single chip microcontrollers.

Architecture CPU, RAM, PROM, I/O, programming concepts, subroutines, instruction sets, arithmetic, stack operation, features of microcontrollers, interrupts, timers, clocks, on chip peripherals, serial busses and interfaces, expansion capability, cross assemblers and emulators, PROM loading, power supplies and mask options

Control electrical calculations.

Math software package e.g. matlab; series expressions; fourier series; linear functions and linearisation; difference equations; differentiation; integration

Rules of matrix algebra; vectors; matrix Fns (Det, Inv, exp); eigenvalues and eigenvectors; linear ordinary differential equations; time domain solution of 2^{nd} order LODEs; state space forms; state space solution of LODES; review and test

Advanced telemetry.

Background to telemetry

Telemetry and its use with supervisory control and data acquisition (SCADA) systems

Data carriers and communication methods

Integration with existing systems

Analysis of system requirements and performance

Specification of systems

Commissioning and maintenance: person – machine interface and telemetry computers; communication front end and network; remote terminal units; single board (small) outstation; remote workstations including portables; Future trends

PLC systems.

Introduction to alternative/enhancing programming methods: structured programming techniques (ie flow charts); limitations with ladder/statement list programming; introduction to other programming methods (ie step sequence special functions, and other high level languages); apply system diagnostic techniques

Regulated and PID loop control: regulated control; proportional + integral + derivative (PID) control; applications of PID control; advantages and disadvantages/limitations of PID control using a programmable logic controller; read, change and monitor data to achieve PID control using a PLC

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Control systems project development.

Project introduction: project selection criteria; industrial visit

Project model selection: brainstorming for project selection; preliminary report

Project model design: project management techniques; system design report

Project model construction

Project model comissioning: model demonstration/presentation; final report

Compensation (tuning) techniques.

History of control; system identification; feedback; tuning techniques; auto-tuning and model based control

Dynamic systems engineering.

Probability and monte carlo methods; queuing; dynamic response of systems; simulation

Transform techniques.

Convolution; laplace transform; transfer function and block diagrams; fourier transform; z transform; transformations; filters and windowing

Digital control using computers/micros.

Types of computer and their uses: on-off control; PID control; 'intelligent' control self tuning controllers, fuzzy logic controllers

PID control: the control algorithm; proportional control; integral control; derivative control

Writing the program for closed loop control: on-off control; PID control

Tuning a PID control loop: choosing the proportional constant; choosing the integral constant; choosing the derivative constant

Sampling rates: minimum sampling rates; nyquist criterion; factors that effect the sampling rate; measuring the sampling rate

Process data acquisition systems.

Industrial measurement applications and sensor characteristics; industrial computer systems and programming; standard computer input/output specifications; noise – grounding, shielding and filtering; signal conditioning; signal processing – analogue signals; signal processing – digital signals; signal transmission and isolation techniques

Advanced control using "C".

"C++" an introduction: history; relationship to "C"; advantages and disadvantages to other languages

Object orientated programming: concepts of stage operation; encapsulation; inheritance; polymorphism

Windows programming: history; graphical user interfaces; consistent user interface; message driven architecture

Windows environment: windows; cursors and the mouse; dialogue boxes; menus; icons

The "C++" development package: editor commands; the edit-compile-run cycle; compiler and linker options; windows programming libraries

"C++" language syntax: differences between "C" and "C++"; data types; classes; program structure

Computer emulation and mimics: purpose of mimics; types of mimics

Interfacing of mimics to control loops: interfacing of mimics within control loops; preparing of data for display purposes

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

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UTE NES603 (A to Z qualifier) A Develop maintenance programs for apparatus & circuits

Descriptor: Develop programs for the maintenance of apparatus and associated *circuits*, including inspection schedules.

Alignment: This unit aligns to and is based on the National Electrotechnology Benchmark Standard EBS 614 – Develop maintenance programs for apparatus and associated circuits.

Specific unit outcomes

This is presented as a composite unit that has four specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES603A A	Develop maintenance programs for apparatus & circuits *(Computer systems)*
UTE NES603B A	Develop maintenance programs for apparatus & circuits *(Electrical)*
UTE NES603C A	Develop maintenance programs for apparatus & circuits *(Electronics)*
UTE NES603D A	Develop maintenance programs for apparatus & circuits *(Instrumentation)*

Elements		Performance criteria	
603.1	Plan and prepare for the development of maintenance programs	603.1.1	Identified *OH&S policies and procedures* to be followed are planned and prepared, and that the work sequence is in accordance with *requirements*
		603.1.2	*Appropriate personnel* are consulted to ensure the programs for maintenance are co-ordinated effectively with others involved on the work site
		603.1.3	Programs to be developed for maintenance are checked against job *requirements*
		603.1.4	Materials necessary to complete the work are identified and detailed in accordance with *established procedures* and checked against job *requirements*

Elements		Performance criteria	
		603.1.5	*Tools, equipment* and *testing devices* needed to carry out the work are identified and detailed in accordance with *established procedures*
		603.1.6	Preparatory work is identified to ensure compliance with *requirements*
603.2	Develop maintenance programs	603.2.1	*OH&S policies and procedures* are followed are detailed
		603.2.2	Normal function of *apparatus* and associated *circuits* are ascertained and detailed in accordance with *requirements*
		603.2.3	*Circuits* isolation and specified testing procedures are detailed where necessary
		603.2.4	*Apparatus* and associated *circuit* maintenance is detailed in accordance with *requirements*
		603.2.5	Response to unplanned events or conditions in accordance with *established procedures* are detailed
		603.2.6	Approval to implement contingencies in accordance with *established procedures* from *appropriate personnel* are detailed
		603.2.7	On-going checks of the quality of work in accordance with *established procedures* are detailed
		603.2.8	Final maintenance inspections of *apparatus* conforming to *requirements* are detailed
		603.2.9	*Notification* of work completion in accordance with *established procedures* is detailed
603.3	Completion of work	603.3.1	Final inspections of developed maintenance programs are undertaken in accordance with *established procedures*
		603.3.2	Maintenance programs completion is *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be

detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment,* tools, *accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

There is no interdependency associated with this unit. However, this unit has been designed as a natural progression from unit UTE NES605 A. Therefore, it is expected that to achieve this unit, without having gained competence in unit UTE NES605 A, will require that the relevant aspects of knowledge and skills related to unit UTE NES605 A be developed and form part of the requirements for achieving competence in this unit.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Calculus.

Differential calculus: the limit concept – definition of the derivative of a function as the slope of a tangent line (the gradient of a curve), easy examples from 1st principles; the rules – derivative of sum (difference), product, quotient, chain (function of a function), use of at most 2 rules for any given functions; the 2nd derivative – implicit differentiation – applications – equations of tangents and normals, stationary points and curve, sketching, rate of change, rectilinear motion, Newton's method; verbally formulated problems involving related rates and maxima/minima

integral calculus: integration as the inverse operation to differentiation: the results – integral of k f(ax + b) where $f(x) = x^n$, six x, cos x, $\sec^2 x$, e^x the method of substitution; the definite integral; applications – areas between curves, rectilinear motion including displacement from acceleration and distance travelled

Data communications systems operations.

Data communications systems fundamentals; principles of operation of a modem; digital data transmission over voice grade lines; digital data transmission and packet switched data; network protocols such as - token ring, token bus, CSMA/CD (ethernet)

Point to point direct connection using serial and parallel protocols; LAN topologies related to – token ring, token bus, CSMA/CD (ethernet) techniques; typical LAN s/w packages (NOS') such as LANtastic and Novell Internet; network interface cards and/or other hardware for typical LAN s/w packages (NOS'); LAN s/w packages (NOS') for a particular situation based upon a finalised system definition

Typical modem operating parameters; physical links – twisted pairs, coaxial cable, infra red (IR), spread spectrum radio, microwave etc; principle features of voice link – DDS, AUSTRPAC and ISDN carrier services; principle features of "PC Anywhere" and "Carbon Copy" packages; functions of routers, bridges etc in order to connect between various types of remote LANs and PCs (ie token ring to ethernet, IBM to MacIntosh); hardware and software required in order to connect remote LANs above

Typical interfacing software such as kermit; physical links

LAN software packages (NOS') such as "LANtastic", "LANmanager"; hardware required for interfacing; select suitable physical lines

Specialised hardware for a LAN printer; serial and parallel printer links – serial, parallel, etc; printer buffer size selection; NOS printer queue management – considering buffer size, spooling and job priority

User priority levels; allocated buffer sizes

Use of a DC ohm-meter to check for short/open circuits in network cabling, network terminators, etc; use of time domain reflectometry (TDR) to locate the position(s) of short/open circuits and other faults in network cabling; use of manufacture supplied diagnostics to test suspected network interface cards; conflicts with I/O addresses, shared memory, DMA or interrupts at any station; typical NOS diagnostics, extended NOS diagnostics

Typical network dial in/out facilities – network cache buffering, network E-mail facilities, network chat facilities; network data security aspects – requirements and typical ways in which these may be implemented; different PC types – ie IBM and MacIntosh in a typical network; typical network remote users and to connect to other LANs'/WANs'

Typical network software backup and recovery files; consequences if typical network software back and recovery files are absent or corrupted; configuring the way typical network software backup and recovery files are generated; use of typical network software backup and recovery files to recover from a system failure/crash

Analysis and design project.

Systems concepts: software and hardware systems; systems development life cycle; roles of the analyst and user

Feasibility analysis: problem definition – scope and objectives, schedules, preliminary report; fact finding interviews – surveys and questionnaires, observations, researching (new technology, similar systems etc); systems design options and alternatives – hardware technologies, batch or online processing, centralised or remote, user inputs and outputs, hardware inputs and outputs, interconnections, existing packages, off-the-shelf components and subsystems, prototyping, application generators, language selection; evaluation of hardware and software – sizing, performance, reliability, ergonomics, support, cost/benefit analysis, feasibility report

Systems analysis: software design tools and methodologies – system flowcharts, data flow diagrams, HIPO charts, data dictionary, ER diagrams, decision tables and decision trees, pseudocode or structured English, structured walkthroughs, application generators, CAS tools, hardware system design tools - manufacturers' data books, application notes, functional block diagrams, flowcharts, test specifications, standards

Internetworking operations.

Bridges: selection of bridges based on given data link types – ethernet to ethernet, token ring to token ring, ethernet to token ring, token ring to fibre distributed data interface (FDDI); bridge installation – network address tables, priority for forwarding of packets, filters to restrict broadcast packets

Routers: selection based on given backbone network layer protocols – ISO, internet; selection based on LAN protocol or multiprotocols to be routed; installation – network address tables, filters to restrict broadcast packets, priority and class of service for forwarding of packets; topology of internetworks using local and remote routers

Formats: IBM systems network architecture (SNA) protocol; DEC DECnet protocol

Topology of internetworks: using gateways with local and remote connection to hosts

Gateway installation: table linking end users to host recognised resources such as SNA controls points (CPs) and logical units (LUs)

Protocol formats: ISO – end system (ES)-to-intermediate system (IS) and IS-to-IS protocols; internet – control message protocol (ICMP), open shortest path first (OSPF) protocol, exterior gateway protocol (EGP); spanning tree bridge protocol data units (BPDUs); (Source) routing information field; route broadcast frame

Relationships: between ISO global network service access points (NSAPs) and local subnet points of attachment (SNPAs); between internet global internet protocol (IP) address and local network point of attachment (NPA)

Protocol formats: for hello – poll and redirect messages, holding time

Format error messages: recognition of – destination unreachable, time (to live) exceeded

Database and 4GL.

DBMS approach: non-database vs database approach; data models – advantages, limitations; user requirements; role of the DBMS administrator

Data analysis: entity – relationship and occurrence; E.R model; representing entities and relationships

Normalisation: tuple; first normal form; other normal forms; conversion to optimal forms

Design and/or specifications: design approaches; development of a corporate data model including long range information system plans; information requirements analysis; logical and physical database design; data dictionary; standards – documentation and security; distributed databases

Relational algebra: relational operators – union, intersection, cartesian product, selection, projection, join, division

Queries: producing enquiry reports; producing formatted output

Programming in 4GL: creation of databases; maintenance of databases; producing reports; formatting outputs

Network layer operations.

Use of CCITT X.25 packet level protocol (PLP) and packet assembler/ disassembler (PAD) hardware and software

Awareness of occupational health and safety: for mains operated electronic equipment when installing hardware

Recognition of format for CCITT X.25 PLP: "Q" bit PAD control; internet protocol

Recognition of format for network service access point (NSAP), CCITT X.21:

Recognition of format for IP addresses including: address resolution protocol (ARP)

Recognition of format for CCITT X.25 PLP including: quality of service; fast select; user facilities; PAD parameters; clear; reset; restart

Recognition of format for IP: type of service; time-to-live; options

Correlation of end user error messages with abnormal traffic

Network administration.

Network installation: review LAN server installation; system configuration; conflict avoidance; disk mirroring; file server preparation; fault tolerant systems; cable preparation; establishing workstations; boot disks; remote boot proms; documenting the network

Establishing network users: establishing accounts; establishing directories; access right and security; login scripts

Establishing printer servers: print spooling

Loading applications software: considerations for selecting and loading applications software

Network maintenance and troubleshooting: monitoring network usage; cable faults; workstation faults; server faults; system backup/restore; diagnostics

Data link planning.

Determination of data link cost/performance criteria

Error control techniques: idle repeat request, selective repeat request, go-back-N retransmission strategy ; calculations for data link utilisation

Data compression techniques: CCITT V.42

Data encryption techniques: data encryption standard (DES)

Data link user configuration factors: line speed – octets per frame, window size

Data link simulation

Analysis of non-OSI data link protocols: asynchronous byte-orientated – KERMIT, synchronous byte-orientated – IBM binary synchronous control (BSC), synchronous bit-orientated – IBM synchronous data link control (SDLC), ANSI advanced data communications control procedure – (ADCCP)

Data link technology trend analysis

System acquisition and evaluation.

Evaluation: typical electronics applications; establishing the need – objectives and requirements; performance specifications; evaluation criteria – performance effectiveness, performance efficiency, ease of use, flexibility, quality of documentation, manufacturer/supplier/support, cost/benefit analysis; techniques – performance evaluation, benchmarks, acceptance testing

Procurement: tenders, contracts; request for proposal; identifying and assessing suppliers; duties and taxes; importing regulations and procedures; purchasing options; maintenance contracts

Implementation: planning installation; training requirements; consumables; changeover

Data communications systems planning.

Network system performance: protocol parameters including – overhead, windowing; node parameters including – congestion, queue length, service time; load traffic estimation based on – number of users, types of application, bandwidth costs

Network system reliability: protocol parameters including – error recovery, link redundancy; node parameters including – component mean time between failure (MTBF); system MTBF with and without single point failure

Network system management: OSI defined functions including – fault configuration, change, performance management, financial services, inventory control, security; concepts – hierarchical vs distributed, architecture, objects, agents, collection point, console, system manager, management information base (MIB); user interface – display of network topology, statistics and error conditions, commands to control remote nodes; system automation – programming language interfaces, alert filtering, software distribution of files and jobs

Help desks: procedures – adequate incident description, incident tracking, problem escalation; tools – view remote screen, file transfer, remote keyboard control

Network personnel: network manager; network administrator; network system engineer; field service technician; service centre technician; technical salesperson

Bandwidth management planning.

Illustrate a system of host to remote terminals via multiplexers showing the relative number of async host ports required; illustrate a system which utilises x.25 and provide for x.25 switches and PADs at the remote end; illustrate bandwith requirements for the two systems; illustrate the host end configuration for both systems; illustrate a resilient configuration; perform a cost/benefit analysis – describe the management benefits of the X.25 system; block schematic diagram for the mux/demux system; provide a block schematic of the X.25 system

Provide the standards and analyse

Provide a brief of the pricing structure of the services offered for DDS and ISDN; develop a simple cost/bandwidth matrix for the ISDN; provide brochures of various manufacturers' terminal adaptors and multiplexers for ISDN connection; develop a cost comparison; illustrate requirements for resilience and define the configuration and costs associated – show how disaster recovery may be planned into the WAN connections

Illustrate a typical LAN and WAN connection with and without resilience using DDS; illustrate a typical LAN and WAN connection with and without resilience using ISDN; show typical costing of hardware for both systems

Electrical engineering mathematics.

Basic determinants and solution of 2/3 simultaneous linear equation by determinants exponents and logs

Time dependent trig functions - $\sin(\omega t+\theta)$

Trig of oblique triangles

Introduction to vectors

Complex numbers

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

Problem solving and decision making: the difference between symptoms and causes of problems – defining problems, specifying problems in terms such as cost, quality and quantity; the contingency approach which differentiates between programmed and non-programmed decisions, as well as rational and bounded rationality problem solving decision making; the steps in the decision

making process – brainstorming, group-think, how and when to involve groups such as nominal groups, the Delphi techniques; practical problem solving and decision making integration in the engineering workplace environment involving decision alternative of certainty risk and uncertainty

Introduction to human behaviour: understanding factors of human behaviour – definition of terms, physical and psychological factors, why people work in engineering industries; concepts and theories of motivation; content and process approaches – critical analysis of applicability of significant theories of motivation and human behaviour to the engineering workplace; people in organisations; individual and group behaviour; formal and informal groups, interpersonal relations and behaviours in organisations; managing/supervising people (as distinct from tasks or projects); the role of the manager/supervisor, applying the theory; situational and contingency approaches, including managing conflict; functional and dysfunctional aspects of conflict; resolving conflict using problem solving techniques

Leadership and discipline: theories – types and styles of leadership; appropriateness of styles, advantages and disadvantages; effective leadership in the engineering workplace – application and evaluation of leadership styles; managing and leading – differences; authority, responsibility, power, delegation; use of decision making processes – Meetings., advisory groups, consultative groups, executive groups; discipline and interpersonal, relations; manager/staff relations, disciplinary processes and purposes, self discipline in organisations

Staff selection and personnel procedures: engineering job analysis, design and description – duties, responsibilities, authority; job requirements – qualifications, specific aptitudes and experience, achievements; effect on award restructuring on engineering job descriptions; engineering staff selection processes; establishing appropriate process, panel, selection criteria; advertising vacancy, matching applicants to criteria; interviewing – preparation, the setting, questions, making the selection, modifying successful and unsuccessful applicants; appointment of engineering staff and conditions of employment; staff placement and induction; role and responsibility of engineering managers/supervisors in the application of relevant industrial awards

Category: Electrical (B)

Common

Advanced DC machines.

Basic DC machine construction and operation: application of DC machines; construction of DC machines; DC machine connections; insulation; ratings; cooling paths; bearings; general maintenance of DC machines

Construction and use of lap and wave windings: coils and elements; generated voltage equation for generator; generated voltage equation for motors; application of lap and wave windings

Process of communication: the use of interpoles; loading of machines; brush shifting

Armature reaction in DC machines: effect of armature reaction on DC machine characteristics; use of compensating winding

External characteristics of a DC generator: performance of generators supplying various loads; voltage regulation as a percentage or per unit value; operation in parallel

Torque equation for a DC motor: shape of motor speed/torque curves; reversal of machines

Starting of DC motors: types of DC motor starters in use; DC motor protection

Speed regulation and speed control of DC motors: methods in use; effect on motor design and operation caused by the use of SCR speed control equipment

Braking of DC motors: plugging; dynamic; regenerative; mechanical

Losses and efficiency

Acceleration of DC motors and loads: characteristics of typical loads; matching loads to a suitable motor; heating of windings; de-rating of motors

Permanent magnet materials and circuits: types of materials and characteristics; BH loop and demagnetisation; temperature effects; reversible losses; irreversible losses; high temperature effects; mechanical properties – handling and magnetisation; application; power density; temperature range; duty cycle

Special DC motors – construction, operation and applications: permanent magnet motors; brushless motors; coreless and moving coil motors; linear motors; printed circuit motor; stepping motors; voice-coil motors

Safety: safety aspects in relation to motors; safety aspects in relation to associated control circuits including the use of PLCs

Operating characteristics: obtaining nameplate details; measuring DC machine parameters; obtaining the magnetising characteristic of a DC generator; determining the external characteristic of DC generators; load characteristics of DC motors; determining the efficiency of a DC machine; speed control of DC motors; braking of DC motors; troubleshooting and repair techniques

Building management systems.

Functions of a BMS: autonomous functions; input; output; general I/O; installation management items; energy management; risk management; information processing; objective; building running costs

BMS hardware: system architecture; communication devices; substations; PCs

Input and output functions: digital – input, outputs; digital output with status feedback; analogue input, output; sensors; alarms

Energy management: night cycle; optimum stop, start; time and event programs; night purge; outside air percentage control; enthalpy control; power demand control; duty cycle; presence detection; lighting control

Information processing functions: computer systems; central system management; programs; system configuration and security; operator – machine interface; data points

Risk and maintenance management: system files; fire – intruder control; access control

Circuit analysis.

Phasors: time domain; frequency domain; frequency, angular frequency and units of measurement

Complex impedance: impedance diagram; resistance; reactance; admittance; conductance; susceptance; equivalent series circuit; equivalent parallel circuit

AC series/parallel circuits: Kirchhoff's laws; series equivalent impedance; parallel equivalent impedance; voltage divider rule; current divider rule; phasor diagrams

Complex power: true power; reactive power and apparent power; units of measurement – watt, volt-amp; reactive, volt amp; power triangle; power factor

Superposition theorem: power considerations

Thevenin and Norton theorems: voltage source models; current source models; practical sources; open circuit voltage; equivalent impedance; short circuit current; source conversion

Star/delta conversions: equivalent circuits; star/delta transformation formulae; selection of appropriate conversion

Fault calculations.

Norton's and Thevenin's theorems and their application to AC circuits: "J" notation and conversion between rectangular and polar – conjugate complex form for maximum power transfer; current and voltage divider rules and their application in AC circuits; theory and application of the "per unit" system; currents and voltages in 3 phase (balanced and unbalanced) circuits; representation of unbalanced currents and voltages using the method of symmetrical components; phasor diagrams for 3 phase circuits; power (P) –

vars (Q), apparent power (s) and power factor and their measurement; factors influencing the impedance of system components – cables, lines, buses and transformers

Calculation of fault currents: calculation/determination of positive, negative and zero sequence impedances; determination of fault current breaking and let-through energy capacities of circuit breakers and fuses; the importance of fault/arc impedances; the impedances operative for phase-to-phase and phase-to-earth faults; calculation of fault currents for phase-to-phase and phase-to-earth faults; "quick" (approximate) calculations by selecting the components with the major impedance

Advanced AC machines.

Three phase induction motor operating principles (wound and cage rotors): basic construction, windings; rotating magnetic field from stationary coils; EMF equation produced by a 3 phase stator winding and its significance; rotor impedance at a given value of slip given standstill values; rotor frequency; relationship between torque and speed for both small and large values of slip; slip for maximum torque; losses; relationship between air-gap power, gross torque, and net torque; definition of torque – starting, pull-up, pull-in, breakdown, maximum, full-load, no load

Analysis of a three phase induction motor using equivalent circuit: extract and approximate equivalent circuits and assumptions used; no-load test, locked rotor test and resistance tests; equivalent circuit component values from the no-load and locked rotor tests; motor performance parameters from the approximate equivalent circuit; slip for maximum torque; slip for maximum power output; motor performance from separation of losses test and load test

Three phase induction motor starting and braking techniques: supply authorities rules regarding direct on line starting; performance of the reduced voltage motor starting techniques; comparison of star/delta, primary resistance, auto-transformers, electronic "soft-start", secondary resistance starters, schematic diagrams; braking functions and methods, schematic diagrams

Three phase synchronous motors: construction and operating principles; cylindrical and salient pole rotors; excitation schemes; equivalent circuit ; measurement of synchronous impedance; causes of hunting and stability limits; power factor correction applications; paralleling and synchronisation techniques

Thee phase synchronous motors starting and braking requirements: power, control circuitry and applications for starting; power, control circuitry and applications for braking circuits

Single phase induction motors: theory of operation and construction; counter rotating field theory and cross field theory; optimum impedance of start winding or capacitor; no-load and locked rotor test; equivalent circuit component values from the no-load and locked rotor test; motor parameters from the equivalent circuit values

Single phase shaded pole, reluctance, hysteresis and universal motors: construction, operation and applications of the various types of fractional kilowatt motors

Acceleration and deceleration time: moment of inertia; reflected inertia and torque through a gearbox; time estimations given motor and load speed/torque characteristics

Cyclic loading – RMS method: motor winding temperature; forward and braking power; peak torque capability; estimation of motor rating when subjected to a cyclic varying load which could be subjected to – discrete power steps, linear power ramps, periods when the rotor is stationary

Co-generation.

Heat and power production

Fuel types: advantages and disadvantages; topping, bottoming and combined co-generation cycles

Prime movers: applicability and relevant efficiencies; commercial viability, competition barriers and site environmental factors

Regulatory and contract issues

Safety requirements

Power system protection.

Identify the types of likely faults for overhead lines, strung buses, insulated buses, transformers and voltage control equipment considering various plant configurations

The principles of operation of over-current, earth fault, differential and impedance/admittance measuring protection

Define selectivity, discrimination (time and current), stability, sensitivity, reliability, security, primary protection, duplicate protection, back-up protection and protection zones

Components used including current/voltage transformers, summation and multi-tapped CTs and interposing transformer

Relays including all or nothing relays, induction disc relays “balanced beam” (and derivative) relays, induction cup/directional relays, biased relays and solid state/micro-processor based relays

Communication systems including hardwired (dedicated and telephone), power line carriers (PLCs), microwave and fibre optics

Protection schemes applied to lines, buses, transformers and other major plant items

Power transformers.

The principles of operation and construction of 3 phase transformers including shell or core type iron circuits, disc coils, sandwich or helix windings, transposition of windings; transportation of large transformers

Tests applied to transformers including tests to establish losses (open and short circuit tests) and the per unit or percentage impedance (voltage); use the results to develop the approximate equivalent circuit of a transformer; calculate referred values, efficiency, regulation and load sharing

Methods of connecting the windings including star, delta, zigzag and open delta; the grouping (on the basis of phase shift) and precautions to be taken for parallel operation; forward and backward roll; calculations involving parallel operating and load sharing

The use of off-load and on-load tap changing to compensate for voltage variation; comparison of fault current levels and voltage regulation requirements

Transformer temperature limitation: the equipment required and the means of cooling transformers; cooling nomenclature; changes of rating based on cooling and multi-rating transformers; oil testing and maintenance; conservator, desiccation, Buchholz relay operation

The choice and use of multi-winding, auto transformers and neutral earthing compensators; types of harmonics produced and methods of attenuation; the use of tertiary windings to suppress harmonics

Qualitative treatment of the effect of connecting single phase loads to three phase transformers

Power system operation.

Control of voltage: conditions leading to voltage collapse and system disintegration; effects on the system of high/low volts; voltage control devices including - voltage regulators applied to generators and synchronous phase modifiers, electromagnetic voltage regulators, series and parallel capacitors, OLTC transformers and static var compensations (SVCs)

The range of devices covered by SVCs including: saturated reactor compensations (SRs), thyristor controlled reactor compensators (TCRs), combined TCR/TSCs and the production of wave-form distorting harmonics and control devices

The importance of the location in the system of voltage control devices

The use of graphical methods to calculate the size of Var regulating plant

Control of power including base load, spinning reserve, regulating machines, rapid start plant, phase shifting transformers and various forms of load shedding; principles and practices of automated control of individual machines, stations and transmission/tieline elements; synchronising power

The relationship between power and frequency: limiting values; machine stabilising including steam by-pass, rapid valving, slip stabilisers and overspeed limiting; use of single pole generator CBs; use of machine AVRs as angular stabilisers; damped and un-damped system oscillations; relationship between fault clearance times and system stability; the calculation of critical clearance angles based on equal area criteria

Types of communication systems including telephone, power line carrier, dedicated cable, microwave links and fibre optics; quantities and signals to be communicated; advantages and disadvantages of the various systems; equipment requirements

Transient over-voltages in power systems; switching and lighting over-voltages and their effect on different plant items; transient over-voltage control and reduction using surge diverters, shield wires and CB are control; insulation systems, insulation co-ordination, insulation grading in plant items, bushings and capacitor bushings

Factors leading to the generation of corona; consequences of corona; reduction of corona including conductor bundling, grading rings and conductor surface treatment

Fault calculations and "power system protection"; location of CTs in major plant items; earthing principles and devices; fault current control/limitation using neutral earthing compensators (NECs), neutral point earth impedances, high conductivity shield wires and parallel feed interlocking; application of different types of protection

PLC systems applications.

Introduction to alternative/enhancing programming methods: structured programming techniques (ie flow charts); limitations with ladder/statement list programming; introduction to other programming methods (ie step sequence special functions, and other high level languages); apply system diagnostic techniques

Regulated and PID loop control: regulated control; proportional + integral + derivative (PID) control; applications of PID control; advantages and disadvantages/limitations of PID control using a programmable controller; read, change and monitor data to achieve PID control using a PLC

Specialist instructions: interrupt driven applications; high speed counters; positional encoders; other specialist features

Communications: common protocols and interface standards; requirements when networking/interfacing PLCs; communication mediums; network types and topologies (LAN, WAN, ring, bus.); hierarchal networks; peer to peer networks; handshaking; open architecture communications; remote I/O

Control electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

Problem solving and decision making: the difference between symptoms and causes of problems – defining problems, specifying problems in terms such as cost, quality and quantity; the contingency approach which differentiates between programmed and non-programmed decisions, as well as rational and bounded rationality problem solving decision making; the steps in the decision making process – brainstorming, group-think, how and when to involve groups such as nominal groups, the Delphi techniques; practical problem solving and decision making integration in the engineering workplace environment involving decision alternative of certainty risk and uncertainty

Introduction to human behaviour: understanding factors of human behaviour – definition of terms, physical and psychological factors, why people work in engineering industries; concepts and theories of motivation; content and process approaches – critical analysis of applicability of significant theories of motivation and human behaviour to the engineering workplace; people in organisations; individual and group behaviour; formal and informal groups, interpersonal relations and behaviours in organisations; managing/supervising people (as distinct from tasks or projects); the role of the manager/supervisor, applying the theory; situational and contingency approaches, including managing conflict; functional and disfunctional aspects of conflict; resolving conflict using problem solving techniques

Leadership and discipline: theories – types and styles of leadership; appropriateness of styles, advantages and disadvantages; effective leadership in the engineering workplace – application and evaluation of leadership styles; managing and leading – differences; authority, responsibility, power, delegation; use of decision making processes – Meetings., advisory groups, consultative

groups, executive groups; discipline and interpersonal, relations; manager/staff relations, disciplinary processes and purposes, self discipline in organisations

Staff selection and personnel procedures: engineering job analysis, design and description – duties, responsibilities, authority; job requirements – qualifications, specific aptitudes and experience, achievements; effect on award restructuring on engineering job descriptions; engineering staff selection processes; establishing appropriate process, panel, selection criteria; advertising vacancy, matching applicants to criteria; interviewing – preparation, the setting, questions, making the selection, modifying successful and unsuccessful applicants; appointment of engineering staff and conditions of employment; staff placement and induction; role and responsibility of engineering managers/supervisors in the application of relevant industrial awards

Engineering project.

Tender documents and contracting; engineering project specifications; client interaction (interpersonal skills); assessment of client need; report writing; preliminary design sketches; preliminary design calculations; general arrangement drawing

Component design: sizing, material selection and brought outside selection of standard components; detailed drawings of parts and assemblies showing linear and geometric tolerancing (where necessary); final report – to contain client brief of requirements and specifications (as tender documents), all drawings, design calculations and any special/novel design problems and/or solutions, a written report; oral presentation

Category: Electronics (C)

Common

Calculus.

Differential calculus: the limit concept – definition of the derivative of a function as the slope of a tangent line (the gradient of a curve), easy examples from 1st principles; the rules – derivative of sum (difference), product, quotient, chain (function of a function), use of at most 2 rules for any given functions; the 2nd derivative – implicit differentiation – applications – equations of tangents and normals, stationary points and curve, sketching, rate of change, rectilinear motion, Newton's method; verbally formulated problems involving related rates and maxima/minima

integral calculus: integration as the inverse operation to differentiation: the results – integral of k f(ax + b) where $f(x) = x^n$, six x, cos x, $\sec^2 x$, e^x the method of substitution; the definite integral; applications – areas between curves, rectilinear motion including displacement from acceleration and distance travelled

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

Problem solving and decision making: the difference between symptoms and causes of problems – defining problems, specifying problems in terms such as cost, quality and quantity; the contingency approach which differentiates between programmed and non-programmed decisions, as well as rational and bounded rationality problem solving decision making; the steps in the decision making process – brainstorming, group-think, how and when to involve groups such as nominal groups, the Delphi techniques; practical problem solving and decision making integration in the engineering workplace environment involving decision alternative of certainty risk and uncertainty

Introduction to human behaviour: understanding factors of human behaviour – definition of terms, physical and psychological factors, why people work in engineering industries; concepts and theories of motivation; content and process approaches – critical analysis of applicability of significant theories of motivation and human behaviour to the engineering workplace; people in organisations; individual and group behaviour; formal and informal groups, interpersonal relations and behaviours in organisations; managing/supervising people (as distinct from tasks or projects); the role of the manager/supervisor, applying the theory; situational and contingency approaches, including managing conflict; functional and disfunctional aspects of conflict; resolving conflict using problem solving techniques

Leadership and discipline: theories – types and styles of leadership; appropriateness of styles, advantages and disadvantages; effective leadership in the engineering workplace – application and evaluation of leadership styles; managing and leading – differences; authority, responsibility, power, delegation; use of decision making processes – Meetings., advisory groups, consultative groups, executive groups; discipline and interpersonal, relations; manager/staff relations, disciplinary processes and purposes, self discipline in organisations

Staff selection and personnel procedures: engineering job analysis, design and description – duties, responsibilities, authority; job requirements – qualifications, specific aptitudes and experience, achievements; effect on award restructuring on engineering job descriptions; engineering staff selection processes; establishing appropriate process, panel, selection criteria; advertising vacancy, matching applicants to criteria; interviewing – preparation, the setting, questions, making the selection, modifying successful and unsuccessful applicants; appointment of engineering staff and conditions of employment; staff placement and induction; role and responsibility of engineering managers/supervisors in the application of relevant industrial awards

Specialisation: Analogue and digital

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Analysis and design project.

Systems concepts: software and hardware systems; systems development life cycle; roles of the analyst and user

Feasibility analysis: problem definition – scope and objectives, schedules, preliminary report; fact finding interviews – surveys and questionnaires, observations, researching (new technology, similar systems etc); systems design options and alternatives – hardware technologies, batch or online processing, centralised or remote, user inputs and outputs, hardware inputs and outputs, interconnections, existing packages, off-the-shelf components and subsystems, prototyping, application generators, language selection; evaluation of hardware and software – sizing, performance, reliability, ergonomics, support, cost/benefit analysis, feasibility report

Systems analysis: software design tools and methodologies – system flowcharts, data flow diagrams, HIPO charts, data dictionary, ER diagrams, decision tables and decision trees, pseudocode or structured English, structured walkthroughs, application generators, CAS tools, hardware system design tools - manufacturers' data books, application notes, functional block diagrams, flowcharts, test specifications, standards

Advanced analogue electronics.

Differential and instrumentation amplifiers

Integrators

Single supply operation – using blocking capacitors and norton amplifiers

Comparators with and without hysteresis; non-saturating comparators

Piece wise approximations to non-linear transfer curves – increasing and decreasing slopes and bipolar curves

Function generators

Precision rectifiers – half-wave and full-wave

Active filters – low-pass, high-pass and band-pass

Applications of power; amplifiers and definitions

Additional considerations related to large signal operations

Class A, B, AB, C and D power amplifiers

Distortion/feedback

Heat transfer and sinking

Data sheet usage related to typical characteristics of fully integrated power amplifiers

Specification and testing of power amplifiers

Advanced circuit analysis.

H-parameters: hybrid parameters; hybrid parameters for the bipolar junction transistor; voltage gain; current gain; dependent sources; input and output impedance

Complex waveforms: fourier series; odd and even functions; half wave symmetry; harmonic components; root mean square value of a complex wave; effect of frequency on inductive and capacitive reactance; effect of reactive components on harmonic component

Digital design.

Types of programmable logic devices; features of programmable array logic (PAL) devices; reprogrammable PALs (GALs); PAL combinatorial design; logic family characteristics; interfacing between logic families; interfacing to external devices; schmitt trigger devices

Project management; advanced state machines; system design considerations; timing analysis and hazards; testing and debugging; engineering standards; documentation

Digital signal processing.

DSP applications; signal sampling; impulse response of linear phase filter; FIR filters; adaptive filters; DSP chip architecture; DSP programming; integer arithmetic; analogue filtering

Simple IIR filter; high-order IIR filter; discrete fourier transform; complex signals; fast fourier transform; FIR filtering using the FFT; data-rate conversion; modulation and demodulation; applications; support chips

Electronic software tools.

Circuit analysis software: general description; documentation (written and on-line); common features – circuit entry, input data format, output data format; hardcopy of circuit and results; evaluation of package

Computer aided drafting (CAD) software: general description; documentation (written and on-line); common circuit schematic features – component selection, text and line selection, placement, movement, erasure, numbering; common printed circuit board design features – component selection, text and circuit trace selection, placement, movement, erasure, manual and auto-routing; hardcopy of results; evaluation of package

Microprocessor applications.

User interface devices (LEDs, 7 segment displays, LCDs, keypads

Serial I/O

Interrupts

Software development techniques (program structure and design, use of assembler features)

Project – operational minimum system

Digital to analogue converters

Analogue to digital converters

Interfacing actuators (relays, solenoids)

Controlling ac power

Linking assembly language modules with high level language modules (using C)

Project work

Specialisation: Communications

Electronic software tools.

Circuit analysis software: general description; documentation (written and on-line); common features – circuit entry, input data format, output data format; hardcopy of circuit and results; evaluation of package

Computer aided drafting (CAD) software: general description; documentation (written and on-line); common circuit schematic features – component selection, text and line selection, placement, movement, erasure, numbering; common printed circuit board design features – component selection, text and circuit trace selection, placement, movement, erasure, manual and auto-routing; hardcopy of results; evaluation of package

Communications engineering project.

Researching and analysing information related to a communications system

Generation and selection of solutions to a communications system problem

Comparison and evaluation of possible technical solutions

Organisation and management of research processes

Antenna systems.

Half wave dipole radiation, radiation resistance, input impedance, gain, beam width, effective radiated power, front to back ratio, TEM wave polarisation, VSWR, specifications

Surface wave propagation, loss factors, sky wave propagation, terrestrial space wave propagation

Radiation pattern diagrams for half wave, folded dipole quarter wave and longer ground plane, yagi antenna types, dimensions, input impedance, applications for these types of antennae

Characteristic impedance, load impedance, attenuation of transmission lines; Smith Charts, parallel wire, coaxial cable, stripline, waveguide mediums; load impedance mismatch, SWR at transmitter and load; impedance matching

Multi element Yagis (3-24): stacked and bayed Yagis; slot panel and bayed dipoles, corner reflector; log periodic; co-linear, end fed dipole; cardioid dipole; circular polarisation; paging antennae; mobile and portable radio antennae; vehicle antennae

Signal coverage, new sites, interference, environmental effects, sharing an existing system wind loading, weight; antennae on structures, mounting materials, coaxial cable connectors, isolation, physical separation, waterproofing, documentation inspections; corrosion, weather effects (wind, snow, rain); pollution; lighting protection, radiation hazard

Antenna separation, duplexers; different radiation patterns resulting from insufficient antenna spacing duplexers enable one antenna and one feeder to be utilised preserving the correct radiation pattern; bandpass, bandstop duplexers; method of connection to transmitters and receivers, waveguide cavity, ceramic types; insertion loss, rejection in transmit and receive legs, power handling, separation temperature range

Construction of a ferrite circulator DC field effects and their alteration of resonant frequencies; direction of signal flow; circularity for each port; permanent or electro-magnets for bias use as a circulator or isolator with a port matched load

Transmission lines.

Types of lines and their applications: microstrip, waveguides; line parameters using primary constants; standing wave patterns for any termination; line parameters, given terminations; DC transients on a transmission line; time-space diagrams and oscillograms; smith charts; single and double stub matching; waveguide propagation and field patterns therein; cavities and field patterns therein; launch/pickup of waves in waveguides and cavities; stripline structures

Optical fibre transmission; components of an optical fibre system; characteristics of optical fibre; safety and handling; attenuation measurements; optical cable installation; optical fibre joining; optical fibre connectors; optical sources and detectors

RF amplifiers.

Classes of amplifiers: class A; class B; class C; efficiency of amplifier classes

RF amplifier terminations: termination of ideal voltage current and RF amplifiers; resonant circuit principles

RF amplifier operation, alignment and neutralisation

RF amplifier coupling methods: impedance transformation/coupling; L and pi coupling circuits; double tuned transformer coupling

Decoupling of RF circuits: radio frequency coils (RFC); capacitor decoupling; ferrite beads

Microstrip amplifiers: stripline geometrics and impedances; application of stripline techniques; basic stripline design

Masthead amplifiers: noise considerations; characteristics

Transmitters and receivers.

Transmitters: block diagram of both high level and low level AM transmitters; class A, class B and class C amplifiers in AM transmitters; applications using AM transmitters; block diagram of the filter method SSB transmitter; block diagram of the phase method SSB transmitter; SSB transmitter stage frequencies; two tone testing of SSB transmitter; block diagram of the direct method FM transmitter; frequency multipliers and converters in FM transmitters; block diagram of the indirect method FM transmitter; classes of stage amplifiers in an FM transmitter; pre-emphasis and de-emphasis in FM systems; stereo FM principles; transmitter frequency stability requirements; transmitter spurious signal suppression; transmitter power level requirements; transmission modes; radiation exposure levels; measure output power of a transmitter; measure output carrier frequency; measure spurious output levels

Receivers: block diagram of a single conversion superheterodyne receiver; RF amplifier – filtering, gain, low noise, antenna match, AGC, stability, typical circuit; local oscillator – frequency stability, signal purity, synthesiser local oscillator, typical circuit; mixers – function, problems, typical circuits; IF strip – function, choice of frequency, IF selectivity, AGC, typical circuits; demodulation – AM, FM, SSB, BFO, DC for AGC, S Meters; image frequency; dual conversion superheterodyne; AM, SSB AND FM receivers; applications of AM, SSB and FM receivers

Microwave systems.

General microwave systems: radar; terrestrial microwave links; satellite microwave links; global positioning system (GPS); fleet management systems

Antenna systems: yagi and dipole arrays (including electronically steerable); slots and slotted arrays; microstrip arrays; horns; axial and offset reflector systems; metallic and dielectric lenses

Terrestrial link planning: K-factor; earth's bulge; refraction; knife-edge diffraction; fresnel zones; absorption; carrier frequency; distance; Tx EIRP; Rx antenna gain

Satellite link planning: tracking requirements and beamwidth; figure of merit; absorption distribution; outage causes; EIRP; C/N; process gain

Microstrip structures: matching circuits; filters; couplers; splitters; circulators

Matching techniques: single stub matching using smith chart; physical length of matching network

Microwave devices.

Waveguide propagation

Cavity devices: couplers; T; hybrid T; directional; diplexers; phase shifters; power splitters; circulators; horns

Stripline structures

Ferrite and dielectric devices

Therminoic microwave devices: klystrons; magnetrons; cross field amplifiers (CFA); travelling wave tubes (TWT)

Solid state microwave devices: diodes – tunnel, PIN, Gunn, TRAPPATT, BARRATT; stimulated emission devices – MASER; parametric amplifiers – Josephson devices (explain need for circulators with the above)

Matching systems: single stub match using a smith chart; determine physical length of matching network

Satellite communications.

Typical satellite communications systems, major sub-systems and critical components; antenna pointing parameters; up/down link considerations; figure of merit; EIRP; common types of baseband signal processing; process gain; types of system access – TDMA, FDMA, CDMA, DAMA, PAM; types of RF modulation – n-FSK, n-PSK, n-QAM

Digital radio.

Digital modulation concepts; baseband signal processing; effect of noise on digital systems; signalling methods; optimising multipath radio reception; digital radio systems

RF principles.

Oscillators and tuned circuits: barkhausen criteria; LC oscillators; crystal oscillators; phase locked loops (PLL)

Filters: butterworth, chebyshev and bessel filter networks; crystal filters; ceramic filters; mechanical filters; surface acoustic wave (SAW) filters

Modulation techniques: amplitude modulation (AM); phase modulation (PM); frequency modulation (FM); single sideband (SSB); double sideband (DSB); high and low level modulation methods; modulator alignment procedures

Demodulation techniques

Frequency multiplier techniques

Mixer circuit techniques 1

Characteristics of components at RF

Communication measurements and techniques.

Operation of digital storage oscilloscope (DSO): analogue – variable persistence mode; single shot storage; digital – saving and recalling set-ups and displays; hardcopy storage; signal processing function

TDR and OTDR operation: transmission line characteristics

Q-meter measurements: Q-meter operation – block diagram; measurement using following connection modes – direct, series, parallel; distributed capacitance

Spectrum analyser: frequency-domain identification of baseband and modulated signals; frequency-domain measurement of signals

Network analyser: component measurement; impedance measurement; insertion loss; load impedance variation with frequency

GPIB bus: GPIB operation; test procedure; equipment connection

Category: Instrumentation (D)

Common

Single chip microcontrollers.

Architecture CPU, RAM, PROM, I/O, programming concepts, subroutines, instruction sets, arithmetic, stack operation, features of microcontrollers, interrupts, timers, clocks, on chip peripherals, serial busses and interfaces, expansion capability, cross assemblers and emulators, PROM loading, power supplies and mask options

Control electrical calculations.

Math software package e.g. matlab; series expressions; fourier series; linear functions and linearisation; difference equations; differentiation; integration

Rules of matrix algebra; vectors; matrix Fns (Det, Inv, exp); eigenvalues and eigenvectors; linear ordinary differential equations; time domain solution of 2^{nd} order LODEs; state space forms; state space solution of LODES; review and test

Advanced telemetry.

Background to telemetry

Telemetry and its use with supervisory control and data acquisition (SCADA) systems

Data carriers and communication methods

Integration with existing systems

Analysis of system requirements and performance

Specification of systems

Commissioning and maintenance: person – machine interface and telemetry computers; communication front end and network; remote terminal units; single board (small) outstation; remote workstations including portables; Future trends

PLC systems.

Introduction to alternative/enhancing programming methods: structured programming techniques (ie flow charts); limitations with ladder/statement list programming; introduction to other programming methods (ie step sequence special functions, and other high level languages); apply system diagnostic techniques

Regulated and PID loop control: regulated control; proportional + integral + derivative (PID) control; applications of PID control; advantages and disadvantages/limitations of PID control using a programmable logic controller; read, change and monitor data to achieve PID control using a PLC

Specialist instructions: interrupt driven applications; high speed counters; positional encoders; other specialist features

Communications: common protocols and interface standards; requirements when networking/interfacing PLCs; communication mediums; network types and topologies (LAN, WAN, ring, bus.); hierarchal networks; peer to peer networks; handshaking; open architecture communications; remote I/O

Control systems project development.

Project introduction: project selection criteria; industrial visit

Project model selection: brainstorming for project selection; preliminary report

Project model design: project management techniques; system design report

Project model construction

Project model comissioning: model demonstration/presentation; final report

Compensation (tuning) techniques.

History of control; system identification; feedback; tuning techniques; auto-tuning and model based control

Dynamic systems engineering.

Probability and monte carlo methods; queuing; dynamic response of systems; simulation

Transform techniques.

Convolution; laplace transform; transfer function and block diagrams; fourier transform; z transform; transformations; filters and windowing

Digital control using computers/micros.

Types of computer and their uses: on-off control; PID control; 'intelligent' control self tuning controllers, fuzzy logic controllers

PID control: the control algorithm; proportional control; integral control; derivative control

Writing the program for closed loop control: on-off control; PID control

Tuning a PID control loop: choosing the proportional constant; choosing the integral constant; choosing the derivative constant

Sampling rates: minimum sampling rates; nyquist criterion; factors that effect the sampling rate; measuring the sampling rate

Process data acquisition systems.

Industrial measurement applications and sensor characteristics; industrial computer systems and programming; standard computer input/output specifications; noise – grounding, shielding and filtering; signal conditioning; signal processing – analogue signals; signal processing – digital signals; signal transmission and isolation techniques

Advanced control using "C".

"C++" an introduction: history; relationship to "C"; advantages and disadvantages to other languages

Object orientated programming: concepts of stage operation; encapsulation; inheritance; polymorphism

Windows programming: history; graphical user interfaces; consistent user interface; message driven architecture

Windows environment: windows; cursors and the mouse; dialogue boxes; menus; icons

The "C++" development package: editor commands; the edit-compile-run cycle; compiler and linker options; windows programming libraries

"C++" language syntax: differences between "C" and "C++"; data types; classes; program structure

Computer emulation and mimics: purpose of mimics; types of mimics

Interfacing of mimics to control loops: interfacing of mimics within control loops; preparing of data for display purposes

Engineering management.

Introduction to organisational management roles/functions, characteristics and responsibilities: principles, concepts and basic definitions of terms such as organisation operatives; role and functional differences between first line, middle and top management including – international roles of figurehead, leader and liaison; informational roles such as monitor, disseminator and communication/spokesperson; decisional roles such as entrepreneur, disturbance handler, resource allocation and negotiator; specific differences between functional and general management roles; with particular emphasis on first line management, the management functions of planning, organising, leading and staffing, directing and controlling; also variations of conceptual, people and technical job related skills at first line, middle and top management with particular emphasis on first line management levels, organisational responsibilities to owners, employees, customers/clients/end product users, the law, and to the public and government; human qualities required to be a successful first line manager such as initiative, self-confidence, integrity and ethics, patience and an open mind; with particular emphasis on first line management, organisation culture which includes such characteristics as individual initiative, risk tolerance, direction, integration, management support, control, identity reward system, conflict tolerance and communication pattern, and all these influences on the functioning of management

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UTE NES604 (A to Z qualifier) A Co-ordinate & manage commissioning processes

Descriptor: Manage resources and information to achieve planned commissioning process outcomes.

Alignment: Nil.

Specific unit outcomes

This is presented as a composite unit that has five specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES604A A	Co-ordinate & manage commissioning processes *(Computer systems)*
UTE NES604B A	Co-ordinate & manage commissioning processes *(Electrical)*
UTE NES604C A	Co-ordinate & manage commissioning processes *(Electronics)*
UTE NES604D A	Co-ordinate & manage commissioning processes *(Instrumentation)*
UTE NES604E A	Co-ordinate & manage commissioning processes *(Refrigeration & a/conditioning)*

Elements		Performance criteria	
604.1	Plan and prepare to manage commissioning processes	604.1.1	Management of commissioning *OH&S policies and procedures* are planned and prepared to ensure these are followed
		604.1.2	Commissioning process schedules are managed in accordance with *requirements*
		604.1.3	*Appropriate personnel* are consulted to ensure commissioning process is managed effectively
		604.1.4	Commissioning processes are managed against *requirements*
		604.1.5	Contribution is made to determine procurement management plan for commissioning processes in accordance with *established procedures* and checked against *requirements*

Elements		Performance criteria	
604.2	Manage commissioning processes	604.2.1	Mechanisms are used to measure, record and report progress of activities in relation to the agreed commissioning process schedules and plans
		604.2.2	Commissioning processes are managed in accordance with *established procedures* and *requirements* to achieve designated objectives
		604.2.3	Records and documentation of commissioning process activities are maintained in accordance with *established procedures* to facilitate quality management and to provide an audit trail
		604.2.4	Results of commissioning process activities are documented and evaluated in accordance with *established procedures* to determine compliance with agreed quality standards
		604.2.5	Shortfalls in quality outcomes are reported in accordance with *established procedures* to enable appropriate action to be initiated
604.3	Inspect and notify completion of work	604.3.1	Quality management issues and responses are reported in accordance with *established procedures*
		604.3.2	Completion of commissioning processes are *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

(E) Refrigeration and air conditioning

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled ‘Underpinning knowledge’.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment,* tools, *accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

There is no interdependency associated with this unit. However, this unit has been designed as a natural progression from unit UTE NES303 A. Therefore, it is expected that to achieve this unit, without having gained competence in unit UTE NES303 A, will require that the relevant aspects of knowledge and skills related to unit UTE NES303 A be developed and form part of the requirements for achieving competence in this unit.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Data link operations.

Use of asynchronous data link hardware and software

Awareness of occupational health and safety for mains operated electronic equipment when installing hardware

Start/stop protocol options: data rate, number of data bits, number of stop bits, even/odd/no parity bit

Use of synchronous data link hardware and software

Recognition of format for OSI high level data link control (HDLC) and 802.2 logical link control (LLC) including data flow control: receiver ready (RR), receiver not ready (RNR), Poll/final (P/F) bit, module counters

Recognition of format for link negotiation commands, link connection and disconnection commands, link layer control service access point (LSAP) and 802.1 defined addresses

OSI HDLC and 802.2 LLC protocol options: data rate, clock encoding, number of octets, half/duplex

Recognition of format for OSI HDLC and 802.2 LLC error procedures: frame reject (FRMR), frame discarding

Correlation of end user error messages with abnormal traffic

Computer networks.

Protocols and the OSI model: rationale for layered protocols; goals of layered protocols; network design problems; communication between layers; the layers

Terminal networks: terminal characteristics; character mode networks – terminal multiplexer; statistical multiplexer, terminal switching exchange; block-mode networks; multidrop lines, poll-select; terminal network protocols, binary synchronous control (BISYNC) formats, protocol operation, user interface, protocol performance; high-level data link control; frame formats, frame types

Delay analysis: introduction to queuing theory; the M/M/I queue in equilibrium; networks of M/M/I queues

Network layer: virtual circuits, datagram; routing algorithms; congestion; bridges, routers, brouters, gateways internetwork protocol, TCP, IPX, XNS

Local area networks: topologies; types of LAN's – ethernet, token ring, token bus, network installation, planning, performance outcomes

Operating system (multiuser).

Operating systems: history; functions of the system

Multiuser and multitasking operating systems: real time applications; interleaved processing techniques; multiprogramming; multitasking; time-sharing; virtual storage; multiprocessing

Language translators: compilers; interpreters; assemblers

File and disk organisation: files and directories; protection and permissions; listings; file location; classification

System command and calls: commonly used commands; retrieving; saving; deleting; copying; creating; printing; linking

Input/output redirection: meaning of; method of achievement

Batch, script or equivalent files: purpose; structure; commands

System utilities: sorting; windowing; device drivers

Computer systems architecture.

Historical milestones in computer architecture; Von Neumann architecture; non Von Neumann architecture; fetch decode execute cycle

Bus architectures: address, data and control; 8/16/32 wide busses; multiplexed and non multiplexed; Von Neumann bottleneck; synchronous, semi-synchronous and asynchronous data transfer; design considerations – reflections and termination, crosstalk, receivers, transceivers and hysteresis; drivers, open collector and tristate; single user and multiuser busses – IBM PC, VME, UNIBUS

System support: instruction pre-fetch pipeline, BIU, EU; DMA devices – cycle steal and burst modes; peripheral CHANNEL support; co-processors and bus interface; typical interrupt structures – intel, Motorola, PDP-II Zilog

CPU Architecture: registers, ALU and control unit; bit slice, Harvard, stack oriented CPUs; machine code and conventional machine; instruction set considerations; addressing modes – direct, indirect, indexed; the micromachine control unit and data pathways; hard wired and microcoded control unit; horizontal versus vertical microcode considerations; gate array, ASICS

Parallel processing: Flynns taxonomy – SISD, SIND, MISD AND MIMD; data pipeline, multiple functional units, interleaved memory, vector and array processors; parallel machines – transputer, hypercubes, connection machines, dataflow machines

Operating system considerations: multiprogramming systems, time-sharing; virtual memory – overlays, physical address space, virtual address space, paging, working set, thrashing, page replacement, segmentation

CACHE: memory, locality of reference principle, hit ratio; mapping techniques – associative, direct, set-associative; write-through, write-back

RISC Machines: RISC versus CISC; instruction set, register sets

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Category: Electrical (B)

Common

Applications of transducers.

Light and radioactivity detection: light sensors; units of light; light measurement terms; photoemissive light sensors; photoconductive light sensors; photovoltaic light sensors; x-ray sensors; nuclear radiation sensors; units of radiation measurement; radiation sensors – photoelectric, ionisation

Temperature detection: temperature-sensing basics; units and terms used; bimetallic, fluid-pressure, resistive, semi-conductor, thermocouple, radiation pyrometer, oscillating-crystal

Fluid flow and pressure detection: fluid flow sensing; units of flow measurement, terminology; rate of flow sensors; quantity of flow sensors; fluid pressure sensing basics; units of pressure measurement; Bellows, Bourdon-tube, diaphragm, and capsule pressure sensors; pressure cell, differential-pressure sensors

Motion and force detection: motion and force sensing; sensors for linear motion; angular motion; speed of rotation; compression; tension, torque; acceleration, vibration; altitude

Moisture and humidity sensors: moisture and humidity measurements basics; moisture and humidity measurement units and terms; hygrometer-type sensors, resistive, dielectic-film, mechanical displacement, oscillating-crystal, aluminium-oxide; psychrometer-type sensors; dew point sensors, temperature-sensing, instant-of-condensation

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

Advanced PLCs.

Medium to high level PLC hardware and software: hardware configuration; addressing; memory map; programming instruction syntax; file manipulation; documentation; saving/restoring programs

Number systems and codes: common number formats (binary, octal, integer, hexadecimal); conversions between formats; codes (BCD, grey, ASCII)

Diagnostics: flags/status words (file); fault locations; scan considerations (fixed, variable, immediate update)

Data manipulation (word): binary word structure; single and double works; word devices; arithmetic instructions; word logical instructions; conversions (BCD to binary, binary to BCD); indirect addressing (image register to word, word to IR, word to word, word to table, table to table); word shift registers (LIFO, FIFO); masking; bit manipulation (bit set, bit clear, bit test); entering data constants; multiplexing

Analogue I/O: common signal types; module resolution; scaling; unscaling; signal offset

Sequencers/drum controllers

Specialisation: Power systems

Power systems analysis.

Impedance of three-phase load: complex analysis; measurement of impedance; conversion of impedance between star and delta

Analysis of mixed load three-phase circuits: star and delta systems; mixed single and three-phase loads; balanced and unbalanced loads; calculation of line and phase currents in both star and delta loads; total line current for mixed loads; power in three-phase systems, including the use of current transformers; power factor; prediction of current and voltage on the loss of the neutral

Measurement in three-phase circuits: measurement of voltage, current, power and power factor in mixed circuits; sources or error

Line voltage drops: cable losses; voltage drop; heat dissipation; Australian Standards and limitations of losses; methods to minimise line losses

Power factor (P.F.) correction: requirement; calculation of reactive element to correct P.F.; synchronous machines for correction of P.F.

Electrical distribution.

Distribution system: systems of distribution used – primary and secondary; voltage levels; supply quality; load curve profiles – residential, industrial, commercial; types of feeders; distribution systems – urban, rural single phase systems – SWER

Overhead lines and installation: industry and safety regulations; overhead conductors – conductor material, current rating factors – heating, voltage drops, power losses, aerial bundled cables – HV and LV, covered conductors; overhead lines poles – types – wood, concrete and steel, installation of poles – tooling, rake, life, labelling, sinking, maintenance of poles – above and below ground, pole strength and loads; crossarms – types and standard sizes; insulators – insulation types, types – pin, suspension or disc, shackle, creepage – necessary clearances, acring horns – insulator mounting; structure types – mechanical properties – working strength, maximum tension, limiting size; stringing charts (use of) – sag – calculations, measurement and tension measurement, sight and wave sagging, sag correction; stays – components, anchorage; use of design schedules – design problems – examples of common design practice line, voltage, structure types used, line deviation, span sag, crossarms, insulators and

stays wind loading and line deviation loading basic surveying, measurement of levels, deviation angle and compass bearings, perform survey of short distribution line extension of produce filed notes

Underground cables: cables types – ratings, core material, design considerations, cable dielectrics, insulating materials and abbreviations, electric stress, cable volt drop and volt drop calculations, cable termination, joints and installation; induction and eddy currents; cable testing - cable fault location; cable drawing

Voltage regulations of feeders and associated equipment: terminology used – distribution system, service line, customer's terminals, customer voltage, utilisation voltage, base voltage, voltage variation and bandwidth; voltage limits and effects for voltage variation; causes of variation – inductance, capacitance and reactance of distribution lines, transformers; methods of voltage control – off-load, on-load tap changers, voltage regulating relays, line drop compensation, different types of voltage regulators; voltage profiles – principles, effect on voltage profiles, limits of voltage, voltage drops due to LV mains transformers, tapsettings feeder and service lines

Specialisation: Control systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphic designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Transmitters and converters.

Pneumatics: principles of flapper nozzles, pneumatic transmitters

Supplementary pneumatic loop equipment: computing relays, lead/lag units, high and low selectors, air to current and high and low selectors, air to current and current to air converters, square root extractors, integrators, regulators, multipliers and dividers

Electronics: electronic transmitters, analogue computing, integrators, high and low signal selector, signal converters

Transducers I to P, P to I converters, analogue to digital and digital to analogue converters, RTD/I, mV/mA, frequency to I, square root extractors and integrators

Linear variable differential transformers

Intrinsic safety

Zener barriers

Explosion/flame proof enclosure

Specialisation: Drive systems

Variable speed drives.

Introduction to variable speed drives: advantages of variable speed drives – speed and direction control, acceleration control, torque control, energy savings; terminology used with variable speed drives – direction – forward and reverse, speed - $^{+}$ve and $^{-}$ve, torque - $^{+}$ve and $^{-}$ve, 4 quadrants of torque/speed operation, acceleration - $^{+}$ve and $^{-}$ve, load power – supply power, efficiency; power electronic converters – common electronic power control circuits for – AC/DC rectifier, un-controlled and controlled, DC/AC inverter, PWM and quasi-square wave AC/AC converters, rectifier linked to inverter and a matrix converter, DC/DC converters, PWM; input and output waveforms for power electronic converters – interference generated by circuits, electrical and audio; electromagnetic compatibility (EMC), introduction to harmonic distortion analysis using microprocessor based test equipment (not mathematical analysis), filtering techniques employed to optimise EMC switching frequency and effects on motor performance and EMC; control system for variable speed drives PWM (pulse width modulated), VVVF drive (variable voltage variable frequency) – inverter control system, speed feedback and control system, current feedback and control system, external interface, selection of, and applications for PWM, VVVF drives; flux vector control drive – inverter control system, speed feedback and control system, current feedback and control system, select of, and applications for slip recovery drives; control system for soft starter – overview of operation of soft starter selection of, and application for soft starters; new development in AC variable speed drive technology – e.g. switched reluctance drive/motor

Protection of AC variable speed drives and motors: sources of failure – loss of cooling, overloading, frequent starting, supply problems, high ambient temperature; methods of protecting against sources of failure; protecting the frequency converter – current limit, over current trim; protecting the AC motor – motor thermal model

Commissioning: purpose; setting parameters; testing

Differentiation of common faults in systems: source of faults; methods to determine nature of fault; includes communications and external interface

Adjust settings: manufacturers specifications; load testing

Identify drive faults: source of faults; fault-finding methods

Selection, installation and fault-finding techniques: choosing size of frequency converter; motor loading and cooling; checking motor loading; over synchronous speed – advantages; mounting position and enclosures; supply and control cable selection and installation; environmental conditions; earthing

Category: Electronics (C)

Common

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Basic determinants and solution of 2/3 simultaneous linear equ by determinants exponents and logs

Time dependent trig functions - $\sin(\omega t+\theta)$

Trig of oblique triangles

Introduction to vectors

Complex numbers

Circuit analysis.

Phasors: time domain; frequency domain; frequency, angular frequency and units of measurement

Complex impedance: impedance diagram; resistance; reactance; admittance; conductance; susceptance; equivalent series circuit; equivalent parallel circuit

AC series/parallel circuits: Kirchhoff's laws; series equivalent impedance; parallel equivalent impedance; voltage divider rule; current divider rule; phasor diagrams

Complex power: true power; reactive power and apparent power; units of measurement – watt, volt-amp; reactive, volt amp; power triangle; power factor

Superposition theorem: power considerations

Thevenin and Norton theorems: voltage source models; current source models; practical sources; open circuit voltage; equivalent impedance; short circuit current; source conversion

Star/delta conversions: equivalent circuits; star/delta transformation formulae; selection of appropriate conversion

Specialisation: Communications

Communication fundamentals.

Basic communication system: radio wave as a T.E.M. wave; radio wave frequency band identification; relationship between frequency – wavelength and velocity of propagation for radio wave

Transmission media: metal cable; waveguide; optical fibre; radio wave paths

Noise: definition; categories; effect on communication systems; communication signals in both the time and frequency domain; fourier analysis of periodic complex waveforms; baseband signals; modulation signals

Modulation techniques: AM full carrier; double sideband; single sideband; vestigial sideband; frequency modulation; phase modulation

Demodulation techniques: AM full carrier; single sideband; frequency modulation; frequency division multiplexing (FDM) F.D.M hierarchy; F.D.M in stereo FM; time division multiplexing (TDM); TDM hierarchy; basic crystal set receiver; TRF receiver

Superheterodyne receiver: block diagram; advantages

Transmitters: AM full carrier; single sideband; FM; digital signals; sampled analogue signals; sampling theorem; pulse code modulation (PCM) – quantisation, quantisation noise, compounding, encoding; digital signal transmission compared to analogue signal transmission; noise in communication systems; signal-to-noise ratio; noise figure; noise factor; noise temperature signal-to-noise bit error rate in digital

Receiver and transmitter circuits.

Receiver block diagrams: principles of dual conversion; DSBFC dual conversion receiver

RF amplifiers: intermodulation; cross modulation; RF amplifier performance

Intermediate frequency (IF) amplifiers: IF amplifier alignment; neutralisation; IF amplifier performance

Demodulation: SSBSC

AGC systems: SSBSC receivers

Phase locked loops (PLL): PLL noise; frequency synthesis using PLLs

Receiver performance criteria: sensitivity test - FM quieting, S/N ratio, SINAD measurements; spurious signal responses; receiver noise figure

NBFM transmitters: operation; tuning and adjustment; testing

Digital transmitters

Specialisation: Analogue and digital

Microprocessor system assembly language programming.

Operation of a microprocessor based computer system: ROM, RAM, IO and major system components

CPU architecture: registers; instruction set considerations – common and advanced instructions; addressing modes supported – direct, indirect, indexed; software interrupts and system calls

Processor and system support: instruction pre-fetch pipeline; system timer chip – function and programming; hardware interrupt programming considerations; DMA devices and support; co-processors and bus interface

Modular programming: separately compiled and linked assembly language modules; library modules; macros

Documentation and debugging: system specification and documentation; debugging and tracing program execution

Electronic instruments.

Loading and matching; connectors; decibels; storage and delay CROs; frequency synthesisers; frequency counters; spectrum analysers; noise and distortion meters; RF communications service monitor

Category: Instrumentation (D)

Common

Control programming style.

Control applications of software; software terminology; relevant programming languages currently available; flowcharts; pseudocode; nassi sniedeman charts; developing algorithms; programming style; programming structure; documentation

Installing a language compiler; using a text editor; compiling source code; generating executable files

Scalar and structured data types; constants and variables; reading from keyboard and writing to screen; arithmetic, relational and logical operations; making decisions using if/then, if/then/else, nested if/then and case; looping operations using while/go, repeat/until and for/do; subprograms; functions; procedures

Installation of computer interface circuit boards; programming to access external devices via I/O boards

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Control electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

On-stream analysis.

On-stream analysis: chromatography; spectroscopic methods; electrical methods; sampling systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphics designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

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Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Final control elements.

Control valve selection and sizing

Pneumatic controllers and positioners

Pumps and blowers

Variable speed drives

Dampers

Category: Refrigeration and air conditioning (E)

Common

Commissioning - HVAC systems.

General requirements: building codes; local government regulations; human comfort – comfort chart; reporting procedures; pre-commissioning checks

Air systems: air tab instruments (air flow, pressure, temperature); fan testing; air balancing procedures; leakage testing; system capacity calculations

Hydronic systems: hydronic tab instruments (fluid flow, pressure, temperature); pumps; pumps curves and system curves; pump testing; hydronic (balancing procedures, general, compensation method); balancing valves; capacity calculations

Plant and equipment: controls; heat exchangers; chillers; boilers; cooling towers

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Specialisation: Control systems

Advanced HVAC control systems.

Control diagrams: electric/electronic control diagrams; electrical installation documents; pneumatic diagrams; DDC diagrams; controls/electrical power circuit interface; nomographs

Evaluate existing automatic control systems: specifications; briefs; descriptions of operation

Control requirements: standard and statutory requirements; economy of operation (energy management)

Building management systems.

Functions of a BMS: autonomous functions; input; output; general I/O; installation management items; energy management; risk management; information processing; objective; building running costs

BMS hardware: system architecture; communication devices; substations; PCs

Input and output functions: digital – input, outputs; digital output with status feedback; analogue input, output; sensors; alarms

Energy management: night cycle; optimum stop, start; time and event programs; night purge; outside air percentage control; enthalpy control; power demand control; duty cycle; presence detection; lighting control

Information processing functions: computer systems; central system management; programs; system configuration and security; operator – machine interface; data points

Risk and maintenance management: system files; fire – intruder control; access control

Energy management.

Energy sources and characteristics: supply authorities; standard units of measurement; electricity; steam; hot water; high temperature hot water; town gas; LP gas; solar; waste heat; petrochemical

Energy requirements: office lighting; air conditioning systems; refrigeration systems; security systems; computer systems; waste disposal systems; standby/emergency systems

Energy auditing process: energy costs and tariffs; energy consumption; predicting future costs; plotting consumption trends; historical data; collecting information using surveys; comparisons of actual to recorded usage; energy balance; instrumentation; estimating savings potential

System operation for energy efficiency: types of systems; efficiency in building structures; operation of a vehicle fleet; proportioning total energy consumption against individual systems; passive building design; preventative maintenance procedures; monitoring building management systems; operation of major and minor plant; inappropriate energy management procedures; building plant control systems

Implementing energy management procedures for a building: recording base year data; climatic conditions for locality; establishing energy costs and tariffs; building and systems surveys; pay back period; survey analysis; energy conservation procedures; implementation issues; monitoring

Methods of energy conservation: time schedules; lighting control

Maintenance practices: filters, fans, appropriate setpoints, dead bands, etc

HVAC system control: night cycle; optimum stop/start; purge cycles; chiller/boiler/cooling tower sequencing; economy cycles (based on temperature or enthalpy); supply air reset; supply water reset; condenser water temperature reset

Electrical load control: power demand control; load limiting; load shedding; set point relaxation; ventilation cycles

Tests and data collection procedures: use of BMS for data collection (trending); use of data recorders (loggers); monitoring building operations generally

Analyse results from test data: compare against standards (BOMA); review current practices against ideal; total consumption Vs peak load; electricity tariffs and implications

Methods of reducing energy usage: plant retrofits; controls; plant – fixed OA to economy boiler to electric reheat, constant volume to VAV; cost/benefit (payback)

Specialisation: HVAC systems

Commercial air conditioning system design.

Design parameters for commercial (single zone) air conditioning applications: e.g. offices, restaurants, hotels, bars; customer and objective; customer concept of environment desired; economics; client brief

Relevant design criteria: building purpose, location, orientation and shape; external environment ambient conditions; internal load diversity; thermal capacity behaviours; thermal load (full and partial)

Zoning and building usage: space and building; occupancies, single purpose, multi-purpose

System selection criteria: economics; environment; control requirements; existing structures; new structures; system components; space for equipment and system; selection of appropriate system, ductwork and components

Systems and applications: design features, engineering, controls and selection procedures for fan direct expansion RAC's, coil units, heat pump, package units, free blow and ducted

HVAC energy conversation techniques: heat recovery systems; night cycle; optimum stop/start; purge cycles; load limiting; load shedding; cost/benefit (payback)

HVAC load estimating.

Building survey: space characteristics; location of equipment; design conditions – outdoor, inside (type of installation); storage of heat in building structures; solar heat – direct and diffuse, glass types and factors, shading devices; film coefficients; heat and water vapour through structures – transmission coefficient; heat and water vapour through structures – transmission coefficient; infiltration; ventilation; internal heat gains; system heat gains

Computer programs: ACAOS; TRANE; CARRIER

Psychrometrics – advanced.

Complex psychrometric processes: sensible cooling and heating and evaporative (adiabatic) cooling; cooling and dehumidfication; cooling and dehumidification with high latent load; cooling and dehumidification out door air; cooling and dehumidification all out door with dehumidified air requirements less than supply air; cooling with evaporative humidification; cooling with near isothermal humidification; spray processes to include cooling and dehumidification with heated spray water – heating and humidification; partial load processes – reheat, by-pass of RA only and, mix of RA and OA; variable air volume; variable coil effective surface temperature; split coil - horizontal, vertical and intertwined

System performance: saturation efficiency of sprayers; system capacity calculated from air quantity and enthalpy change

Required plant capacity and airflow rates: effects of coil by-pass factor and ADP; calculation of dehumidified air quantity – using both TSH and ERSH methods

Psychrometric formulae and charts: properties of air; gas constants; derivation of air constants; combined gas laws; Dalton's law of partial pressures; Carrier's equation; psychrometric property tables; psychrometric charts; air mixing equations; air quantity equations

Commercial refrigeration systems design.

Calculation of capacity in heat exchangers

Evaporators: commercial types and applications; coil bypass factor; effects of evaporator TD on space humidity; effects on air circulation on product conditions; selection criteria and selection tables

Condensers: commercial types and applications; effects of ambient conditions; condenser control; heat rejection factor; condenser TD; selection criteria and selection tables

Compressors: types and applications; capacity; power; effect of operating conditions; actual requirements; post defrost loads; pull down torque requirements, high, medium and low back pressure compressors; selection tables, motor selection

Liquid expansion devices: types, operation and applications; effects from subcooling; distributor types, operation and applications; selection tables

System load balance point

Line sizing and design: velocity tables; pressure drop in lines and fittings; oil migration stabilisation; refrigerant velocity; effect of varying system capacity; oil traps; risers; double risers; liquid migration; design for parallel components and multiplex systems

Automatic controls: refrigerant regulating valves; solenoid valves; expansion valves; condenser pressure regulating valves; evaporator pressure regulating valves; crankcase pressure regulating valves; cycling controls; pressure-stats; thermostats; defrost controls; monitoring and alarm controls; refrigeration automation systems; control strategies; control modes

Specialisation: Refrigeration systems

Industrial refrigeration systems design.

Standards and codes: AS1677, detailed understanding; AS3666, overview; ozone protection regulations

Operating characteristics: Ph charts; refrigerating effect, relate back to air and fluid coolers; heat of compression, relate back to screw, rotary and reciprocating compressors; heat rejected on high side of the system, relate back to air cooled, evaporative, and water cooled condensers; required mass flow rate of refrigerant and volume; flow rate at various points in system; theoretical compressor power; required condenser capacity

Major system components: refrigerants, including R717 and R22; secondary refrigerants; component lubricant refrigerant compatibility evaporators; condensers, cooling towers; compressors; expansion valves; interconnecting piping and isolating valves; pilot operated valves; defrost system components for air, water, recycled water, hot gas, electric, methods

Moderate and low temperature industrial refrigeration systems: direct – flooded and pumped liquid recirculation systems; evaporators; multistaged compression; direct staging; cascade staging; compound compressors; desuperheaters; liquid injection; direct expansion intercoolers; open and closed intercoolers; basic designs of accumulators/intercooler vessels; oil cooling methods; oil stabilisation – return and oil recovery in flooded systems

Multiple evaporators and multiple compressors: parallel evaporators; multiple temperature systems; evaporator pressure regulators; temperature control methods; parallel compressors; pipework layout; methods of establishing pressure drop in dry and wet suction lines

Indirect refrigeration systems: classification according to AS1677; applications; evaporators; heat exchangers – types, construction, selection; secondary refrigerants; brines; antifreeze solutions

Flooded systems: applications; equipment; accumulators; level controls; liquid recirculation pumps; liquid pressure relief valve

Cryogenic systems: applications and equipment; system components; refrigerants; design safety; economics

Basic control sequences: maintaining evaporator conditions; staging and suction pressure control; maintaining condenser conditions; control of intermediate pressure – methods of industrial refrigeration compressor capacity control

Noise and vibration control.

Fundamentals of sound: frequency; decibels; octave bands; direct sound; velocity; sound pressure level; sound power level; sound meters

Noise and people: physical measurement of sound; weighting networks; NR curves; noise damage to hearing; evaluate daily noise exposures; peak noise levels; attenuation of hearing protectors; excess noise levels permissible; Noise Abatement Act

Identify and analyse problems: one-dimensional sound waves; standing waves; energy in a sound wave; sources; effects of air turbulence; transmitters; amplifiers; absorptivity; reflectivity; room characteristics; acoustic design in buildings; fan and air noise transmission in ducts

Methods of control: natural attenuation; sound absorbing materials, placement; duct lining; lined plenums; lined duct splitters; duct attenuators; white noise; vibration isolators

Acoustic specifications: attenuator ratings

Energy Management systems for commercial refrigeration.

Functions of a commercial refrigeration E.M.S: general control function; inputs; outputs; communications; graphing; supervising; data logging; scheduling; alarms; power consumption

E.M.S control components: identify components, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensor; state the function and operating parameters of components - pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors

Installation requirements and consideration: installation of controller(s); installation of refrigerant leak detector systems; installation accessory boards; installation of pressure transducers and wiring; installation of temperature sensors and wiring; control wiring considerations

System design and applications: select control components to suit given applications – determine system operating parameters, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors, defrost, alarm panel

Programming a control system: display terminal and keypad functions; calibration of sensors; changing original settings; program a given set of parameters to suit an application

Component testing and fault-finding: trouble shooting; testing components

UTE NES605 (A to Z qualifier) A Co-ordinate & manage routine maintenance

Descriptor: Manage resources and information to achieve planned routine maintenance outcomes.

Alignment: Nil.

Specific unit outcomes

This is presented as a composite unit that has five specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES605A A	Co-ordinate & manage routine maintenance *(Computer systems)*
UTE NES605B A	Co-ordinate & manage routine maintenance *(Electrical)*
UTE NES605C A	Co-ordinate & manage routine maintenance *(Electronics)*
UTE NES605D A	Co-ordinate & manage routine maintenance *(Instrumentation)*
UTE NES605E A	Co-ordinate & manage routine maintenance *(Refrigeration & a/conditioning)*

Elements		Performance criteria	
605.1	Plan and prepare to manage routine maintenance	605.1.1	Management of routine maintenance *OH&S policies and procedures* is planned and prepared to ensure these are followed
		605.1.2	Routine maintenance schedules are managed in accordance with *requirements*
		605.1.3	*Appropriate personnel* are consulted to ensure routine maintenance is managed effectively
		605.1.4	Routine maintenance is managed against *requirements*
		605.1.5	Contribution is made to determine procurement management plan for routine maintenance in accordance with *established procedures* and checked against *requirements*

Elements		Performance criteria	
605.2	Manage routine maintenance	605.2.1	Mechanisms are used to measure, record and report progress of activities in relation to the agreed routine maintenance schedules and plans
		605.2.2	Routine maintenance is managed in accordance with *established procedures* and *requirements* to achieve designated objectives
		605.2.3	Records and documentation of routine maintenance activities are maintained in accordance with *established procedures* to facilitate quality management and to provide an audit trail
		605.2.4	Results of routine maintenance activities are documented and evaluated in accordance with *established procedures* to determine compliance with agreed quality standards
		605.2.5	Shortfalls in quality outcomes are reported in accordance with *established procedures* to enable appropriate action to be initiated
605.3	Inspect and notify completion of work	605.3.1	Quality management issues and responses are reported in accordance with *established procedures*
		605.3.2	Completion of routine maintenance is *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

(E) Refrigeration and air conditioning

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment,* tools, *accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Nil.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Data link operations.

Use of asynchronous data link hardware and software

Awareness of occupational health and safety for mains operated electronic equipment when installing hardware

Start/stop protocol options: data rate, number of data bits, number of stop bits, even/odd/no parity bit

Use of synchronous data link hardware and software

Recognition of format for OSI high level data link control (HDLC) and 802.2 logical link control (LLC) including data flow control: receiver ready (RR), receiver not ready (RNR), poll/final (P/F) bit, module counters

Recognition of format for link negotiation commands, link connection and disconnection commands, link layer control service access point (LSAP) and 802.1 defined addresses

OSI HDLC and 802.2 LLC protocol options: data rate, clock encoding, number of octets, half/duplex

Recognition of format for OSI HDLC and 802.2 LLC error procedures: frame reject (FRMR), frame discarding

Correlation of end user error messages with abnormal traffic

Computer networks.

Protocols and the OSI model: rationale for layered protocols; goals of layered protocols; network design problems; communication between layers; the layers

Terminal networks: terminal characteristics; character mode networks – terminal multiplexer; statistical multiplexer, terminal switching exchange; block-mode networks; multidrop lines, poll-select; terminal network protocols, binary synchronous control (BISYNC) formats, protocol operation, user interface, protocol performance; high-level data link control; frame formats, frame types

Delay analysis: introduction to queuing theory; the M/M/I queue in equilibrium; networks of M/M/I queues

Network layer: virtual circuits, datagram; routing algorithms; congestion; bridges, routers, brouters, gateways internetwork protocol, TCP, IPX, XNS

Local area networks: topologies; types of LAN's – ethernet, token ring, token bus, network installation, planning, performance outcomes

Operating system (multiuser).

Operating systems: history; functions of the system

Multiuser and multitasking operating systems: real time applications; interleaved processing techniques; multiprogramming; multitasking; time-sharing; virtual storage; multiprocessing

Language translators: compilers; interpreters; assemblers

File and disk organisation: files and directories; protection and permissions; listings; file location; classification

System command and calls: commonly used commands; retrieving; saving; deleting; copying; creating; printing; linking

Input/output redirection: meaning of; method of achievement

Batch, script or equivalent files: purpose; structure; commands

System utilities: sorting; windowing; device drivers

Computer systems architecture.

Historical milestones in computer architecture; Von Neumann architecture; non Von Neumann architecture; fetch decode execute cycle

Bus architectures: address, data and control; 8/16/32 wide busses; multiplexed and non multiplexed; Von Neumann bottleneck; synchronous, semi-synchronous and asynchronous data transfer; design considerations – reflections and termination, crosstalk, receivers, transceivers and hysteresis; drivers, open collector and tristate; single user and multiuser busses – IBM PC, VME, UNIBUS

System support: instruction pre-fetch pipeline, BIU, EU; DMA devices – cycle steal and burst modes; peripheral CHANNEL support; co-processors and bus interface; typical interrupt structures – intel, Motorola, PDP-II Zilog

CPU Architecture: registers, ALU and control unit; bit slice, Harvard, stack oriented CPUs; machine code and conventional machine; instruction set considerations; addressing modes – direct, indirect, indexed; the micromachine control unit and data pathways; hard wired and microcoded control unit; horizontal versus vertical microcode considerations; gate array, ASICS

Parallel processing: Flynns taxonomy – SISD, SIND, MISD AND MIMD; data pipeline, multiple functional units, interleaved memory, vector and array processors; parallel machines – transputer, hypercubes, connection machines, dataflow machines

Operating system considerations: multiprogramming systems, time-sharing; virtual memory – overlays, physical address space, virtual address space, paging, working set, thrashing, page replacement, segmentation

CACHE: memory, locality of reference principle, hit ratio; mapping techniques – associative, direct, set-associative; write-through, write-back

RISC Machines: RISC versus CISC; instruction set, register sets

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Category: Electrical (B)

Common

Applications of transducers.

Light and radioactivity detection: light sensors; units of light; light measurement terms; photoemissive light sensors; photoconductive light sensors; photovoltaic light sensors; x-ray sensors; nuclear radiation sensors; units of radiation measurement; units of radiation measurement; radiation sensors – photoelectric, ionisation

Temperature detection: temperature-sensing basics; units and terms used; bimetallic, fluid-pressure, resistive, semi-conductor, thermocouple, radiation pyrometer, oscillating-crystal

Fluid flow and pressure detection: fluid flow sensing; units of flow measurement, terminology; rate of flow sensors; quantity of flow sensors; fluid pressure sensing basics; units of pressure measurement; Bellows, Bourdon-tube, diaphragm, and capsule pressure sensors; pressure cell, differential-pressure sensors

Motion and force detection: motion and force sensing; sensors for linear motion; angular motion; speed of rotation; compression; tension, torque; acceleration, vibration; altitude

Moisture and humidity sensors: moisture and humidity measurements basics; moisture and humidity measurement units and terms; hygrometer-type sensors, resistive, dielectic-film, mechanical displacement, oscillating-crystal, aluminium-oxide; psychrometer-type sensors; dew point sensors, temperature-sensing, instant-of-condensation

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

Advanced PLCs.

Medium to high level PLC hardware and software: hardware configuration; addressing; memory map; programming instruction syntax; file manipulation; documentation; saving/restoring programs

Number systems and codes: common number formats (binary, octal, integer, hexadecimal); conversions between formats; codes (BCD, grey, ASCII)

Diagnostics: flags/status words (file); fault locations; scan considerations (fixed, variable, immediate update)

Data manipulation (word): binary word structure; single and double works; word devices; arithmetic instructions; word logical instructions; conversions (BCD to binary, binary to BCD); indirect addressing (image register to word, word to IR, word to word, word to table, table to table); word shift registers (LIFO, FIFO); masking; bit manipulation (bit set, bit clear, bit test); entering data constants; multiplexing

Analogue I/O: common signal types; module resolution; scaling; unscaling; signal offset

Sequencers/drum controllers

Specialisation: Power systems

Power systems analysis.

Impedance of three-phase load: complex analysis; measurement of impedance; conversion of impedance between star and delta

Analysis of mixed load three-phase circuits: star and delta systems; mixed single and three-phase loads; balanced and unbalanced loads; calculation of line and phase currents in both star and delta loads; total line current for mixed loads; power in three-phase systems, including the use of current transformers; power factor; prediction of current and voltage on the loss of the neutral

Measurement in three-phase circuits: measurement of voltage, current, power and power factor in mixed circuits; sources or error

Line voltage drops: cable losses; voltage drop; heat dissipation; Australian Standards and limitations of losses; methods to minimise line losses

Power factor (P.F.) correction: requirement; calculation of reactive element to correct P.F.; synchronous machines for correction of P.F.

Electrical distribution.

Distribution system: systems of distribution used – primary and secondary; voltage levels; supply quality; load curve profiles – residential, industrial, commercial; types of feeders; distribution systems – urban, rural single phase systems – SWER

Overhead lines and installation: industry and safety regulations; overhead conductors – conductor material, current rating factors – heating, voltage drops, power losses, aerial bundled cables – HV and LV, covered conductors; overhead lines poles – types – wood, concrete and steel, installation of poles – tooling, rake, life, labelling, sinking, maintenance of poles – above and below ground, pole strength and loads; crossarms – types and standard sizes; insulators – insulation types, types – pin, suspension or disc, shackle, creepage – necessary clearances, acring horns – insulator mounting; structure types – mechanical properties – working strength, maximum tension, limiting size; stringing charts (use of) – sag – calculations, measurement and tension measurement, sight and wave sagging, sag correction; stays – components, anchorage; use of design

schedules – design problems – examples of common design practice line, voltage, structure types used, line deviation, span sag, crossarms, insulators and stays wind loading and line deviation loading basic surveying, measurement of levels, deviation angle and compass bearings, perform survey of short distribution line extension of produce filed notes

Underground cables: cables types – ratings, core material, design considerations, cable dielectrics, insulating materials and abbreviations, electric stress, cable volt drop and volt drop calculations, cable termination, joints and installation; induction and eddy currents; cable testing - cable fault location; cable drawing

Voltage regulations of feeders and associated equipment: terminology used – distribution system, service line, customer's terminals, customer voltage, utilisation voltage, base voltage, voltage variation and bandwidth; voltage limits and effects for voltage variation; causes of variation – inductance, capacitance and reactance of distribution lines, transformers; methods of voltage control – off-load, on-load tap changers, voltage regulating relays, line drop compensation, different types of voltage regulators; voltage profiles – principles, effect on voltage profiles, limits of voltage, voltage drops due to LV mains transformers, tapsettings feeder and service lines

Specialisation: Control systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphics designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Transmitters and converters.

Pneumatics: principles of flapper nozzles, pneumatic transmitters

Supplementary pneumatic loop equipment: computing relays, lead/lag units, high and low selectors, air to current and high and low selectors, air to current and current to air converters, square root extractors, integrators, regulators, multipliers and dividers

Electronics: electronic transmitters, analogue computing, integrators, high and low signal selector, signal converters

Transducers I to P, P to I converters, analogue to digital and digital to analogue converters, RTD/I, mV/mA, frequency to I, square root extractors and integrators

Linear variable differential transformers

Intrinsic safety

Zener barriers

Explosion/flame proof enclosure

Specialisation: Drive systems

Variable speed drives.

Introduction to variable speed drives: advantages of variable speed drives – speed and direction control, acceleration control, torque control, energy savings; terminology used with variable speed drives – direction – forward and reverse, speed - $^{+}$ve and $^{-}$ve, torque - $^{+}$ve and $^{-}$ve, 4 quadrants of torque/speed operation, acceleration - $^{+}$ve and $^{-}$ve, load power – supply power, efficiency; power electronic converters – common electronic power control circuits for – AC/DC rectifier, un-controlled and controlled, DC/AC inverter, PWM and quasi-square wave AC/AC converters, rectifier linked to inverter and a matrix converter, DC/DC converters, PWM; input and output waveforms for power electronic converters – interference generated by circuits, electrical and audio; electromagnetic compatibility (EMC), introduction to harmonic distortion analysis using microprocessor based test equipment (not mathematical analysis), filtering techniques employed to optimise EMC switching frequency and effects on motor performance and EMC; control system for variable speed drives PWM (Pulse width modulated), VVVF drive (variable voltage variable frequency) – inverter control system, speed feedback and control system, current feedback and control system, external interface, selection of, and applications for PWM, VVVF drives; flux vector control drive – inverter control system, speed feedback and control system, current feedback and control system, select of, and applications for slip recovery drives; control system for soft starter – overview of operation of soft starter selection of, and application for soft starters; new development in AC variable speed drive technology – e.g. switched reluctance drive/motor

Protection of AC variable speed drives and motors: sources of failure – loss of cooling, overloading, frequent starting, supply problems, high ambient temperature; methods of protecting against sources of failure; protecting the frequency converter – current limit, over current trim; protecting the AC motor – motor thermal model

Commissioning: purpose; setting parameters; testing

Differentiation of common faults in systems: source of faults; methods to determine nature of fault; includes communications and external interface

Adjust settings: manufacturers specifications; load testing

Identify drive faults: source of faults; fault-finding methods

Selection, installation and fault-finding techniques: choosing size of frequency converter; motor loading and cooling; checking motor loading; over synchronous speed – advantages; mounting position and enclosures; supply and control cable selection and installation; environmental conditions; earthing

Category: Electronics (C)

Common

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Basic determinants and solution of 2/3 simultaneous linear equ by determinants exponents and logs

Time dependent trig functions - $\sin(\omega t+\theta)$

Trig of oblique triangles

Introduction to vectors

Complex numbers

Circuit analysis.

Phasors: time domain; frequency domain; frequency, angular frequency and units of measurement

Complex impedance: impedance diagram; resistance; reactance; admittance; conductance; susceptance; equivalent series circuit; equivalent parallel circuit

AC series/parallel circuits: Kirchhoff's laws; series equivalent impedance; parallel equivalent impedance; voltage divider rule; current divider rule; phasor diagrams

Complex power: true power; reactive power and apparent power; units of measurement – watt, volt-amp; reactive, volt amp; power triangle; power factor

Superposition theorem: power considerations

Thevenin and Norton theorems: voltage source models; current source models; practical sources; open circuit voltage; equivalent impedance; short circuit current; source conversion

Star/delta conversions: equivalent circuits; star/delta transformation formulae; selection of appropriate conversion

Specialisation: Communications

Communication fundamentals.

Basic communication system: radio wave as a T.E.M. wave; radio wave frequency band identification; relationship between frequency – wavelength and velocity of propagation for radio wave

Transmission media: metal cable; waveguide; optical fibre; radio wave paths

Noise: definition; categories; effect on communication systems; communication signals in both the time and frequency domain; fourier analysis of periodic complex waveforms; baseband signals; modulation signals

Modulation techniques: AM full carrier; double sideband; single sideband; vestigial sideband; frequency modulation; phase modulation

Demodulation techniques: AM full carrier; single sideband; frequency modulation; frequency division multiplexing (FDM) F.D.M hierarchy; F.D.M in stereo FM; time division multiplexing (TDM); TDM hierarchy; basic crystal set receiver; TRF receiver

Superheterodyne receiver: block diagram; advantages

Transmitters: AM full carrier; single sideband; FM; digital signals; sampled analogue signals; sampling theorem; pulse code modulation (PCM) – quantisation, quantisation noise, compounding, encoding; digital signal transmission compared to analogue signal transmission; noise in communication systems; signal-to-noise ratio; noise figure; noise factor; noise temperature signal-to-noise bit error rate in digital

Receiver and transmitter circuits.

Receiver block diagrams: principles of dual conversion; DSBFC dual conversion receiver

RF amplifiers: intermodulation; cross modulation; RF amplifier performance

Intermediate frequency (IF) amplifiers: IF amplifier alignment; neutralisation; IF amplifier performance

Demodulation: SSBSC

AGC systems: SSBSC receivers

Phase locked loops (PLL): PLL noise; frequency synthesis using PLLs

Receiver performance criteria: sensitivity test - FM quieting, S/N ratio, SINAD measurements; spurious signal responses; receiver noise figure

NBFM transmitters: operation; tuning and adjustment; testing

Digital transmitters

Specialisation: Analogue and digital

Microprocessor system assembly language programming.

Operation of a microprocessor based computer system: ROM, RAM, IO and major system components

CPU architecture: registers; instruction set considerations – common and advanced instructions; addressing modes supported – direct, indirect, indexed; software interrupts and system calls

Processor and system support: instruction pre-fetch pipeline; system timer chip – function and programming; hardware interrupt programming considerations; DMA devices and support; co-processors and bus interface

Modular programming: separately compiled and linked assembly language modules; library modules; macros

Documentation and debugging: system specification and documentation; debugging and tracing program execution

Electronic instruments.

Loading and matching; connectors; decibels; storage and delay CROs; frequency synthesisers; frequency counters; spectrum analysers; noise and distortion meters; RF communications service monitor

Category: Instrumentation (D)

Common

Control programming style.

Control applications of software; software terminology; relevant programming languages currently available; flowcharts; pseudocode; nassi sniedeman charts; developing algorithms; programming style; programming structure; documentation

Installing a language compiler; using a text editor; compiling source code; generating executable files

Scalar and structured data types; constants and variables; reading from keyboard and writing to screen; arithmetic, relational and logical operations; making decisions using if/then, if/then/else, nested if/then and case; looping operations using while/go, repeat/until and for/do; subprograms; functions; procedures

Installation of computer interface circuit boards; programming to access external devices via I/O boards

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Control electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

On-stream analysis.

On-stream analysis: chromatography; spectroscopic methods; electrical methods; sampling systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphics designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Final control elements.

Control valve selection and sizing

Pneumatic controllers and positioners

Pumps and blowers

Variable speed drives

Dampers

Category: Refrigeration and air conditioning (E)

Common

Commissioning - HVAC systems.

General requirements: building codes; local government regulations; human comfort – comfort chart; reporting procedures; pre-commissioning checks

Air systems: air tab instruments (air flow, pressure, temperature); fan testing; air balancing procedures; leakage testing; system capacity calculations

Hydronic systems: hydronic tab instruments (fluid flow, pressure, temperature); pumps; pumps, curves and system curves; pump testing; hydronic (balancing procedures, general, compensation method); balancing valves; capacity calculations

Plant and equipment: controls; heat exchangers; chillers; boilers; cooling towers

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Specialisation: Control systems

Advanced HVAC control systems

Control diagrams: electric/electronic control diagrams; electrical installation documents; pneumatic diagrams; DDC diagrams; controls/electrical power circuit interface; nomographs

Evaluate existing automatic control systems: specifications; briefs; descriptions of operation

Control requirements: standard and statutory requirements; economy of operation (energy management)

Building management systems.

Functions of a BMS: autonomous functions; input; output; general I/O; installation management items; energy management; risk management; information processing; objective; building running costs

BMS hardware: system architecture; communication devices; substations; PCs

Input and output functions: digital – input, outputs; digital output with status feedback; analogue input, output; sensors; alarms

Energy management: night cycle; optimum stop, start; time and event programs; night purge; outside air percentage control; enthalpy control; power demand control; duty cycle; presence detection; lighting control

Information processing functions: computer systems; central system management; programs; system configuration and security; operator – machine interface; data points

Risk and maintenance management: system files; fire – intruder control; access control

Energy management.

Energy sources and characteristics: supply authorities; standard units of measurement; electricity; steam; hot water; high temperature hot water; town gas; LP gas; solar; waste heat; petrochemical

Energy requirements: office lighting; air conditioning systems; refrigeration systems; security systems; computer systems; waste disposal systems; standby/emergency systems

Energy auditing process: energy costs and tariffs; energy consumption; predicting future costs; plotting consumption trends; historical data; collecting information using surveys; comparisons of actual to recorded usage; energy balance; instrumentation; estimating savings potential

System operation for energy efficiency: types of systems; efficiency in building structures; operation of a vehicle fleet; proportioning total energy consumption against individual systems; passive building design; preventative maintenance procedures; monitoring building management systems; operation of major and minor plant; inappropriate energy management procedures; building plant control systems

Implementing energy management procedures for a building: recording base year data; climatic conditions for locality; establishing energy costs and tariffs; building and systems surveys; pay back period; survey analysis; energy conservation procedures; implementation issues; monitoring

Methods of energy conservation: time schedules; lighting control

Maintenance practices: filters, fans, appropriate setpoints, dead bands, etc

HVAC system control: night cycle; optimum stop/start; purge cycles; chiller/boiler/cooling tower sequencing; economy cycles (based on temperature or enthalpy); supply air reset; supply water reset; condenser water temperature reset

Electrical load control: power demand control; load limiting; load shedding; set point relaxation; ventilation cycles

Tests and data collection procedures: use of BMS for data collection (trending); use of data recorders (loggers); monitoring building operations generally

Analyse results from test data: compare against standards (BOMA); review current practices against ideal; total consumption Vs peak load; electricity tariffs and implications

Methods of reducing energy usage: plant retrofits; controls; plant – fixed OA to economy boiler to electric reheat, constant volume to VAV; cost/benefit (payback)

Specialisation: HVAC systems

Commercial air conditioning system design.

Design parameters for commercial (single zone) air conditioning applications: e.g. offices, restaurants, hotels, bars; customer and objective; customer concept of environment desired; economics; client brief

Relevant design criteria: building purpose, location, orientation and shape; external environment ambient conditions; internal load diversity; thermal capacity behaviours; thermal load (full and partial)

Zoning and building usage: space and building; occupancies, single purpose, multi-purpose

System selection criteria: economics; environment; control requirements; existing structures; new structures; system components; space for equipment and system; selection of appropriate system, ductwork and components

Systems and applications: design features, engineering, controls and selection procedures for fan direct expansion RAC's, coil units, heat pump, package units, free blow and ducted

HVAC energy conversation techniques: heat recovery systems; night cycle; optimum stop/start; purge cycles; load limiting; load shedding; cost/benefit (payback)

HVAC load estimating.

Building survey: space characteristics; location of equipment; design conditions – outdoor, inside (type of installation); storage of heat in building structures; solar heat – direct and diffuse, glass types and factors, shading devices; film coefficients; heat and water vapour through structures – transmission coefficient; heat and water vapour through structures – transmission coefficient; infiltration; ventilation; internal heat gains; system heat gains

Computer programs: ACAOS; TRANE; CARRIER

Psychrometrics – advanced.

Complex psychrometric processes: sensible cooling and heating and evaporative (adiabatic) cooling; cooling and dehumidfication; cooling and dehumidification with high latent load; cooling and dehumidification out door air; cooling and dehumidification all out door with dehumidified air requirements less than supply air; cooling with evaporative humidification; cooling with near isothermal humidification; spray processes to include cooling

and dehumidification with heated spray water – heating and humidification; partial load processes – reheat, by-pass of RA only and, mix of RA and OA; variable air volume; variable coil effective surface temperature; split coil - horizontal, vertical and intertwined

System performance: saturation efficiency of sprayers; system capacity calculated from air quantity and enthalpy change

Required plant capacity and airflow rates: effects of coil by-pass factor and ADP; calculation of dehumidified air quantity – using both TSH and ERSH methods

Psychrometric formulae and charts: properties of air; gas constants; derivation of air constants; combined gas laws; Dalton's law of partial pressures; Carrier's equation; psychrometric property tables; psychrometric charts; air mixing equations; air quantity equations

Commercial refrigeration systems design.

Calculation of capacity in heat exchangers

Evaporators: commercial types and applications; coil bypass factor; effects of evaporator TD on space humidity; effects on air circulation on product conditions; selection criteria and selection tables

Condensers: commercial types and applications; effects of ambient conditions; condenser control; heat rejection factor; condenser TD; selection criteria and selection tables

Compressors: types and applications; capacity; power; effect of operating conditions; actual requirements; post defrost loads; pull down torque requirements, high, medium and low back pressure compressors; selection tables, motor selection

Liquid expansion devices: types, operation and applications; effects from subcooling; distributor types, operation and applications; selection tables

System load balance point

Line sizing and design: velocity tables; pressure drop in lines and fittings; oil migration stabilisation; refrigerant velocity; effect of varying system capacity; oil traps; risers; double risers; liquid migration; design for parallel components and multiplex systems

Automatic controls: refrigerant regulating valves; solenoid valves; expansion valves; condenser pressure regulating valves; evaporator pressure regulating valves; crankcase pressure regulating valves; cycling controls; pressure-stats; thermostats; defrost controls; monitoring and alarm controls; refrigeration automation systems; control strategies; control modes

Specialisation: Refrigeration systems

Industrial refrigeration systems design.

Standards and codes: AS1677, detailed understanding; AS3666, overview; ozone protection regulations

Operating characteristics: Ph charts; refrigerating effect, relate back to air and fluid coolers; heat of compression, relate back to screw, rotary and reciprocating compressors; heat rejected on high side of the system, relate back to air cooled, evaporative, and water cooled condensers; required mass flow rate of refrigerant and volume; flow rate at various points in system; theoretical compressor power; required condenser capacity

Major system components: refrigerants, including R717 and R22; secondary refrigerants; component lubricant refrigerant compatibility evaporators; condensers, cooling towers; compressors; expansion valves; interconnecting piping and isolating valves; pilot operated valves; defrost system components for air, water, recycled water, hot gas, electric, methods

Moderate and low temperature industrial refrigeration systems: direct – flooded and pumped liquid recirculation systems; evaporators; multistaged compression; direct staging; cascade staging; compound compressors; desuperheaters; liquid injection; direct expansion intercoolers; open and closed intercoolers; basic designs of accumulators/intercooler vessels; oil cooling methods; oil stabilisation – return and oil recovery in flooded systems

Multiple evaporators and multiple compressors: parallel evaporators; multiple temperature systems; evaporator pressure regulators; temperature control methods; parallel compressors; pipework layout; methods of establishing pressure drop in dry and wet suction lines

Indirect refrigeration systems: classification according to AS1677; applications; evaporators; heat exchangers – types, construction, selection; secondary refrigerants; brines; antifreeze solutions

Flooded systems: applications; equipment; accumulators; level controls; liquid recirculation pumps; liquid pressure relief valve

Cryogenic systems: applications and equipment; system components; refrigerants; design safety; economics

Basic control sequences: maintaining evaporator conditions; staging and suction pressure control; maintaining condenser conditions; control of intermediate pressure – methods of industrial refrigeration compressor capacity control

Noise and vibration control.

Fundamentals of sound: frequency; decibels; octave bands; direct sound; velocity; sound pressure level; sound power level; sound meters

Noise and people: physical measurement of sound; weighting networks; NR curves; noise damage to hearing; evaluate daily noise exposures; peak noise levels; attenuation of hearing protectors; excess noise levels permissible; Noise Abatement Act

Identify and analyse problems: one-dimensional sound waves; standing waves; energy in a sound wave; sources; effects of air turbulence; transmitters; amplifiers; absorptivity; reflectivity; room characteristics; acoustic design in buildings; fan and air noise transmission in ducts

Methods of control: natural attenuation; sound absorbing materials, placement; duct lining; lined plenums; lined duct splitters; duct attenuators; white noise; vibration isolators

Acoustic specifications: attenuator ratings

Energy management systems for commercial refrigeration.

Functions of a commercial refrigeration E.M.S: general control function; inputs; outputs; communications; graphing; supervising; data logging; scheduling; alarms; power consumption

E.M.S control components: identify components, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensor; state the function and operating parameters of components – pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors

Installation requirements and consideration: installation of controller(s); installation of refrigerant leak detector systems; installation accessory boards; installation of pressure transducers and wiring; installation of temperature sensors and wiring; control wiring considerations

System design and applications: select control components to suit given applications – determine system operating parameters, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors, defrost, alarm panel

Programming a control system: display terminal and keypad functions; calibration of sensors; changing original settings; program a given set of parameters to suit an application

Component testing and fault-finding: trouble shooting; testing components

UTE NES606 (A to Z qualifier) A Co-ordinate & manage installation projects

Descriptor: Manage resources and information; participate in planning and monitoring quality; develop and maintain a safe and equitable work environment to achieve planned project outcomes.

Alignment: Nil.

Specific unit outcomes

This is presented as a composite unit that has five specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES606A A	Co-ordinate & manage installation projects *(Computer systems)*
UTE NES606B A	Co-ordinate & manage installation projects *(Electrical)*
UTE NES606C A	Co-ordinate & manage installation projects *(Electronics)*
UTE NES606D A	Co-ordinate & manage installation projects *(Instrumentation)*
UTE NES606E A	Co-ordinate & manage installation projects *(Refrigeration & a/conditioning)*

Elements		Performance criteria	
606.1	Plan and prepare to manage projects	606.1.1	Management of projects' *OH&S policies and procedures* are planned and prepared to ensure these are followed
		606.1.2	Project schedules are managed in accordance with *requirements*
		606.1.3	*Appropriate personnel* are consulted to ensure projects are managed effectively
		606.1.4	Projects are managed against *requirements*
		606.1.5	Contribution is made to determine human resource and procurement management plans for projects in accordance with *established procedures* and checked against *requirements*

Elements		Performance criteria	
606.2	Manage projects	606.2.1	Mechanisms are used to measure, record and report progress of activities in relation to the agreed project schedules and plans
		606.2.2	Projects are managed in accordance with *established procedures* and *requirements* to achieve designated objectives
		606.2.3	Records and documentation of project activities are maintained in accordance with *established procedures* to facilitate quality management and to provide an audit trail
		606.2.4	Results of project activities are documented and evaluated in accordance with *established procedures* to determine compliance with agreed quality standards
		606.2.5	Shortfalls in quality outcomes are reported in accordance with *established procedures* to enable appropriate action to be initiated
606.3	Inspect and notify completion of work	606.3.1	Quality management issues and responses are reported in accordance with *established procedures*
		606.3.2	Completion of projects are *notified* in accordance with *established procedures*

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(A) Computer systems

(B) Electrical

(C) Electronics

(D) Instrumentation

(E) Refrigeration and air conditioning

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit in the related *category* and *specialisation* which is to be exhibited across a *representative range* of applications; autonomously and to *requirements*.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace for each of the *categories* and areas of *specialisation* undertaken from those listed in the Range statement or Evidence guide.
- demonstrating an understanding of the underpinning knowledge and skills identified for the *categories* and related *specialisation* undertaken in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of applications which includes such things as *apparatus, circuits, wiring systems, plant, equipment,* tools, *accessories, components* and the like relative to that required for the *category* undertaken within and relevant to this unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Nil.

Underpinning knowledge

This section specifies the knowledge and skills required to underpin the elements and performance criteria relevant to the unit. This, with other aspects of evidence, will ensure that an individual is able to transfer and apply such knowledge and skills to new situations and environments.

This section includes that set of knowledge and skills additional to that specified in the above mentioned section titled 'Interdependent assessment of units'.

Since this unit covers a range of *categories* each having multiple *specialisations* a content listing is provided below. Each *category* has all of the required underpinning knowledge and skill listed even though this sometimes results in duplication between *categories*.

Category: Computer systems (A)

Common

Data link operations.

Use of asynchronous data link hardware and software

Awareness of occupational health and safety for mains operated electronic equipment when installing hardware

Start/stop protocol options: data rate, number of data bits, number of stop bits, even/odd/no parity bit

Use of synchronous data link hardware and software

Recognition of format for OSI high level data link control (HDLC) and 802.2 logical link control (LLC) including data flow control: receiver ready (RR), receiver not ready (RNR), poll/final (P/F) bit, module counters

Recognition of format for link negotiation commands, link connection and disconnection commands, link layer control service access point (LSAP) and 802.1 defined addresses

OSI HDLC and 802.2 LLC protocol options: data rate, clock encoding, number of octets, half/duplex

Recognition of format for OSI HDLC and 802.2 LLC error procedures: frame reject (FRMR), frame discarding

Correlation of end user error messages with abnormal traffic

Computer networks.

Protocols and the OSI model: rationale for layered protocols; goals of layered protocols; network design problems; communication between layers; the layers

Terminal networks: terminal characteristics; character mode networks – terminal multiplexer; statistical multiplexer, terminal switching exchange; block-mode networks; multidrop lines, poll-select; terminal network protocols, binary synchronous control (BISYNC) formats, protocol operation, user interface, protocol performance; high-level data link control; frame formats, frame types

Delay analysis: introduction to queuing theory; the M/M/I queue in equilibrium; networks of M/M/I queues

Network layer: virtual circuits, datagram; routing algorithms; congestion; bridges, routers, brouters, gateways internetwork protocol, TCP, IPX, XNS

Local area networks: topologies; types of LAN's – ethernet, token ring, token bus, network installation, planning, performance outcomes

Operating system (multiuser).

Operating systems: history; functions of the system

Multiuser and multitasking operating systems: real time applications; interleaved processing techniques; multiprogramming; multitasking; time-sharing; virtual storage; multiprocessing

Language translators: compilers; interpreters; assemblers

File and disk organisation: files and directories; protection and permissions; listings; file location; classification

System command and calls: commonly used commands; retrieving; saving; deleting; copying; creating; printing; linking

Input/output redirection: meaning of; method of achievement

Batch, script or equivalent files: purpose; structure; commands

System utilities: sorting; windowing; device drivers

Computer systems architecture.

Historical milestones in computer architecture; Von Neumann architecture; non Von Neumann architectures; fetch decode execute cycle

Bus architectures: address, data and control; 8/16/32 wide busses; multiplexed and non multiplexed; Von Neumann bottleneck; synchronous, semi-synchronous and asynchronous data transfer; design considerations – reflections and termination, crosstalk, receivers, transceivers and hysteresis; drivers, open collector and tristate; single user and multiuser busses – IBM PC, VME, UNIBUS

System support: instruction pre-fetch pipeline, BIU, EU; DMA devices – cycle steal and burst modes; peripheral CHANNEL support; co-processors and bus interface; typical interrupt structures – intel, Motorola, PDP-II Zilog

CPU Architecture: registers, ALU and control unit; bit slice, Harvard, stack oriented CPUs; machine code and conventional machine; instruction set considerations; addressing modes – direct, indirect, indexed; the micromachine control unit and data pathways; hard wired and microcoded control unit; horizontal versus vertical microcode considerations; gate array, ASICS

Parallel processing: Flynns taxonomy – SISD, SIND, MISD AND MIMD; data pipeline, multiple functional units, interleaved memory, vector and array processors; parallel machines – transputer, hypercubes, connection machines, dataflow machines

Operating system considerations: multiprogramming systems, time-sharing; virtual memory – overlays, physical address space, virtual address space, paging, working set, thrashing, page replacement, segmentation

CACHE: memory, locality of reference principle, hit ratio; mapping techniques – associative, direct, set-associative; write-through, write-back

RISC Machines: RISC versus CISC; instruction set, register sets

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Category: Electrical (B)

Common

Applications of transducers.

Light and radioactivity detection: light sensors; units of light; light measurement terms; photoemissive light sensors; photoconductive light sensors; photovoltaic light sensors; x-ray sensors; nuclear radiation sensors; units of radiation measurement; units of radiation measurement; radiation sensors – photoelectric, ionisation

Temperature detection: temperature-sensing basics; units and terms used; bimetallic, fluid-pressure, resistive, semi-conductor, thermocouple, radiation pyrometer, oscillating-crystal

Fluid flow and pressure detection: fluid flow sensing; units of flow measurement, terminology; rate of flow sensors; quantity of flow sensors; fluid pressure sensing basics; units of pressure measurement; Bellows, Bourdon-tube, diaphragm, and capsule pressure sensors; pressure cell, differential-pressure sensors

Motion and force detection: motion and force sensing; sensors for linear motion; angular motion; speed of rotation; compression; tension, torque; acceleration, vibration; altitude

Moisture and humidity sensors: moisture and humidity measurements basics; moisture and humidity measurement units and terms; hygrometer-type sensors, resistive, dielectic-film, mechanical displacement, oscillating-crystal, aluminium-oxide; psychrometer-type sensors; dew point sensors, temperature-sensing, instant-of-condensation

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

Advanced PLCs.

Medium to high level PLC hardware and software: hardware configuration; addressing; memory map; programming instruction syntax; file manipulation; documentation; saving/restoring programs

Number systems and codes: common number formats (binary, octal, integer, hexadecimal); conversions between formats; codes (BCD, grey, ASCII)

Diagnostics: flags/status words (file); fault locations; scan considerations (fixed, variable, immediate update)

Data manipulation (word): binary word structure; single and double works; word devices; arithmetic instructions; word logical instructions; conversions (BCD to binary, binary to BCD); indirect addressing (image register to word, word to IR, word to word, word to table, table to table); word shift registers (LIFO, FIFO); masking; bit manipulation (bit set, bit clear, bit test); entering data constants; multiplexing

Analogue I/O: common signal types; module resolution; scaling; unscaling; signal offset

Sequencers/drum controllers

Specialisation: Power systems

Power systems analysis.

Impedance of three-phase load: complex analysis; measurement of impedance; conversion of impedance between star and delta

Analysis of mixed load three-phase circuits: star and delta systems; mixed single and three-phase loads; balanced and unbalanced loads; calculation of line and phase currents in both star and delta loads; total line current for mixed loads; power in three-phase systems, including the use of current transformers; power factor; prediction of current and voltage on the loss of the neutral

Measurement in three-phase circuits: measurement of voltage, current, power and power factor in mixed circuits; sources or error

Line voltage drops: cable losses; voltage drop; heat dissipation; Australian Standards and limitations of losses; methods to minimise line losses

Power factor (P.F.) correction: requirement; calculation of reactive element to correct P.F.; synchronous machines for correction of P.F.

Electrical distribution.

Distribution system: systems of distribution used – primary and secondary; voltage levels; supply quality; load curve profiles – residential, industrial, commercial; types of feeders; distribution systems – urban, rural single phase systems – SWER

Overhead lines and installation: industry and safety regulations; overhead conductors – conductor material, current rating factors – heating, voltage drops, power losses, aerial bundled cables – HV and LV, covered conductors; overhead lines poles – types – wood, concrete and steel, installation of poles – tooling, rake, life, labelling, sinking, maintenance of poles – above and below ground, pole strength and loads; crossarms – types and standard sizes; insulators – insulation types, types – pin, suspension or disc, shackle, creepage – necessary clearances, acring horns – insulator mounting; structure types – mechanical properties – working strength, maximum tension, limiting size; stringing charts (use of) – sag – calculations, measurement and tension measurement, sight and wave sagging, sag correction; stays – components, anchorage; use of design

schedules – design problems – examples of common design practice line, voltage, structure types used, line deviation, span sag, crossarms, insulators and stays wind loading and line deviation loading basic surveying, measurement of levels, deviation angle and compass bearings, perform survey of short distribution line extension of produce filed notes

Underground cables: cables types – ratings, core material, design considerations, cable dielectrics, insulating materials and abbreviations, electric stress, cable volt drop and volt drop calculations, cable termination, joints and installation; induction and eddy currents; cable testing - cable fault location; cable drawing

Voltage regulations of feeders and associated equipment: terminology used – distribution system, service line, customer's terminals, customer voltage, utilisation voltage, base voltage, voltage variation and bandwidth; voltage limits and effects for voltage variation; causes of variation – inductance, capacitance and reactance of distribution lines, transformers; methods of voltage control – off-load, on-load tap changers, voltage regulating relays, line drop compensation, different types of voltage regulators; voltage profiles – principles, effect on voltage profiles, limits of voltage, voltage drops due to LV mains transformers, tapsettings feeder and service lines

Specialisation: Control systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphics designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Transmitters and converters.

Pneumatics: principles of flapper nozzles, pneumatic transmitters

Supplementary pneumatic loop equipment: computing relays, lead/lag units, high and low selectors, air to current and high and low selectors, air to current and current to air converters, square root extractors, integrators, regulators, multipliers and dividers

Electronics: electronic transmitters, analogue computing, integrators, high and low signal selector, signal converters

Transducers I to P, P to I converters, analogue to digital and digital to analogue converters, RTD/I, mV/mA, frequency to I, square root extractors and integrators

Linear variable differential transformers

Intrinsic safety

Zener barriers

Explosion/flame proof enclosure

Specialisation: Drive systems

Variable speed drives.

Introduction to variable speed drives: advantages of variable speed drives – speed and direction control, acceleration control, torque control, energy savings; terminology used with variable speed drives – direction – forward and reverse, speed - $^{+}$ve and $^{-}$ve, torque - $^{+}$ve and $^{-}$ve, 4 quadrants of torque/speed operation, acceleration - $^{+}$ve and $^{-}$ve, load power – supply power, efficiency; power electronic converters – common electronic power control circuits for – AC/DC rectifier, un-controlled and controlled, DC/AC inverter, PWM and quasi-square wave AC/AC converters, rectifier linked to inverter and a matrix converter, DC/DC converters, PWM; input and output waveforms for power electronic converters – interference generated by circuits, electrical and audio; electromagnetic compatibility (EMC), introduction to harmonic distortion analysis using microprocessor based test equipment (not mathematical analysis), filtering techniques employed to optimise EMC switching frequency and effects on motor performance and EMC; control system for variable speed drives PWM (Pulse width modulated), VVVF drive (variable voltage variable frequency) – inverter control system, speed feedback and control system, current feedback and control system, external interface, selection of, and applications for PWM, VVVF drives; flux vector control drive – inverter control system, speed feedback and control system, current feedback and control system, select of, and applications for slip recovery drives; control system for soft starter – overview of operation of soft starter selection of, and application for soft starters; new development in AC variable speed drive technology – e.g. switched reluctance drive/motor

Protection of AC variable speed drives and motors: sources of failure – loss of cooling, overloading, frequent starting, supply problems, high ambient temperature; methods of protecting against sources of failure; protecting the frequency converter – current limit, over current trim; protecting the AC motor – motor thermal model

Commissioning: purpose; setting parameters; testing

Differentiation of common faults in systems: source of faults; methods to determine nature of fault; includes communications and external interface

Adjust settings: manufacturers specifications; load testing

Identify drive faults: source of faults; fault-finding methods

Selection, installation and fault-finding techniques: choosing size of frequency converter; motor loading and cooling; checking motor loading; over synchronous speed – advantages; mounting position and enclosures; supply and control cable selection and installation; environmental conditions; earthing

Category: Electronics (C)

Common

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Engineering mathematics.

Matrices: the operations – addition (subtraction), scalar multiplication, matrix multiplication up to 3x3 matrices; identity matrix, inverse matrix; elementary algebraic manipulation of matrices; solving linear equations using inverse matrices and determinants

Quadratic functions: graphs of quadratic functions represented by parabolas and significance of the leading coefficient; zeros represented graphically; solve quadratic equations by factoring and quadratic formula; solve simultaneously linear and quadratic equations algebraically and geometrically

Exponential and logarithmic functions: laws of indices; graph of $f(x) = ka^{bx}$, emphasising a = 10, e; definition of the logarithm to any base; graph of $f(x) = k \log_a bx$, emphasising a = 10, e; solve exponential and simple log equations using indices, logs, calculator, graphically; change of log base, emphasising 10 and e; growth and decay

Trigonometric functions: the ratios – sin, cos, tan, cosec, sec, cot; degrees, radians; graphs of k f(ax + b) where f(x) = sin x, cos x, tan x, and significance of k, a, b; trigonometric identities; solving trigonometric equations

Basic determinants and solution of 2/3 simultaneous linear equ by determinants exponents and logs

Time dependent trig functions - $\sin(\omega t+\theta)$

Trig of oblique triangles

Introduction to vectors

Complex numbers

Circuit analysis.

Phasors: time domain; frequency domain; frequency, angular frequency and units of measurement

Complex impedance: impedance diagram; resistance; reactance; admittance; conductance; susceptance; equivalent series circuit; equivalent parallel circuit

AC series/parallel circuits: Kirchhoff's laws; series equivalent impedance; parallel equivalent impedance; voltage divider rule; current divider rule; phasor diagrams

Complex power: true power; reactive power and apparent power; units of measurement – watt, volt-amp; reactive, volt amp; power triangle; power factor

Superposition theorem: power considerations

Thevenin and Norton theorems: voltage source models; current source models; practical sources; open circuit voltage; equivalent impedance; short circuit current; source conversion

Star/delta conversions: equivalent circuits; star/delta transformation formulae; selection of appropriate conversion

Specialisation: Communications

Communication fundamentals.

Basic communication system: radio wave as a T.E.M. wave; radio wave frequency band identification; relationship between frequency – wavelength and velocity of propagation for radio wave

Transmission media: metal cable; waveguide; optical fibre; radio wave paths

Noise: definition; categories; effect on communication systems; communication signals in both the time and frequency domain; fourier analysis of periodic complex waveforms; baseband signals; modulation signals

Modulation techniques: AM full carrier; double sideband; single sideband; vestigial sideband; frequency modulation; phase modulation

Demodulation techniques: AM full carrier; single sideband; frequency modulation; frequency division multiplexing (FDM) F.D.M hierarchy; F.D.M in stereo FM; time division multiplexing (TDM); TDM hierarchy; basic crystal set receiver; TRF receiver

Superheterodyne receiver: block diagram; advantages

Transmitters: AM full carrier; single sideband; FM; digital signals; sampled analogue signals; sampling theorem; pulse code modulation (PCM) – quantisation, quantisation noise, compounding, encoding; digital signal transmission compared to analogue signal transmission; noise in communication systems; signal-to-noise ratio; noise figure; noise factor; noise temperature signal-to-noise bit error rate in digital

Receiver and transmitter circuits.

Receiver block diagrams: principles of dual conversion; DSBFC dual conversion receiver

RF amplifiers: intermodulation; cross modulation; RF amplifier performance

Intermediate frequency (IF) amplifiers: IF amplifier alignment; neutralisation; IF amplifier performance

Demodulation: SSBSC

AGC systems: SSBSC receivers

Phase locked loops (PLL): PLL noise; frequency synthesis using PLLs

Receiver performance criteria: sensitivity test - FM quieting, S/N ratio, SINAD measurements; spurious signal responses; receiver noise figure

NBFM transmitters: operation; tuning and adjustment; testing

Digital transmitters

Specialisation: Analogue and digital

Microprocessor system assembly language programming.

Operation of a microprocessor based computer system: ROM, RAM, IO and major system components

CPU architecture: registers; instruction set considerations – common and advanced instructions; addressing modes supported – direct, indirect, indexed; software interrupts and system calls

Processor and system support: instruction pre-fetch pipeline; system timer chip – function and programming; hardware interrupt programming considerations; DMA devices and support; co-processors and bus interface

Modular programming: separately compiled and linked assembly language modules; library modules; macros

Documentation and debugging: system specification and documentation; debugging and tracing program execution

Electronic instruments.

Loading and matching; connectors; decibels; storage and delay CROs; frequency synthesisers; frequency counters; spectrum analysers; noise and distortion meters; RF communications service monitor

Category: Instrumentation (D)

Common

Control programming style.

Control applications of software; software terminology; relevant programming languages currently available; flowcharts; pseudocode; nassi sniedeman charts; developing algorithms; programming style; programming structure; documentation

Installing a language compiler; using a text editor; compiling source code; generating executable files

Scalar and structured data types; constants and variables; reading from keyboard and writing to screen; arithmetic, relational and logical operations; making decisions using if/then, if/then/else, nested if/then and case; looping operations using while/go, repeat/until and for/do; subprograms; functions; procedures

Installation of computer interface circuit boards; programming to access external devices via I/O boards

Electrical control 'C' programming.

'C' language: uses; advantages and disadvantages

'C' development package: editor commands; the edit-compile-run cycle; compiler and linker options; header files

Language syntax: data types; arithmetic and logical operations; program structure

Control structure: sequential; repetition; selection

Functions: macros; global and local variables; intrinsic functions used in control; writing functions, linking in external functions to control hardware; numerical and character arrays; sequential file reading and writing

Control electrical calculations.

Algebra, exponentials and logarithms; solution of equations; functions and graphing; vectors and complex numbers; Boolean algebra; impedance calculations; elementary circuit analysis

On-stream analysis.

On-stream analysis: chromatography; spectroscopic methods; electrical methods; sampling systems

SCADA systems.

System requirements

Use, features and facilities of different SCADA packages

Hardware requirements

PLC interface requirements

Networking requirements of the system

Mimics and animated graphics: graphics designs; balance of layout

Trending: analysis of process to select data; sampling of the process in terms of temperatures, time, weight; viewing data and graphical representation of selected information; trend graphs and data matching

Alarm logging: analysing select data, applying limits and specification applied to processes; corrective action of alarm status

Recipes and scheduling: methods of producing libraries for different process conditions, required for varied production runs; analysis of different production runs; alarm limits/material specifications; scheduling, setting limits and evoking program changes

Data collection and databasing: producing a database of variables; conversion of raw data into appropriate databasing software package

Reports: types and layout of reports; analysis of data

Programming language: automation of tasks within the software package

Implementation and applications: networking; types of networks; co-ordination and access of networking by linking to mainframe or factory network

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Final control elements.

Control valve selection and sizing

Pneumatic controllers and positioners

Pumps and blowers

Variable speed drives

Dampers

Category: Refrigeration and air conditioning (E)

Common

Commissioning - HVAC systems.

General requirements: building codes; local government regulations; human comfort – comfort chart; reporting procedures; pre-commissioning checks

Air systems: air tab instruments (air flow, pressure, temperature); fan testing; air balancing procedures; leakage testing; system capacity calculations

Hydronic systems: hydronic tab instruments (fluid flow, pressure, temperature); pumps; pumps curves and system curves; pump testing; hydronic (balancing procedures, general, compensation method); balancing valves; capacity calculations

Plant and equipment: controls; heat exchangers; chillers; boilers; cooling towers

Writing technical documents.

Preparing an outline of a technical document relevant to a specified industry

Writing a technical document

Technical writing skills and strategies

Meetings.

Convener skills; interpersonal skills; organising skills; reading and writing skills; meeting and convention processes; handling conflict

Specialisation: Control systems

Advanced HVAC control systems.

Control diagrams: electric/electronic control diagrams; electrical installation documents; pneumatic diagrams; DDC diagrams; controls/electrical power circuit interface; nomographs

Evaluate existing automatic control systems: specifications; briefs; descriptions of operation

Control requirements: standard and statutory requirements; economy of operation (energy management)

Building management systems.

Functions of a BMS: autonomous functions; input; output; general I/O; installation management items; energy management; risk management; information processing; objective; building running costs

BMS hardware: system architecture; communication devices; substations; PCs

Input and output functions: digital – input, outputs; digital output with status feedback; analogue input, output; sensors; alarms

Energy management: night cycle; optimum stop, start; time and event programs; night purge; outside air percentage control; enthalpy control; power demand control; duty cycle; presence detection; lighting control

Information processing functions: computer systems; central system management; programs; system configuration and security; operator – machine interface; data points

Risk and maintenance management: system files; fire – intruder control; access control

Energy management.

Energy sources and characteristics: supply authorities; standards units of measurement; electricity; steam; hot water; high temperature hot water; town gas; LP gas; solar; waste heat; petrochemical

Energy requirements: office lighting; air conditioning systems; refrigeration systems; security systems; computer systems; waste disposal systems; standby/emergency systems

Energy auditing process: energy costs and tariffs; energy consumption; predicting future costs; plotting consumption trends; historical data; collecting information using surveys; comparisons of actual to recorded usage; energy balance; instrumentation; estimating savings potential

System operation for energy efficiency: types of systems; efficiency in building structures; operation of a vehicle fleet; proportioning total energy consumption against individual systems; passive building design; preventative maintenance procedures; monitoring building management systems; operation of major and minor plant; inappropriate energy management procedures; building plant control systems

Implementing energy management procedures for a building: recording base year data; climatic conditions for locality; establishing energy costs and tariffs; building and systems surveys; pay back period; survey analysis; energy conservation procedures; implementation issues; monitoring

Methods of energy conservation: time schedules; lighting control

Maintenance practices: filters, fans, appropriate setpoints, dead bands, etc

HVAC system control: night cycle; optimum stop/start; purge cycles; chiller/boiler/cooling tower sequencing; economy cycles (based on temperature or enthalpy); supply air reset; supply water reset; condenser water temperature reset

Electrical load control: power demand control; load limiting; load shedding; set point relaxation; ventilation cycles

Tests and data collection procedures: use of BMS for data collection (trending); use of data recorders (loggers); monitoring building operations generally

Analyse results from test data: compare against standards (BOMA); review current practices against ideal; total consumption Vs peak load; electricity tariffs and implications

Methods of reducing energy usage: plant retrofits; controls; plant – fixed OA to economy boiler to electric reheat, constant volume to VAV; cost/benefit (payback)

Specialisation: HVAC systems

Commercial air conditioning system design.

Design parameters for commercial (single zone) air conditioning applications: e.g. offices, restaurants, hotels, bars; customer and objective; customer concept of environment desired; economics; client brief

Relevant design criteria: building purpose, location, orientation and shape; external environment ambient conditions; internal load diversity; thermal capacity behaviours; thermal load (full and partial)

Zoning and building usage: space and building; occupancies, single purpose, multi-purpose

System selection criteria: economics; environment; control requirements; existing structures; new structures; system components; space for equipment and system; selection of appropriate system, ductwork and components

Systems and applications: design features, engineering, controls and selection procedures for fan direct expansion RAC's, coil units, heat pump, package units, free blow and ducted

HVAC energy conversation techniques: heat recovery systems; night cycle; optimum stop/start; purge cycles; load limiting; load shedding; cost/benefit (payback)

HVAC load estimating.

Building survey: space characteristics; location of equipment; design conditions – outdoor, inside (type of installation); storage of heat in building structures; solar heat – direct and diffuse, glass types and factors, shading devices; film coefficients; heat and water vapour through structures – transmission coefficient; infiltration; ventilation; internal heat gains; system heat gains

Computer programs: ACAOS; TRANE; CARRIER

Psychrometrics – advanced.

Complex psychrometric processes: sensible cooling and heating and evaporative (adiabatic) cooling; cooling and dehumidfication; cooling and dehumidification with high latent load; cooling and dehumidification out door air; cooling and dehumidification all out door with dehumidified air requirements less than supply air; cooling with evaporative humidification; cooling with near isothermal humidification; spray processes to include cooling and dehumidification with heated spray water – heating and humidification;

partial load processes – reheat, by-pass of RA only and, mix of RA and OA; variable air volume; variable coil effective surface temperature; split coil - horizontal, vertical and intertwined

System performance: saturation efficiency of sprayers; system capacity calculated from air quantity and enthalpy change

Required plant capacity and airflow rates: effects of coil by-pass factor and ADP; calculation of dehumidified air quantity – using both TSH and ERSH methods

Psychrometric formulae and charts: properties of air; gas constants; derivation of air constants; combined gas laws; Dalton's law of partial pressures; Carrier's equation; psychrometric property tables; psychrometric charts; air mixing equations; air quantity equations

Commercial refrigeration systems design.

Calculation of capacity in heat exchangers

Evaporators: commercial types and applications; coil bypass factor; effects of evaporator TD on space humidity; effects on air circulation on product conditions; selection criteria and selection tables

Condensers: commercial types and applications; effects of ambient conditions; condenser control; heat rejection factor; condenser TD; selection criteria and selection tables

Compressors: types and applications; capacity; power; effect of operating conditions; actual requirements; post defrost loads; pull down torque requirements, high, medium and low back pressure compressors; selection tables, motor selection

Liquid expansion devices: types, operation and applications; effects from subcooling; distributor types, operation and applications; selection tables

System load balance point

Line sizing and design: velocity tables; pressure drop in lines and fittings; oil migration stabilisation; refrigerant velocity; effect of varying system capacity; oil traps; risers; double risers; liquid migration; design for parallel components and multiplex systems

Automatic controls: refrigerant regulating valves; solenoid valves; expansion valves; condenser pressure regulating valves; evaporator pressure regulating valves; crankcase pressure regulating valves; cycling controls; pressure-stats; thermostats; defrost controls; monitoring and alarm controls; refrigeration automation systems; control strategies; control modes

Specialisation: Refrigeration systems

Industrial refrigeration systems design.

Standards and codes: AS1677, detailed understanding; AS3666, overview; ozone protection regulations

Operating characteristics: Ph charts; refrigerating effect, relate back to air and fluid coolers; heat of compression, relate back to screw, rotary and reciprocating compressors; heat rejected on high side of the system, relate back to air cooled, evaporative, and water cooled condensers; required mass flow rate of refrigerant and volume; flow rate at various points in system; theoretical compressor power; required condenser capacity

Major system components: refrigerants, including R717 and R22; secondary refrigerants; component lubricant refrigerant compatibility evaporators; condensers, cooling towers; compressors; expansion valves; interconnecting piping and isolating valves; pilot operated valves; defrost system components for air, water, recycled water, hot gas, electric, methods

Moderate and low temperature industrial refrigeration systems: direct – flooded and pumped liquid recirculation systems; evaporators; multistaged compression; direct staging; cascade staging; compound compressors; desuperheaters; liquid injection; direct expansion intercoolers; open and closed intercoolers; basic designs of accumulators/intercooler vessels; oil cooling methods; oil stabilisation – return and oil recovery in flooded systems

Multiple evaporators and multiple compressors: parallel evaporators; multiple temperature systems; evaporator pressure regulators; temperature control methods; parallel compressors; pipework layout; methods of establishing pressure drop in dry and wet suction lines

Indirect refrigeration systems: classification according to AS1677; applications; evaporators; heat exchangers – types, construction, selection; secondary refrigerants; brines; antifreeze solutions

Flooded systems: applications; equipment; accumulators; level controls; liquid recirculation pumps; liquid pressure relief valve

Cryogenic systems: applications and equipment; system components; refrigerants; design safety; economics

Basic control sequences: maintaining evaporator conditions; staging and suction pressure control; maintaining condenser conditions; control of intermediate pressure – methods of industrial refrigeration compressor capacity control

Noise and vibration control.

Fundamentals of sound: frequency; decibels; octave bands; direct sound; velocity; sound pressure level; sound power level; sound meters

Noise and people: physical measurement of sound; weighting networks; NR curves; noise damage to hearing; evaluate daily noise exposures; peak noise

levels; attenuation of hearing protectors; excess noise levels permissible; Noise Abatement Act

Identify and analyse problems: one-dimensional sound waves; standing waves; energy in a sound wave; sources; effects of air turbulence; transmitters; amplifiers; absorptivity; reflectivity; room characteristics; acoustic design in buildings; fan and air noise transmission in ducts

Methods of control: natural attenuation; sound absorbing materials, placement; duct lining; lined plenums; lined duct splitters; duct attenuators; white noise; vibration isolators

Acoustic specifications: attenuator ratings

Energy management systems for commercial refrigeration.

Functions of a commercial refrigeration E.M.S: general control function; inputs; outputs; communications; graphing; supervising; data logging; scheduling; alarms; power consumption

E.M.S control components: identify components, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensor; state the function and operating parameters of components - pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors

Installation requirements and consideration: installation of controller(s); installation of refrigerant leak detector systems; installation accessory boards; installation of pressure transducers and wiring; installation of temperature sensors and wiring; control wiring considerations

System design and applications: select control components to suit given applications – determine system operating parameters, pressure sensors, temperature sensors, time clocks, humidity sensors, liquid level sensors, leak detector sensors, defrost, alarm panel

Programming a control system: display terminal and keypad functions; calibration of sensors; changing original settings; program a given set of parameters to suit an application

Component testing and fault-finding: trouble shooting; testing components

UTE NES607 A
Develop & apply electrotechnology contracting business plans

Descriptor: Develop business planning related to installation, maintenance, repair and servicing of electrical/electronic apparatus and systems under formal and informal contract arrangements.

Specific unit outcomes

This is presented as a composite unit that has two specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES607N A	Develop & apply electrotechnology contracting business plans *(Administration)*
UTE NES607P A	Develop & apply electrotechnology contracting business plans *(Technical)*

Elements		Performance criteria	
607.1	Devise a business plan	607.1.1	Contracting business opportunities are investigated and determined
		607.1.2	Products and services to be offered are determined from investigation into contracting business opportunities
		607.1.3	Marketing needs are identified
		607.1.4	Financial needs of the business are determined
607.2	Construct business plan	607.2.1	Business goals and objectives are specified and documented
		607.2.2	Strategies for marketing products and services are developed and documented
		607.2.3	Strategies for securing finances are established
		607.2.4	Functions and levels of personnel needed to conduct the business are identified
		607.2.5	Processes for evaluating business performance and improving the business plan are established and documented

		607.2.6	Structure of the business is established to comply with legislative and regulatory requirements and ethical practices
607.3	Implement business plan	607.3.1	Procedures are established for conducting business to achieve the goals set down in the business plan and in accordance with legislative requirements and ethical practices
		607.3.2	Business performance is monitored in accordance with the business plan and necessary improvements made to ensure business goals are achieved

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(N) Administration

(P) Technical

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of activities and where required support the outcomes of other units within a qualification structure.

Interdependent assessment of units

Assessment in this unit is related to the knowledge associated with other units within a qualification structure, where appropriate.

Underpinning knowledge

Common

Occupational health and safety implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1994); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; meetings and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Contracting business establishment.

Business performance and structures: strengths and weaknesses; characteristics of the entrepreneur - management skills, personal appraisal, personal development, self-motivation, goal setting and planning; sources of information; legal structure - sole trader, partnerships, corporations, trusts

The marketplace: market opportunities created through developments in technology, legislation and society; agencies and franchises; scope and relevance; points to be considered in agreements; assessing the marketplace using surveys and statistics on market opportunities in general; further training to fulfil market niches; competitive business characteristics including pricing; positioning strategy; demographic distribution of potential client groups; advertising media in their general costs, characteristics, features and viability for the small contracting business

Costing: cost of labour in wages; long service leave allowance; workcare/ compensation insurance; termination/redundancy allowance; workplace facilities; holiday leave loading; other as applicable; long term annual/weekly chargeable hours for a small contracting business; including the influence of non chargeable labour; annual leave; public holidays; sick/compassionate leave; RDO's, long service; site and workplace non-chargeable periods - workshop organisation and cleaning, training, business-place meeting, poorly utilisation on site; industry cost/comparison ratios for typical small contracting businesses; including the listing of a variety of expense categories and expressing these as a

percentage of the total - materials, wages and profit, indirect employment overheads, motor vehicle, equipment/capital items, advertising, accounting, finance expenses, phone; the complete overhead burden; break-even hourly charge-out rates then setting realistic rates to include profit margins; reasons for differing chargeable rates being encountered, including the practice of some businesses - recovering some of the overhead burden in high material profits, sacrificing profit to win jobs, recovering some of the overhead burden by separate call-out charges; break-even charting exercises to examine the effects of differing charge-out rates; attaining different chargeable hours over the time period and different business expense; sales budgets

Legal requirements.

Commonality of legislation between States

Legislation applicable to contracting

Commonwealth legislation: Australian Securities Commission Act; Corporations Law; Copyright, Design and Patents Acts; Freedom of Information Act; Human Rights and Equal Opportunities Act; Industrial Relations Act; Mutual Recognition Act; Racial Discrimination Act; Sex Discrimination Act; Superannuation Acts; Trade Practices Act; other necessary legislation

Legislation applicable to contractors and/or their employees

State legislation: Anti-discrimination Act; Building and Construction Industry Portable Long Service Leave Act; Building Act; Building Services Authority Act; Business Names Act; Companies Act; Employment Acts; Fair Trading Act; Fire Services Act; Freedom of Information Act; Health Acts; Industrial Relations Act; Motor Vehicles Safety Act; Occupational/Workplace Health and Safety Act; Partnership Acts; Superannuation Acts; Vocational Education/Industrial and Commercial Training Acts; Worker's Compensation Act; Apprentices; Awards; Applicable Codes of Practice; other necessary legislation

Financial control.

General management policy: trade associations; business ethics; forms of assistance; quality assurance, State purchasing policies; operational policies; insurance requirements

Financial requirements: cash flow forecasting; sources of finance; loan application; review business plan

Financial monitoring: book keeping - manual entry systems and commercial entry systems; balance sheets; payroll records; debtor control; information technology as a tool; payment claiming, including rise and fall; taxation, including PAYE, FBT, sales tax, capital gains and PPS requirements

Management of human and physical resources: defining, advertising and interviewing for employment; human resource management; comparing subcontract, casual and full time employment of labour; resolution of industrial

conflict; enterprise bargaining; award conditions, including termination and redundancy; physical resource management; project control

Industrial computer systems.

Computer systems overview

PC hardware orientation

DOS commands

DOS set-up commands

Windows operations

Word processors

Spreadsheets

Databases as used for control applications

CAD/vector graphics

Control applications

Specialisation: Administration

Maintenance planning.

Planning work: origin of maintenance work; workorder/request routing; resources - labour, materials, equipment spares

Scheduling work: operations of organisation; maintenance windows; creation of a work schedule

Project planning: review of available software; collection of data; input of data; project updating

Break even analysis: purpose; financial factors; calculation; modified break even point

Sources of business finance

Credit control: need for credit control; types of credit control systems; supporting credit control documents

Financing capital equipment: nature of capital expenditure; justification of capital expenditure; pay back period

Financial management.

Fundamentals of the accounting process: the accountant's role; accounting tools available to managers; financial terminology; the accounting processes

Financial reports: information for effective financial management; production efficiency ratios; key financial and accounting reports

Budgeting: purpose; elements of a budget; zero based budgeting; preparation of budget

Overheads: nature of overheads; allocation of overhead expenses; overhead recovery rates

Supply and storage management.

The principles influencing store layout and security: yard/lay-down area stores function; benefits and problems; efficient handling and preservation of material and equipment

Selection of suitable recording system for verification of inwards goods and services receipts: methods of physical identification; quantity checks and "as ordered" endorsement; implementation of quality assurance inspections; methods and recording of inspections

Stock control: principles; bin systems; maximum/minimum control systems; parts or materials grouping methods; application of total stock controlling functions

Ordering systems: methods of achieving effective purchasing/stores co-ordination; acknowledgment of priorities; total communication of needs; response and anticipation; "follow-up" system

Reporting/forecasting: effecting a reporting system communicating with areas of consumption of all stored goods; introduction of early warning systems identifying major variations to normal consumption rates; provision of effective forecasting system

Support materials: selection; control; maintenance; providing production back-up by supply of aids, equipment, machinery and tools

Constant communication with all production units

Project planning.

Tenders: reasons for calling these; requirements/constraints in a tender document; reasons for inclusions of constraints

Production costs: estimating costs of fulfilling a contract

Data: tender submission data to a visual monitoring system schedule; mathematical formulae used for conversion of data to time/cost; forecasting and control; extracting and using data

Continuous achievement recording: using graphical "S" curves

Customer/client relations.

What is customer relations

Perception

Interpersonal skills for customer relations

Resolving disputes

International protocol

How other companies do it

Customer expectations

Developing a customer relations strategy

Specialisation: Technical

Estimating, tendering and contracting.

Tender documents: project drawings; specifications; other tender documentation

Contracts – basic structure of law including: basic court structure; common law; statute law; criminal law; law of tort

Essential features of a contract including: intention to create legal relationships; offer and acceptance including (verbal, mail, facsimile, implied); form and consideration; capacity; genuine consent; legal object

Letters and diaries including: formal structure; without prejudice; evidence making

Relationships between various contracts, estimates, tenders and related documents including Australian Standards; industry contract terms and conditions

Estimating: tools of estimating; methods of extracting, recording, compiling, and calculating data; comparison of methods; factors and conditions affecting estimating outcomes

Project management: charting and scheduling of project times and resources; activities and documentation associated with projects

Computer aided maintenance.

Maintenance management objectives: responsibilities of management; preventative maintenance; predictive maintenance

Computerised maintenance systems: software and hardware requirements; justification of computerised systems

Planning, plant numbering and data collection: plant numbering systems; ways of collecting data; create specific forms of data collection; plan a common and uniform approach to input data; create flow charts for the input of data

Structuring and data input: organise plant into hierarchical order; using maintenance management software; input data

Preventative and predictive maintenance: selection of appropriate equipment to suit each category; setting equipment on computer for each strategy; failure patterns of equipment

Equipment history and costs: retrieve from computer plant history and costs; retrieve from computer plant costs through the hierarchical structure

Project planning an estimating.

Introduction to project planning

Simple and complex projects: start and finish dates, events, activities and durations, dependencies, plans , specification, budget, materials, plant and equipment

The project planning process: project life cycle, starting a project, progressive monitoring, finishing, constraints of time, budget and quality, project outcomes. need for reports and meetings, budgets, records and project tracking information

The project planning environment: projects within continuing organisations; project applications and project application of management principles; company and public authority organisation; industrial relations; safety, finance; legal aspects; types of contracts

Importance of project planning: brief history. the mutual benefits to society, management, clients and workers of effective project planning. the low salvage value of unsuccessful or uncompleted projects, follies

Contract documents: different types of contracts (acts and regulations); contract documentation; contract administration; contract variation

Graphical representation of projects: construction scheduling; the gantt bar chart (horizontal time, vertical activities, variations, specific examples and limitations); the critical path (alternative paths to the finish node, the critical path, forward and backward pass, earliest and latest start and finish times, slack or float times, special terminology, calculation procedures, calendaring); relevant computer software packages

Customer/client relations.

What is customer relations

Perception

Interpersonal skills for customer relations

Resolving disputes

International protocol

How other companies do it

Customer expectations

Developing a customer relations strategy

UTE NES608 A
Apply electrotechnology contracting business practices

Descriptor: Apply financial and business operational management practices related to installation, maintenance, repair and servicing of electrical/electronic apparatus and systems under formal and informal contract arrangements.

Specific unit outcomes

This is presented as a composite unit that has two specific units as outcomes, based on the *category* in which competence is achieved. This is done because of the high degree of commonality in process or function. Reporting the unit with the inclusion of a *category* allows for the identification of the necessary training outcomes in terms of the generic and transferable skills and at the same time reflects the work classification(s) generally understood by industry. The specific unit outcomes are:

UTE NES607N A	Develop & apply electrotechnology contracting business plans *(Administration)*
UTE NES607P A	Develop & apply electrotechnology contracting business plans *(Technical)*

Elements		Performance criteria	
608.1	Manage business operations	608.1.1	*Established procedures* for developing work plans and schedules for contracted work are implemented and used
		608.1.2	*Established procedures* for managing and recording business activities, staff data, evaluating performance and validating compliance with statutory requirements are utilised
		608.1.3	Materials are ordered to secure optimum price and in time to meet work schedules
		608.1.4	Equipment necessary to carry out work is made available and maintained
		608.1.5	Systems to assist in ensuring quality of products and services are adopted
608.2	Manage staff	608.2.1	Human resource requirements are determined and specified in terms of competencies, remuneration and working conditions
		608.2.2	Personnel are recruited and selected in accordance with established requirements

Elements		Performance criteria	
		608.2.3	Industrial relations matters which may impact on the business are investigated to clarify workplace rights and obligations of employers and employees
608.3	Manage finances	608.3.1	Sources of finance are evaluated and procured in accordance with business plan
		608.3.2	*Established procedures* for ensuring adequate cash flow to maximise business returns are implemented and used
		608.3.3	Financial records and transactions are kept up to date in accordance with *established procedures* and legislative requirements
608.4	Apply ethical practices	608.4.1	Employees, colleagues and customers are treated fairly and with respect in all business dealings
		608.4.2	Information is used in an appropriate and proper way
		608.4.3	Acceptable practices are implemented to promote increases in efficiency and productivity
		608.4.4	Real and apparent conflicts of interest are avoided

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and intended scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Categories

This unit recognises the commonality of skills and knowledge that exists for the unit as well as the additional specific outcome; which is to be reported on. Therefore, competency can be displayed on one, some or all of the following categories and in addition to the respective common underpinning knowledge associated with the selected specialisation:

(N) Administration

(P) Technical

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of activities and where required support the outcomes of other units within a qualification structure.

Interdependent assessment of units

Assessment in this unit is related to the knowledge associated with other units within a qualification structure, where appropriate.

Underpinning knowledge

Common

Occupational health and safety implementing and monitoring.

Legislation and Australian Standards: AS1470 – 1986; OHSC:7025 (1994); generic competencies A, B and C; relevant acts (electrical); general duty of care

Policy and program development: assigning accountability; focus on improvement

Consultative processes: OH&S committee; meetings and workshops; information gathering

Training and development: provision and type; dissemination of information; cultural considerations; literacy considerations

Hazard identification and assessment: safety audits; workplace inspections; injury and illness records, statistics; complaints and observations; contributing factors to a hazard (exposure, severity, human differences)

Risk assessment and management: hierarchy of control (elimination, substitution, design, mitigation)

Management and improvement: promoting OH&S activities; integration management structures; evaluation of control strategies; evaluation of educational and training programs

Contracting business establishment.

Business performance and structures: strengths and weaknesses; characteristics of the entrepreneur - management skills, personal appraisal, personal development, self-motivation, goal setting and planning; sources of information; legal structure - sole trader, partnerships, corporations, trusts

The marketplace: market opportunities created through developments in technology, legislation and society; agencies and franchises; scope and relevance; points to be considered in agreements; assessing the marketplace using surveys and statistics on market opportunities in general; further training to fulfil market niches; competitive business characteristics including pricing; positioning strategy; demographic distribution of potential client groups; advertising media in their general costs, characteristics, features and viability for the small contracting business

Costing: cost of labour in wages; long service leave allowance; workcare/ compensation insurance; termination/redundancy allowance; workplace facilities; holiday leave loading; other as applicable; long term annual/weekly chargeable hours for a small contracting business; including the influence of non chargeable labour; annual leave; public holidays; sick/compassionate leave; RDO's, long service; site and workplace non-chargeable periods - workshop organisation and cleaning, training, business-place meeting, poorly utilisation on site; industry cost/comparison ratios for typical small contracting businesses; including the listing of a variety of expense categories and expressing these as a percentage of the total - materials, wages and profit, indirect employment

overheads, motor vehicle, equipment/capital items, advertising, accounting, finance expenses, phone; the complete overhead burden; break-even hourly charge-out rates then setting realistic rates to include profit margins; reasons for differing chargeable rates being encountered, including the practice of some businesses - recovering some of the overhead burden in high material profits, sacrificing profit to win jobs, recovering some of the overhead burden by separate call-out charges; break-even charting exercises to examine the effects of differing charge-out rates; attaining different chargeable hours over the time period and different business expense; sales budgets

Legal requirements.

Commonality of legislation between States

Legislation applicable to contracting

Commonwealth legislation: Australian Securities Commission Act; Corporations Law; Copyright, Design and Patents Acts; Freedom of Information Act; Human Rights and Equal Opportunities Act; Industrial Relations Act; Mutual Recognition Act; Racial Discrimination Act; Sex Discrimination Act; Superannuation Acts; Trade Practices Act; other necessary legislation

Legislation applicable to contractors and/or their employees

State legislation: Anti-discrimination Act; Building and Construction Industry Portable Long Service Leave Act; Building Act; Building Services Authority Act; Business Names Act; Companies Act; Employment Acts; Fair Trading Act; Fire Services Act; Freedom of Information Act; Health Acts; Industrial Relations Act; Motor Vehicles Safety Act; Occupational/Workplace Health and Safety Act; Partnership Acts; Superannuation Acts; Vocational Education/Industrial and Commercial Training Acts; Worker's Compensation Act; Apprentices; Awards; Applicable Codes of Practice; other necessary legislation

Financial control.

General management policy: trade associations; business ethics; forms of assistance; quality assurance, State purchasing policies; operational policies; insurance requirements

Financial requirements: cash flow forecasting; sources of finance; loan application; review business plan

Financial monitoring: book keeping - manual entry systems and commercial entry systems; balance sheets; payroll records; debtor control; information technology as a tool; payment claiming, including rise and fall; taxation, including PAYE, FBT, sales tax, capital gains and PPS requirements

Management of human and physical resources: defining, advertising and interviewing for employment; human resource management; comparing subcontract, casual and full time employment of labour; resolution of industrial conflict; enterprise bargaining; award conditions, including termination and redundancy; physical resource management; project control

Industrial computer systems.

Computer systems overview

PC hardware orientation

DOS commands

DOS set-up commands

Windows operations

Word processors

Spreadsheets

Databases as used for control applications

CAD/vector graphics

Control applications

Specialisation: Administration

Maintenance planning.

Planning work: origin of maintenance work; workorder/request routing; resources - labour, materials, equipment spares

Scheduling work: operations of organisation; maintenance windows; creation of a work schedule

Project planning: review of available software; collection of data; input of data; project updating

Break even analysis: purpose; financial factors; calculation; modified break even point

Sources of business finance

Credit control: need for credit control; types of credit control systems; supporting credit control documents

Financing capital equipment: nature of capital expenditure; justification of capital expenditure; pay back period

Financial management.

Fundamentals of the accounting process: the accountant's role; accounting tools available to managers; financial terminology; the accounting processes

Financial reports: information for effective financial management; production efficiency ratios; key financial and accounting reports

Budgeting: purpose; elements of a budget; zero based budgeting; preparation of budget

Overheads: nature of overheads; allocation of overhead expenses; overhead recovery rates

Supply and storage management.

The principles influencing store layout and security: yard/lay-down area stores function; benefits and problems; efficient handling and preservation of material and equipment

Selection of suitable recording system for verification of inwards goods and services receipts: methods of physical identification; quantity checks and "as ordered" endorsement; implementation of quality assurance inspections; methods and recording of inspections

Stock control: principles; bin systems; maximum/minimum control systems; parts or materials grouping methods; application of total stock controlling functions

Ordering systems: methods of achieving effective purchasing/stores co-ordination; acknowledgment of priorities; total communication of needs; response and anticipation; "follow-up" system

Reporting/forecasting: effecting a reporting system communicating with areas of consumption of all stored goods; introduction of early warning systems identifying major variations to normal consumption rates; provision of effective forecasting system

Support materials: selection; control; maintenance; providing production back-up by supply of aids, equipment, machinery and tools

Constant communication with all production units

Project planning.

Tenders: reasons for calling these; requirements/constraints in a tender document; reasons for inclusions of constraints

Production costs: estimating costs of fulfilling a contract

Data: tender submission data to a visual monitoring system schedule; mathematical formulae used for conversion of data to time/cost; forecasting and control; extracting and using data

Continuous achievement recording: using graphical "S" curves

Customer/client relations.

What is customer relations

Perception

Interpersonal skills for customer relations

Resolving disputes

International protocol

How other companies do it

Customer expectations

Developing a customer relations strategy

Specialisation: Technical

Estimating, tendering and contracting.

Tender documents: project drawings; specifications; other tender documentation

Contracts – basic structure of law including: basic court structure; common law; statute law; criminal law; law of tort

Essential features of a contract including: intention to create legal relationships; offer and acceptance including (verbal, mail, facsimile, implied); form and consideration; capacity; genuine consent; legal object

Letters and diaries including: formal structure; without prejudice; evidence making

Relationships between various contracts, estimates, tenders and related documents including Australian Standards; industry contract terms and conditions

Estimating: tools of estimating; methods of extracting, recording, compiling, and calculating data; comparison of methods; factors and conditions affecting estimating outcomes

Project management: charting and scheduling of project times and resources; activities and documentation associated with projects

Computer aided maintenance.

Maintenance management objectives: responsibilities of management; preventative maintenance; predictive maintenance

Computerised maintenance systems: software and hardware requirements; justification of computerised systems

Planning, plant numbering and data collection: plant numbering systems; ways of collecting data; create specific forms of data collection; plan a common and uniform approach to input data; create flow charts for the input of data

Structuring and data input: organise plant into hierarchical order; using maintenance management software; input data

Preventative and predictive maintenance: selection of appropriate equipment to suit each category; setting equipment on computer for each strategy; failure patterns of equipment

Equipment history and costs: retrieve from computer plant history and costs; retrieve from computer plant costs through the hierarchical structure

Project planning an estimating.

Introduction to project planning

Simple and complex projects: start and finish dates, events, activities and durations, dependencies, plans , specification, budget, materials, plant and equipment

The project planning process: project life cycle, starting a project, progressive monitoring, finishing, constraints of time, budget and quality, project outcomes. need for reports and meetings, budgets, records and project tracking information

The project planning environment: projects within continuing organisations; project applications and project application of management principles; company and public authority organisation; industrial relations; safety, finance; legal aspects; types of contracts

Importance of project planning: brief history. the mutual benefits to society, management, clients and workers of effective project planning. the low salvage value of unsuccessful or uncompleted projects, follies

Contract documents: different types of contracts (acts and regulations); contract documentation; contract administration; contract variation

Graphical representation of projects: construction scheduling; the gantt bar chart (horizontal time, vertical activities, variations, specific examples and limitations); the critical path (alternative paths to the finish node, the critical path, forward and backward pass, earliest and latest start and finish times, slack or float times, special terminology, calculation procedures, calendaring); relevant computer software packages

Customer/client relations.

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UTE NES609 (A to Z qualifier) A Develop & manage maintenance programs for hazardous area electrical equipment

Descriptor: Develop and manage maintenance programs for explosion-protected equipment, systems and installations, including periodic and sample inspections and in accordance with *requirements.*

Alignment: This unit aligns to the Competency Standard 'Electrical equipment in hazardous areas' CS-EEHA-001-1998, unit NEE 010.

Specific unit outcomes

This is a composite unit that can be achieved in any of seven *endorsements* related to explosion protection techniques. This is done because of the high degree of commonality in knowledge, process and function. Reporting the unit with the inclusion of one or more *endorsements* will identify the necessary applied skills related to workplace outcomes and at the same time reflects the work classification(s) generally understood by industry. The specific unit *endorsements* are:

UTE NES609T A	Develop & manage maintenance programs for hazardous area electrical equipment *(Mixed explosion-protection techniques Ex mixed)*
UTE NES609U A	Develop & manage maintenance programs for hazardous area electrical equipment *(Pressurised enclosure Ex p)*
UTE NES609V A	Develop and manage maintenance programs for hazardous area electrical equipment *(Dust-exclusion ignition-proof Dip)*
UTE NES609W A	Develop & manage maintenance programs for hazardous area electrical equipment *(Non-sparking Ex n)*
UTE NES609X A	Develop & manage maintenance programs for hazardous area electrical equipment *(Intrinsic safety Ex I)*
UTE NES609Y A	Develop & manage maintenance programs for hazardous area electrical equipment *(Increased safety equipment Ex e)*
UTE NES609Z A	Develop & manage maintenance programs for hazardous area electrical equipment (*Flameproof enclosure Ex d)*

Elements		Performance criteria	
609.1	Establish maintenance requirements	609.1.1	Policies and procedures are developed to include OH&S practices, skills required and frequency and level of maintenance work
		609.1.2	Systems are established to manage and record maintenance work and up-date *hazardous area records* in accordance with *requirements*
		609.1.3	Level of repair to be done under maintenance work is established in accordance with *requirements*
		609.1.4	Arrangements are made to check that the *hazardous area*, *explosion-protected equipment* and *installation* comply with *hazardous area records*
		609.1.5	Discrepancies between the *hazardous area*, *explosion-protected equipment* and *installation* and the *hazardous area records* are documented and arrangements made to ensure the area is appropriately classified and *explosion-protection* systems are adequate
609.2	Develop and implement maintenance schedule	609.2.1	Maintenance schedules are developed from recommendations of *standards* and equipment manufacturers and in accordance with *requirements*
		609.2.2	Procedures are developed and implemented to ensure the maintenance program is followed in accordance with the planned schedule and *requirements*
		609.2.3	Procedures are developed and implemented to ensure the *hazardous area records* are maintained in accordance with planned schedule and *requirements*
609.3	Evaluate maintenance program	609.3.1	*Periodic* and *sample inspection* reports used to ascertain maintenance quality and the need for revision of maintenance schedule and frequency
		609.3.2	Maintenance schedule is periodically reviewed and revised to maintain the *integrity* of the explosion-protection system

Range statement

General

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Endorsements

Competency can be demonstrated in relation of the to any classified hazardous areas listed:

(T) Mixed explosion-protection techniques Ex mixed

(U) Pressurised enclosure Ex p

(V) Dust-exclusion ignition-proof DIP

(W) Non-sparking Ex n

(X) Intrinsic safety Ex i

(Y) Increased safety equipment Ex e

(Z) Flameproof enclosure Ex d

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating consistent performance for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the underpinning knowledge and skills identified in the section, of this unit titled ‘Underpinning knowledge’.

Competency must be demonstrated in relation to the explosion-protection technique for which competency is sought. It is essential that the following aspects of competency be demonstrated:

- Establishing maintenance policies and procedures that encompass OH&S responsibilities;
- Establishing management maintenance systems that address the special requirements for explosion-protected equipment and installations;
- Ensuring a hazardous area is appropriately classified and explosion-protection strategies are adequate;
- Developing and implementing maintenance plans and schedules in relation to explosion-protected equipment and installations;
- Evaluating maintenance programs in relation to explosion-protected equipment and installations.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of *plant, equipment,* tools, *accessories, components* and the like for the *category* undertaken within a unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Competency in this unit should be assessed only after the competencies relating to developing and managing maintenance of electrical equipment and installations at *AQF* Certificate III level have been achieved.

Underpinning knowledge

Evidence of knowledge related to hazardous areas and to Ex mixed, Ex p, DIP, Ex n, Ex i, Ex e and Ex d and any other technique relevant to a particular workplace is required. The following is a summary of knowledge related to hazardous areas:

Safe working requirements and procedures; definition of a hazardous area; conditions that lead to an explosion.; meaning of the terms "combustion", "detonation" and "propagation"; OH&S responsibilities; parties responsible for safety of hazardous areas; definition of classes and zones; identify classes, zones and groups from system design documentation; characteristics of an explosive atmosphere (LEL/UEL) and relationship to ignition energy; combustible properties of materials

The following is a summary of knowledge of explosion-protected equipment and applicable to an explosion-protection technique:

Method of explosion protection; mechanisms of explosion protection employed by a technique; interpretation of installation limitations specified in certification and approval documentation; requirements of electrical protection devices; application and limitations of equipment; identification of gas grouping and temperature class of equipment; parties responsible for certification/approval system; temperature limitations of wiring and equipment; limitations on non-metallic and specific alloy enclosures; interpretation of equipment marking; application, selection and use of fasteners; requirements for testing circuits; requirements for detailed initial/sample and close/visual inspections; standards and procedures for terminating and connecting cables; relationship between equipment, cables and glands; standards and requirements for the installation of equipment and wiring; purpose, selection and application of sealing compounds; actions and conditions that will void explosion-protection; standards for wiring systems in hazardous areas; requirements for establishing and maintaining hazardous area records (site dossier); requirements of programmed maintenance; maintenance requirements and procedures for an explosion-protection technique

UTE NES610 A
Ensure the safety of hazardous areas

Descriptor: Ensure that potentially explosive atmospheres that may be generated by production, processing or servicing activities are identified and correctly categorised and appropriate *explosion-protected equipment* is selected, installed and maintained in accordance with *requirements.*

Alignment: This unit aligns to the Competency Standard 'Electrical equipment in hazardous areas' CS-EEHA-001-1998, unit NEE 002.

Elements		Performance criteria	
610.1	Establish possibility of explosive hazard	610.1.1	*Competent person* or persons are engaged to provide advice on the nature and extent of any explosive hazard on the site
		610.1.2	Measures are taken to ensure explosive hazards are identified and the area classified by *competent person* or persons in accordance with *requirements*
		610.1.3	Arrangements are made to establish a *hazardous area records* system in accordance with *requirements*
610.2	Establish explosion-protection strategies for site	610.2.1	*Competent person* or persons are engaged to design the explosion-protection system and installation
		610.2.2	Where applicable explosion-protection system and installation design is verified with *Statutory Authority* for compliance with *requirements*
610.3	Implement explosion-protection strategies	610.3.1	*Competent person* or persons are engaged to install explosion-protected equipment and wiring system
		610.3.2	Procedures are implemented to ensure the explosion-protected equipment and wiring system installation is tested and inspected in accordance with *requirements*
610.4	Establish and implement procedures for maintaining explosion protection	610.4.1	Competent person or persons are engaged to develop *inspection/maintenance schedules*, including the level and intervals for *periodic inspections*, for the *explosion-protected equipment* and *wiring system*
		610.4.2	Procedures are developed to ensure *periodic inspections*, testing and maintenance are carried out to documented schedule and in accordance with *requirements*

Elements	Performance criteria
	610.4.3 Procedures are established for assuring data related to explosion-protection is filed in *hazardous area records* in accordance with *requirements*

Range statement

Competency can be demonstrated in relation to any potentially hazardous area.

Generic items in this unit are shown in italics, e.g. *established procedures*. The definition and scope covered by generic items is described in the Glossary that forms an integral part of this range statement.

Currency in unit of competency

In order to maintain currency in this unit on-going competency development is to occur. This would include keeping abreast of any changes in legislation, regulations, procedures, technology and the like related to the scope and application of this unit.

Evidence guide

This Evidence guide is intended to include components defined within the Range Statement, of which the Glossary is an integral part. Terms in italics, e.g. *consistent performance*, with respect to the Evidence guide are also contained in the Glossary.

Critical aspects of evidence

Achieving competence

Achievement of this unit of competency is based on each of the following conditions being met:

- demonstrating *consistent performance* for each element of the unit.
- meeting the performance criteria associated with each element of competence by employing the techniques, procedures, information and resources available in the workplace.
- demonstrating an understanding of the Underpinning knowledge and skills identified in the section, of this unit titled 'Underpinning knowledge'.

Competence should be demonstrated in relation to the managerial responsibilities for ensuring the workplace is safe and without risk to health. It is essential that the following aspects of competency be demonstrated:

- Application of relevant statutory requirements;
- Establishing procedures for engaging competent persons;
- Establishing and maintaining procedures for identifying potentially explosive hazards;

- Establishing procedures for implementing and maintaining explosion-protection strategies.

Reporting requirements

The reporting of the judgements about competence must be in the context of the individual unit being assessed and the qualification to be issued. Regulatory requirements in individual jurisdictions may require recording of additional information. Recognition of knowledge and skills transfer may be maximised by recording and issuing transcripts covering additional information. This could be detailed statements about the achievement of knowledge and skills. Any additional reporting is a matter for negotiation between the RTO and its clients.

Maintaining competence

Consideration should be given to periodic evaluations of skills and knowledge within this unit that are critical to safety, operation of plant and equipment and the like, particularly where relevant skills and knowledge are not frequently practiced.

Context of assessment

Competency will be determined on evidence of having *consistently performed* across a *representative range* of *plant, equipment,* tools, *accessories, components* and the like for the *category* undertaken within a unit of competency; autonomously and to requirements. Equivalent evidence from other sources is also acceptable.

Interdependent assessment of units

Competency in this unit should be assessed in combination with other competencies required by a given industry or enterprise for site management.

Underpinning knowledge

Evidence of knowledge related to hazardous areas and to managerial occupational health and safety obligations. The following is a summary of knowledge related to hazardous areas:

Safe working requirements and procedures; definition of a hazardous area; conditions that lead to an explosion; meaning of the terms "combustion", "detonation" and "propagation"; characteristics of an explosive atmosphere (LEL/UEL); OH&S responsibilities; parties responsible for safety of hazardous areas; practices for meeting the statutory requirements to ensure a hazardous areas is safe; sources of data needed to classify a hazardous area; requirements and strategies of hazard management control systems; purpose of certifying explosion-protection equipment; arrangements for approval for use of explosion-protected equipment; establishing and maintaining site 'dossier'; relationship between Australian, New Zealand and other standards