Unit 49: Installing and Commissioning Engineering Equipment

Unit code: L/600/0337

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit will give learners the knowledge and skills needed to correctly install, commission and hand over a range of mechanical and electrical engineering systems.

Unit introduction

The correct installation and commissioning of engineering equipment is a vital aspect in preventing its failure at a later date. This unit gives learners an insight into how both mechanical and electrical/electronic equipment is installed and commissioned. Learners will have a chance to demonstrate their practical skills in installing and commissioning a piece of engineering equipment used on an engineering system. The system worked on can be from any of a variety of industry sectors, ranging from traditional mechanical systems to one found in the medical sector.

Before an installation/commissioning engineer leaves the equipment in the hands of its new owner, they need to ensure correct handover has taken place. The last part of this unit will give learners the opportunity to show that they are aware and know about this process.

Learning outcomes

On completion of this unit a learner should:

1 Know how to install and commission mechanical equipment

2 Know how to install and commission electrical/electronic equipment

3 Be able to install and commission equipment used on an engineered system

4 Know how to hand over an installation after commissioning an engineered system.

Unit content

1 Know how to install and commission mechanical equipment

Installation procedure: procedures to include:

- pre-installation activities eg site accessibility, utilities availability, installation consumables, documentation availability
- during installation activities eg adhering to risk assessment, COSHH and other relevant safety standards, authority to carry out the installation activities, providing safe access and working arrangements, safe isolation of services, disposing of waste items in a safe and environmentally acceptable manner, leaving the work area in a safe condition
- methods and techniques eg marking out of locating and securing positions, drilling and hole preparation, fitting inserts, positioning equipment, aligning equipment, levelling equipment, shimming and packing, fitting anti-vibration mountings, securing by using mechanical fixings, applying screw fastening locking devices
- using moving equipment eg slings, cranes, fork lift, portable lifting devices, block and tackle, rollers/ skates, hoists, jacks
- using instruments eg straight edges and feeler gauges, engineer's levels, dial test indicators, measuring instruments, plumb lines and taut wires, alignment telescopes, laser equipment, self-diagnosis equipment
- making connections eg mechanical, electrical wired, fluid power, utility service
- testing that the installation works
- checking and testing activities eg six point, half-split, input-to-output, functional testing, self-diagnostics, emergent problem sequence, injection and sampling, unit substitution
- completing relevant paperwork eg installation records, company specific paperwork, job card

Types of mechanical equipment: eg machine tools, industrial compressors, conveyors, turbines, elevators, processing plant, hoppers or large storage vessels, lifting and handling equipment, engines, process control equipment

Commissioning procedure: procedures to include:

- pre-commissioning activities eg site accessibility, checking installation, ensure documentation is available
- using methods and techniques eg start-up procedures, confirming that the equipment/system meets specifications, running equipment at the recommended initial settings, checking for leaks during operations, making sensory checks, running through the operating sequence, checking for correct functioning, loading the system incrementally, making any necessary adjustments to settings to achieve the specification parameters, conducting a trial run of the equipment at full power/speed/flow, confirming that the final product/process outcomes meet specifications, monitoring and recording measurements and observations, shutting down/isolating the equipment/installation to a safe condition
- using instruments/devices eg alignment, levelling, linear measuring, speed measuring, multimeter, continuity tester, bleeding equipment, pressure testing, flow testing, diagnostic aids, PLC/PC equipment
- completing relevant paperwork eg commissioning log/record, job sheet, company specific paperwork, handover report

2 Know how to install and commission electrical/electronic equipment

Installation procedure: procedures to include:

- pre-installation activities eg site accessibility, utilities availability, installation consumables, documentation availability
- during installation activities eg adhering to risk assessment, COSHH and other relevant safety standards, authority to carry out the installation activities, providing safe access and working arrangements, safe isolation of services, disposing of waste items in a safe and environmentally acceptable manner, leaving the work area in a safe condition
- methods and techniques eg marking out of location positions for components/modules, positioning and securing of equipment and components, securing by using mechanical fixings, securing by using masonry fixings, drilling and hole preparation, levelling and alignment
- connecting to electrical supplies eg single phase, three phase, direct current, low voltage (up to 115v), combination power circuits
- using test instruments eg multimeter, watt meter, voltmeter, ammeter, insulation resistance tester, light meter, earth-loop impedance tester
- making cable terminations eg sealing and protecting cable connections, making mechanical/screwed/clamped connections, soldering and de-soldering, attaching suitable cable identification, routeing and securing wires and cables, heat shrinking, crimping, stripping cable insulation/protection, adding cable end fittings
- testing that the installation works
- checking and testing activities eg six point, half-split, input-to-output, functional testing, self-diagnostics, emergent problem sequence, injection and sampling, unit substitution
- completing relevant paperwork eg installation records, company specific paperwork, job card

Types of electrical/electronic equipment: module/components eg switchgear, alarm devices, programmable controllers, power factor correction devices, motors and starters, luminaries, panels or sub-assemblies, control devices, communication equipment, cable connectors, encoders or resolvers, conduit, bus bars, safety devices, emergency/standby batteries, overload protection devices, sensors and actuators, electronic modules/units, trunking, tray work; cable types eg mineral, armoured, data/communication, fibre optics, PVC, screened, loom/harness

Commissioning procedure: procedures to include:

- pre-commissioning activities eg site accessibility, checking installation, ensuring documentation is available
- methods and techniques eg start-up procedures, confirming equipment/system meets specification, running equipment at recommended initial settings, checking electrical integrity, making sensory checks, running through the operating sequence, checking for correct functioning, loading the system incrementally, making necessary adjustments to settings to achieve specification parameters, conducting a trial run of the equipment at full power/speed/flow, monitoring and recording measurements and observations, shutting down/isolating the equipment/installation to a safe condition; using instruments/devices eg multimeter, watt meter, voltmeter, ammeter, insulation resistance tester, light meter, earth-loop impedance tester
- completing relevant paperwork eg commissioning log/record, job sheet, company specific, handover report

3 Be able to install and commission equipment used on an engineered system

Installation activity: activities to include:

- methods and techniques eg marking out positions, drilling and preparing holes, moving and positioning, aligning and levelling, shimming and packing, fitting anti-vibration mountings, securing items
- using test instruments eg alignment devices, linear measuring devices, electrical measuring equipment, fluid/power testing equipment, instrumentation test equipment, PLC/PC test equipment
- checking and adjusting eg making visual checks of the installation for completeness and freedom from damage, topping up fluid/oil reservoirs, ensuring that all bolts are correctly torqued and locking devices are fitted to fasteners, ensuring that all electrical connections are correctly made, earth bonding is secure and connections covered, ensuring that all pipe connections are correctly made, secure and leak free, ensuring that all moving parts are guarded and clear of obstruction, checking that the system operates to the installation specification, making sensory checks of the system
- checking and testing activities eg six point, half-split, input-to-output, functional testing, self-diagnostics, emergent problem sequence, injection and sampling, unit substitution
- completing relevant paperwork eg installation records, company specific paperwork, job card

Engineering system: equipment/components eg mechanical (such as machine tool, processing plant, turbine engine, transfer equipment, heat and ventilation), electrical/electronic (such as switchgear, distribution panels, motors, starters, luminaries), fluid power (such as compressors, pumps, accumulators, filters, regulators), process controller (such as PLCs, data communication links), instrumentation and control (such as pressure, flow, temperature, speed, weight), medical (such as cardiovascular, physiological monitoring and infusion, anaesthetic and ventilation, medical imaging, mechanical and electromechanical assistive technology)

Commissioning activity: activities to include:

- pre-start up eg checking for damage, correct positioning, correctly secured, utilities operative, appropriate fluid levels, clear of obstructions, correct labelling, guards, fences and safety systems operative
- methods, techniques and procedures eg running system (low speed), checking for leaks, sensory checks, incrementally load, conducting trial run, monitoring and recording measurements, shutting down and isolating
- using instruments eg devices (such as alignment, measuring), testing, electrical measurement
- completing relevant paperwork eg commissioning log/report, corrective action report, job sheet, customer-specific documentation, handover report

4 Know how to hand over an installation after commissioning an engineered system

Handover procedures: run the installation; confirm all safety procedures are working; give instructions eg modifications, unusual features, operating instructions, service/maintenance requirements; handover documentation; people involved eg commissioning engineer, maintenance supervisor, production/process supervisor; complete all relevant paperwork eg job card, installation and commissioning report, handover paperwork; confirm handover of responsibility for the equipment.

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe an installation procedure for a given type of mechanical equipment	**M1** explain the differences and similarities when installing mechanical and electrical/electronic types of equipment, including safety considerations	**D1** explain the importance of correct installation, commissioning and handover procedures.
P2 describe a commissioning procedure for a newly installed given type of mechanical equipment	**M2** describe how a given piece of equipment used on an engineering system was installed and commissioned.	
P3 describe an installation procedure for a given type of electrical/electronic equipment containing five different modules/ components and two different types of cable		
P4 describe a commissioning procedure for a given newly installed type of electrical/ electronic equipment		
P5 carry out an installation activity for a given piece of equipment used on an engineering system [IE1, TW1, TW2, TW3]		
P6 carry out a commissioning activity for a given piece of equipment used on an engineering system [IE1, TW1, TW2, TW3]		
P7 describe how to hand over an engineering system after installation and commissioning. [IE1, RL6]		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

When delivering this unit tutors should ensure that learners have a sound understanding of the underpinning installation and commissioning procedures before starting the practical work in learning outcome 3.

The first two learning outcomes are about the knowledge required to install and commission mechanical and electrical/electronic types of equipment. Equipment in this sense is listed within the unit content and includes such things as conveyors or pumps for learning outcome 1 and electrical/electronic equipment that contains both a range of modules/components and cable types for learning outcome 2. An example of a suitable electrical engineering system might involve switchgear, starter, cable connectors, conduit and emergency/stand-by batteries, requiring both armoured and PVC cable types. Learners need to understand that pre-installation and pre-commissioning activities are important and support the limitation of risk.

The activities in learning outcomes 1 and 2 could be developed through a series of workshop demonstrations underpinned by classroom discussion and teaching. Handouts and recorded notes to support what learners have done or learned are also important. Learners should be given an opportunity to work with or know about as wide a range of mechanical and electrical/electronic types of equipment as possible. Centres should try to ensure that learners become fully aware of any differences and similarities between the mechanical and electrical/electronic activities. This should also be kept in mind when carrying out practical work.

Learning outcome 3 is about being able to carry out installation and commissioning activities for a simple piece of equipment used on a wider engineering system. This piece of equipment should be simple and does not need to have both mechanical and electrical/electronic requirements. However some of the engineering systems that could be used, such as medical equipment, will have such a dual requirement.

When delivering learning outcome 4 centres should ensure that learners are aware of all of the requirements of handover procedures listed in the unit content. Discussion should also include reasons why hand over sometimes goes wrong and the causes of this.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole class teaching: • introduction to unit, scheme of work and method of assessment • introduce and describe different types of mechanical engineering equipment • explain different installation procedures for mechanical engineering systems • class discussion on why pre-installation and pre-commissioning activities are so important and how they help limit risk. *Practical activities:* • series of tutor-led workshop demonstrations of a range of mechanical equipment, their requirements and associated activities.
Preparing for and carrying out **Assignment 1, Part 1: Installing Mechanical Systems** (P1 and P2)
Whole class teaching: • introduce and describe different types of electrical/electronic engineering equipment • explain different installation procedures for electrical/electronic engineering systems. *Practical activities:* • series of tutor-led workshop demonstrations of a range of electrical/electronic equipment, their requirements and associated activities.
Preparing for and carrying out **Assignment 1, Part 2: Installing Electrical Systems** (P3 and P4)
Whole class teaching: • explain common features and differences in installation activities and commissioning procedures for mechanical and electrical systems.
Preparing for and carrying out **Assignment 2: Installation and Commissioning in an Engineering System** (P5, P6, M1 and M2)
Whole class teaching: • explain handover procedures. *Practical activities:* • series of tutor-led workshop demonstrations on handover procedures for specific systems.
Preparing for and carrying out **Assignment 3: Handing Over** (P7 and D1)
Feedback on assessment, unit review and evaluation.

Assessment

Evidence can be generated through a variety of methods such as, assignments, practical activities and in-class written assessments.

To achieve a pass grade, learners must be able to describe installation and commissioning procedures for both mechanical and electrical/electronic types of equipment. They will also need to demonstrate, through a practical activity, that they can install and commission a simple piece of equipment as used on an engineering system. Finally, they need to demonstrate that they know how to hand over an engineering system that has been installed and commissioned, although actual handover is not required. The criteria associated with learning outcomes 1, 2 and 4 relate to equipment in its wider sense, whereas the criteria associated with learning outcome 3 relate to simpler equipment that is likely to be found on more complex engineering systems.

To achieve a merit grade learners must show that they understand the differences and similarities when installing mechanical and electrical/electronic types of equipment, including safety considerations. They will also be able to describe how a given piece of equipment used on an engineering system was installed and commissioned. This piece of equipment and installation and commissioning could relate to that carried out as a practical activity for some of the pass criteria requirements.

To achieve a distinction grade learners must show they understand the importance of correct installation, commissioning and handover procedures.

This unit could be assessed through the use of three assignments. The first assignment could cover the pass criteria associated with learning outcomes 1 and 2 (P1, P2, P3 and P4). Written tasks could be given that ask learners to describe an installation procedure for a given type of mechanical equipment and describe a commissioning procedure for a given newly installed type of mechanical equipment (P1 and P2). Because the type of mechanical equipment is given, different learners can be given different types of mechanical equipment according to their preferred area. Whilst examples are given in the unit content, this list is not exhaustive.

A similar set of tasks could be given for P3 and P4. Whilst again there is freedom of choice for the type of electrical/electronic equipment given, it must include five different modules/components and two different types of cable.

For all four criteria evidence is likely to be in the form of a written response. If any descriptions are given verbally then a very detailed record of this needs to be kept, supported by a witness statement/observation record.

A second assignment could address criteria P5, P6, M1 and M2. Again, individual tasks could be set to target each criterion. Physical resources need to be made available to support the practical activity carried out for P5 and P6. Again, the given engineering system can based on the learner's preferred area of work. Whilst examples are given in the unit content this list is not exhaustive. Centres should not make the practical task too complex.

Evidence for P5 and P6 is likely to be in the form of a witness statement/observation record supported by supplementary records such as pre-start check sheets, annotated photographs and completed documentation etc.

Further written tasks could be set to cover criteria M1 and M2. Responses and evidence are likely to be in the form of a written report.

The final assignment could address criteria P7 and D1. This could ask learners to describe how to hand over an engineering system after installation and commissioning (P7). This could be based on the practical activity carried out in the second assignment. The assignment could also ask them to explain the importance of correct installation, commissioning and handover procedures (D1). It is important that this assignment is attempted last as it relies on understanding gained from the other assignments and activities.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3 and P4	Part 1: Installing Mechanical Systems Part 2: Installing Electrical Systems	learners need to describe to a new member of staff the common installation and commissioning techniques for mechanical and engineering systems.	A written report setting out the common techniques and procedures for a range of different systems and describing the installation and commissioning procedures for a newly installed mechanical and electrical system.
P5, P6, M1 and M2	Installation and Commissioning in an Engineering System	A practical activity installing a simple, learner-selected system.	A record of observation by the tutor of the learner's installation activity. A witness statement/ observation record supported by written supplementary records such as pre-start check sheets, annotated photographs and completed documentation This could be included in a written report completed by the learner.
P7 and D1	Handing Over	Written activity based on the previous, practical assignment requiring learners to describe the hand over of the specific engineering system.	A written report describing the hand over procedures appropriate as follow-up to the practical activity, explaining the importance of correct installation, commissioning and handover procedures.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
		Engineering Process Plant Services and Operations

This unit contributes towards the knowledge requirements for the following units in the Level 3 SEMTA National Occupational Standards for Installation and Commissioning:

- Unit 4: Handing Over and Confirming Completion of Installation or Commissioning Activities
- Unit 5: Installing Mechanical Equipment
- Unit 6: Installing Electrical/Electronic Equipment
- Unit 7: Installing Equipment to Produce an Engineered System
- Unit 20: Commissioning Mechanical Equipment and Systems
- Unit 21: Commissioning Electrical/Electronic Equipment and Systems
- Unit 22: Commissioning Engineered Systems.

Essential resources

Centres delivering this unit will require access to a variety of instruments used in installation and commissioning work along with relevant industrial standard documentation. A range of both mechanical and electrical/electronic equipment types are required, particularly engineering system equipment/components as listed in the unit content.

Employer engagement and vocational contexts

Further information on employer engagement is available from the organisations listed below:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei/
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional Business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Blaus J – *Electrical Installations* (Butterworth-Heinemann, 2005) ISBN 0435401998

Linsley T – *Advanced Electrical Installation Work* (Newnes, 2005) ISBN 0750666269

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	identifying what information is needed to resolve problems when installing a given piece of equipment
Reflective learners	evaluating their own experiences in any difficulties faced with installing equipment and communicating their experiences and knowledge to others to ensure successful use of equipment
Team workers	collaborating with others to install equipment and assuming different roles in an installation team.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are ...
Independent enquirers	when planning and carrying out pre-commissioning procedures to identify potential problems
Creative thinkers	changing ideas and assumptions in the face of new experiences in installing different types of equipment
Reflective learners	reviewing their own work in installation and communicating installation and maintenance instructions to users
Team workers	when collaborating with others as part of an installation team
Self-managers	dealing with competing pressures of installation, safety issues and productive use of systems and equipment.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Follow and understand the need for safety and security practices	detailing commissioning procedures for hand over to users
ICT – Find and select information	
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	finding information on the installation of a wide range of unfamiliar systems and equipment
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	developing and completing relevant paperwork
Present information in ways that are fit for purpose and audience	presenting suitable information for users when handing over documentation
Mathematics	
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	installing different equipment types or in unfamiliar situations and environments
English	
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	preparing documentation and filling out forms in commissioning procedures.